Sexual Risk Behavior and Heavy Drinking Among Weekly Marijuana Users

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ABSTRACT. Objective: Sexual behavior that incurs increased risk for sexually transmitted infections and HIV incidence is associated with both heavy alcohol and marijuana use. Whereas detrimental effects of alcohol on increased sexual risk have been documented in event-level and laboratory studies, less is known about the combined use of alcohol and marijuana and their relative impact on sexual risk behavior. We examined the degree to which both heavy drinking and marijuana use were associated with condomless sexual intercourse with casual versus main partners in a sample of weekly marijuana smokers. **Method:** Participants reported substance use and sexual activity using a 60-day Timeline Followback interview method ($n = 112$). **Results:** Results of generalized estimating equations indicated that both alcohol and marijuana use were independently associated with greater odds of having sexual intercourse but were not associated with greater odds of unprotected sex with a casual partner. Heavy drinking on a given day was associated with increased odds of having casual protected sex. Using both substances synergistically increased the likelihood of unprotected sex with a main partner. **Conclusions:** Findings suggest that behaviors posing higher sexual risk (condomless intercourse or sex with casual partners) occur on days when alcohol use exceeds moderate drinking guidelines. Interventions designed to reduce sexual risk behaviors may need to specifically target heavy drinking alone or when used with marijuana. (*J. Stud. Alcohol Drugs, 77,* 104–112, 2016)

S EXUAL BEHAVIOR THAT INCURS increased risk for sexually transmitted infections and HIV has been frequently linked with alcohol use (Hendershot & George, 2007; Irwin et al., 2006; Shuper et al., 2009). Studies have demonstrated correlations between alcohol consumption and risky sexual behaviors (Leigh & Stall, 1993) including having multiple or casual sexual partners (Castilla et al., 1999; Cooper, 2002; Valera et al., 2009) and failure to use condoms (Graves, 1995). Alcohol administration research provides additional support to survey-based studies in that alcohol acutely increases intentions to engage in unprotected sex, which are known to be linked to risk behavior (Rehm et al., 2012). Marijuana use has also been implicated as a contributing factor in sexual risk behavior (Castilla et al., 1999; Hittner & Kennington, 2008; Shrier et al., 1997), with marijuana users more likely to have multiple sexual partners (Bell et al., 1997; Guo et al., 2002; Poulin & Graham, 2001; Valera et al., 2009), less likely to use contraceptives (Costa et al., 1996; Guo et al., 2002; Kingree & Betz, 2003; Shrier et al., 1997), and being at increased risk for contracting sexually transmitted infections (De Genna et al., 2007) and HIV (Fernández et al., 2004).

Despite some evidence that alcohol and marijuana use are associated with risky sex, there are a number of contradictory findings from correlational (Valera et al., 2009; Wechsler et al., 1995) and experimental studies. For example, although acute alcohol administration has been found to increase risky sex intentions and impair perception of risk (Purdie et al., 2011; Rehm et al., 2012), acute administration of marijuana and expectation that marijuana was used were both found to increase caution in decisions involving sexual risk and awareness of risks (Metrik et al., 2012). Mixed findings on co-occurrence between alcohol and marijuana and risky sex behaviors may reflect methodological limitations of correlational research in which causal inference about alcohol or marijuana's impact on sexual risk is untenable. Experimental research is similarly hampered by laboratory setting limitations assessing sexual intentions instead of behavior in a natural environment.

Event-level analysis of sexual risk data can potentially address limitations in global association studies and experimental research by examining situational factors in a natural setting. The most basic event-level analysis, known as critical-incident study, quantifies information related to the most recent sexual event, including prior alcohol and other drug use (Weinhardt & Carey, 2000), collected at a single time point (e.g., Connor et al., 2013; Hendershot et al., 2010; Leigh et al., 2008a) or over multiple time points (e.g., Walsh et al., 2014). Such studies yield inconsistent findings including positive associations with risky sex (i.e., unprotected sex with a nonsteady partner) for alcohol (Brown & Vanable, 2007; Connor et al., 2013) and marijuana (Hendershot et al., 2010) as well as nonsignificant associations with risky sex for alcohol (Leigh et al., 2008a; Temple & Leigh, 1992;

Temple et al., 1993) and marijuana (Brodbeck et al., 2006; Leigh et al., 2008a). A meta-analysis of studies investigating alcohol use before or during discrete sexual encounters also found that drinking was not related to condom use (Leigh, 2002).

More comprehensive event-level studies collect data on all recent sexual encounters rather than one event using methods such as a daily diary (e.g., Leigh et al., 2008a), ecological momentary assessment (Shiffman et al., 2008), or reliable Timeline Followback (TLFB) methods (e.g., Carey et al., 2001) that provide information about both sexual encounters and substance use on a daily level during a specific period. Using time-varying covariates, researchers can answer questions about alcohol and marijuana use on days when sexual activity and risky sex were reported. The TLFB relies on established memory aids to facilitate recall and permits collection of enriched contextual information on the co-occurrence of several risk behaviors. Several daily diary studies (Hensel et al., 2011; Kiene et al., 2009; Leigh et al., 2008b; Morrison et al., 2003) and a 30-day TLFB study with men who have sex with men (MSM; Irwin et al., 2006) have indicated mixed findings on drinking and unprotected sex. However, differentiating heavy drinking from moderate drinking levels has helped explicate these inconsistencies (Hittner & Kennington, 2008; Kahler et al., 2015; Valera et al., 2009). When level of alcohol use has been specifically examined, sexual risk behaviors (including HIV risk) were strongly and consistently linked with heavy episodic drinking, particularly in the MSM studies (Kahler et al., 2015; Vosburgh et al., 2012; Wen et al., 2012).

On the contrary, the limited number of multiple-event-level studies on marijuana use and risky sex do not find an association (Hensel et al., 2011; Kahler et al., 2015; Vosburgh et al., 2012; Walsh et al., 2014), with few exceptions (Anderson & Stein, 2011; Drumright et al., 2006). Marijuana was associated with unprotected anal intercourse in a study in which the majority of marijuana users also used methamphetamine, a drug directly linked with this sex risk outcome (Drumright et al., 2006). Marijuana was also associated with condom nonuse with casual partners in an all-women study that selected women reporting at least one occasion of heterosexual intercourse in the past 90 days (Anderson & Stein, 2011). Importantly, the Anderson and Stein (2011) study was the first to have specifically examined independent and combined effects of marijuana and alcohol (any vs. none) on sexual risk behavior. Both alcohol and marijuana use on a given TLFB day were associated with sexual activity. Alcohol was specifically associated with sex with a casual partner, but only marijuana was associated with condom nonuse with casual partners; there was no evidence of the synergistic effect of alcohol and marijuana use on sex-risk outcomes (Anderson & Stein, 2011). Other multiple-event-level assessment studies found increased quantity of alcohol, but not marijuana, use to be negatively associated with condom use in college women (Walsh et al., 2014) and both substances to be associated with sexual encounters but not with unprotected sex in adolescent women (Hensel et al., 2011). It is thus unknown whether marijuana, alone or in combination with heavy drinking, may be associated with risky sex in day-level analysis in predominantly heterosexual samples of both genders.

Present study

The literature has indicated a mixed relationship between alcohol and marijuana use and sexual risk behavior. There is preliminary evidence that such inconsistencies may be explained by the combined use of the two drugs or by level of alcohol use; however, these factors have not previously been addressed concurrently in one comprehensive study of both genders. The present study addresses this critical gap in knowledge in a sample of marijuana users. The study differentiates the effects of heavy and moderate levels of alcohol consumption versus no alcohol use as well as marijuana use. Importantly, it examines relative versus synergistic effects of marijuana use and alcohol consumption on sexual intercourse using a 60-day TLFB interview among mostly heterosexual young adult men and women. The primary aim was to examine whether marijuana use, moderate levels of alcohol use, and heavy alcohol use patterns were associated with sexual risk behaviors versus any sexual activity.

Because partner type has been shown to be an important factor in sexual risk outcomes (Brown & Vanable, 2007; Kiene et al., 2009; Scott-Sheldon et al., 2010), we differentiated between four main categories of sexual activity incorporating partner type (main or casual) and also condom use versus nonuse: protected sexual intercourse with a main partner, unprotected intercourse with a main partner, protected intercourse with a casual partner, and unprotected intercourse with a casual partner. There are three main hypotheses of this study. First, alcohol and marijuana use (vs. nonuse) on a given day may be independently associated with greater odds of sexual activity (vs. no sex) and risky sexual behavior (vs. other sexual behavior) on a given sexual activity day. Second, use of both alcohol and marijuana on a given day would either have simple additive effects or would synergistically increase the odds of sexual activity and risky sexual behaviors. Third, the effects of alcohol use on sexual behaviors would be more pronounced when alcohol use is heavy on a given day versus no alcohol use on that day. Because of established gender differences in sexual behavior and attitudes about sexual risk behaviors (Crowe & George, 1989; Petersen & Hyde, 2010) and evidence that it may affect the relationship of substance use to sexual behavior (Scott-Sheldon et al., 2010), gender was an important covariate included in all sex behavior models in this study.

Method

Sample description

This study uses data obtained from participants ($N = 151$) who completed the baseline assessment session of an experimental study of marijuana's acute effects on impulsivity (Metrik et al., 2012). Participants who did not report any sexual activity in the past 60 days ($n = 36$) and female participants reporting exclusive homosexual status on the Kinsey scale described below ($n = 3$) were excluded from the analysis (because they were not considered to be at risk). Analyses were completed on the remaining participants ($n = 112$). As previously described (for details, see Metrik et al., 2012), this institutional review board–approved study of marijuana users comprised participants recruited through newspaper advertisements, flyers, and social media websites who met several inclusion criteria: native English speakers, 18–30 years of age, marijuana use at least once a week in the past month and at least 10 times in the past 6 months, and self-reported ability to abstain from marijuana for 24 hours without withdrawal. Exclusion criteria were history of substance use treatment and intent to quit or receive treatment for cannabis misuse; past-month affective disorder or history of panic attacks, psychotic state, or suicidal state; alcohol dependence; and smoking 20 or more tobacco cigarettes a day. See Table 1a for sample demographics.

Measures

The TLFB (Dennis et al., 2004) assessed past-60-day number of marijuana, alcohol, and tobacco cigarette use days and incidents of sexual intercourse for each of these days including any vaginal or anal sex (Carey et al., 2001). The TLFB is a calendar-assisted structured interview that provides a way to cue memory to enhance recall accuracy. The TLFB interview is established as a psychometrically sound retrospective method for assessing alcohol use (Sobell & Sobell, 1978, 1980), cannabis use (Dennis et al., 2004), and sexual behaviors (Carey et al., 2001; Weinhardt et al., 1998).

For alcohol use, 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 distilled spirits); each day was also coded for use of marijuana (yes or no). For each sexual episode, participants were asked about condom use versus nonuse and also partner type (main or casual). Participants were given the following instructions with regard to the definitions of main and casual partners: "For our purposes, a main partner is someone that you have sex with and you consider this person to be the person that you are serious about. A casual partner is anyone that you have sex with but you do not consider this person to be a main partner to you. This person can be someone you've had sex

TABLE 1A. Demographic characteristics ($n = 112$)

Variable	M	SD
Age, in years	21.7	3.2
	n	%
Men	71	63
Race/ethnicity		
White[a]	82	73
African American	8	7
Asian American	5	5
Mixed ethnic origin/other	17	15
Hispanic ethnicity	12	11
In college	68	61
Sexual orientation		
Exclusively heterosexual	88	78
Predominantly heterosexual, incidentally homosexual	13	11
Predominantly heterosexual, more than incidentally homosexual	3	3
Equally heterosexual and homosexual	4	4
Predominantly homosexual	3	3
Exclusively homosexual	1	1

Notes: Percentages are based on available data per group. [a]Refers to non-Hispanic White.

with only once, or a few times, or you have sex with them on an on-going, casual basis. The important thing, however, is that this person is not a main partner."

Descriptive items from the Cognitive Appraisal of Risky Events Questionnaire–Revised, Past Frequency scale (CARE-R; Fromme et al., 1997; Katz et al., 2000) assessed the number of sexual partners, the number of new sexual partners, and the number of weeks dating an exclusive partner in the past 6 months. Items from the Marijuana History and Smoking questionnaire—including questions about age at onset, number of times used marijuana per day, amount of money spent on marijuana, and other questions (Metrik et al., 2009)—were used descriptively to characterize marijuana use in this sample. Kinsey's Heterosexual–Homosexual Rating Scale (Kinsey et al., 1948) was used to assess sexual orientation. The scale ranges from 0 (for those who identify themselves as exclusively heterosexual) to 6 (for those who identify themselves as exclusively homosexual), and 1–5 for those who identify with varying levels of sexual activity with either sex.

Data analysis plan

Descriptive values of participant demographics—including self-reported alcohol, marijuana, and tobacco use and sexual orientation and activity—were calculated using IBM SPSS Statistics for Windows, Version 22 (IBM Corp., Armonk, NY). Generalized estimation equations (GEE; Liang & Zeger, 1986) were used to examine participant substance use and sexual activity over the past 60 days. GEE analyses included time-varying alcohol use, marijuana use, and the interactions between alcohol and marijuana use as predictors of the odds of having casual-unprotected, casual-protected,

TABLE 1b. Substance use characteristics (*n* = 112)

Variable	M	SD
Timeline Followback summary variables		
% drinking days	22.15	16.40
No. of alcoholic drinks/drinking day	4.79	3.04
% heavy drinking days	11.51	13.87
No. of same-day marijuana and		
alcohol use days	7.69	6.70
% same-day marijuana and		
alcohol use days	12.83	11.17
% marijuana use days	42.10	24.07
% smoking tobacco days	63.33	39.85
No. of cigarettes per day		
(for *n* = 55 tobacco smokers)	5.94	5.21
Marijuana use history variables		
Age at regular marijuana use	16.3	1.1
Times used marijuana on an average day	1.87	1.05
Money spent on marijuana in past 30 days[a]	89.73	146.22
Money spent on marijuana in past 6 months[a]	479.46	1,051.38

	n	%
Marijuana ounces used per week		
Less than 1/16th	23	21
1/16th	24	21
1/8th	19	17
More than 1/8th	46	41
Combined use of alcohol and marijuana		
in past 60 days		
Never	8	7.1
Seldom	25	22.3
Occasionally	51	45.5
Frequently	23	20.5
Repeatedly	5	4.5
DSM-IV alcohol abuse	27	24

Notes: No. = number; DSM-IV = *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (American Psychiatric Association, 1994). [a]In U.S. dollars.

TABLE 2. Timeline Followback sexual intercourse activity days by sexual activity type (*n* = 112)

Variable	No. of participants *n* (% men)	No. of days *n*	%
Any sex with main partner (MP)	90[a] (58%)	1,369	
Any MP unprotected	60[b] (65%)	1,046	15
Any MP protected	36 (47%)	323	5
Any sex with casual partner (CP)	29[a] (83%)	112	
Any CP unprotected	10 (100%)	45	1
Any CP protected	22 (77%)	67	1

Notes: Of 6,710 available person-days, 22% were when any sexual intercourse was endorsed. [a]This includes seven participants who endorsed sexual intercourse with both main and casual partners; [b]this includes six participants who endorsed both protected and unprotected sexual intercourse with main partner.

main-unprotected, or main-protected sex on a given day. Time-varying variables carried three gender-adjusted levels of alcohol use on a given day: 0 = *0 drinks;* 1 = *moderate drinking:* 1–5 standard drinks for men (1–4 standard drinks for women); and 2 = *heavy drinking:* ≥5 drinks for men (≥4 drinks for women) based on the National Institute on Alcohol Abuse and Alcoholism (2005) guidelines. The interaction term tests whether the effects of alcohol and marijuana use are additive or multiplicative.

If the interaction is not significant, then the effects of alcohol and marijuana use can simply be added when determining the odds of a given sexual behavior. A significant interaction, by contrast, suggests that the combined use of alcohol and marijuana contributes to greater (or lesser) risk than would be predicted by the addition of the main effects of each. In addition, an initial GEE model of odds of any sex was conducted to provide a reference when considering each of the four subtypes of sexual activity. Subsequent analyses by sexual activity type included only sex days, and the reference for each outcome was thus all other types of sexual activity. GEE models were run using a logit link function and an exchangeable correlation matrix with dichotomous time-varying predictors and outcomes. The control variables were as follows: age, gender, race (White non-Hispanic vs. all other racial or ethnic groups), college status (currently attending vs. not attending), and sexual preference (predominantly heterosexual vs. all other sexual preference groups).

Results

Descriptive results

Demographic and alcohol and marijuana use variables are presented in Tables 1a and 1b. The 112 participants provided data for a total of 6,710 person-days, with 22% of days when any sexual intercourse was endorsed (Table 2).

CARE-R frequency of involvement with dating partner

Participants (*n* = 106 responses) defined an exclusive dating partner as someone they have dated for at least a mean of 8.38 (*SD* = 7.40) weeks. Among those with past TLFB 60-day history of sexual intercourse with a main partner, exclusive dating partner was described on the CARE-R as someone dated for at least a mean of 9.09 weeks (*SD* = 7.91). On average, participants (*n* = 106 responses) reported having 1.9 (*SD* = 1.8) different sexual partners in the past 6 months. Of those, there was an average of 1 (*M* = 1.04, *SD* = 1.65) new sexual partner in the past 6 months (based on *n* = 90 responses to this question). Specifically, participants with a past TLFB 60-day history of sexual intercourse with a main partner reported on average 1.70 (*SD* = 1.49) different sexual partners in the past 6 months (on CARE-R). Regarding the same question, participants with a history of casual partners reported on average 3.36 (*SD* = 2.69) different partners.

Marijuana and alcohol use in relation to the odds of having any sex

The GEE analyses of alcohol and marijuana use predicting the odds of having intercourse on a given day showed an

TABLE 3.   Number of days engaging in four types of sexual intercourse when alcohol and/or marijuana were used and not used

	Casual unprotected		Casual protected		Main unprotected		Main protected	
Variable	No marijuana n (%)	Marijuana n (%)	No marijuana n (%)	Marijuana n (%)	No marijuana n (%)	Marijuana n (%)	No marijuana n (%)	Marijuana n (%)
No alcohol	14 (67)	15 (63)	7 (35)	20 (43)	381 (77)	341 (62)	123 (71)	104 (69)
Moderate drinking	0 (0)	2 (8)	3 (15)	3 (6)	68 (14)	98 (18)	29 (17)	18 (12)
Heavy drinking	7 (33)	7 (29)	10 (50)	24 (51)	45 (9)	113 (20)	21 (12)	28 (19)
Total	21 (100)	24 (100)	20 (100)	47 (100)	494 (100)	552 (100)	173 (100)	150 (100)

Notes: Alcohol use was coded as 0 = *no alcohol;* 1 = *moderate drinking:* 1–5 standard drinks for men (1–4 for women); and 2 = *heavy drinking:* 5+ drinks for men (4+ drinks for women).

additive risk model. Specifically, both alcohol and marijuana use (OR = 1.74, $p < .001$) independently predicted greater odds of having sex, but their combination did not produce even greater odds than the independent effect of each substance (Heavy Alcohol × Marijuana interaction, $p > .05$; Moderate Alcohol × Marijuana interaction, $p > .16$). As shown in Table 4, this held for moderate and heavy alcohol use, indicating that consuming between 1 and 5 (1 and 4 for women) drinks and more than 5 (or 4 for women) drinks was related to an almost twofold increase in the odds of having intercourse (OR = 1.90 and 1.95, respectively, $p < .001$).

Marijuana and alcohol use in relation to the odds of each sexual activity type

Table 3 displays person-day counts in each drinking category (0 drinks, 1–5 drinks for men/1–4 drinks for women, and 5+/4+ drinks) by marijuana use (use vs. nonuse days) within each of the four sexual activity types. The GEE analyses of sexual activity days showed nonsignificant associations between either substance and casual unprotected sex. As shown in Table 4, neither moderate nor heavy drinking nor marijuana use on a given day were significantly associated with this high-risk sexual activity (ps > .10). For control variables in this model, currently attending college was significantly associated with greatly reduced odds of engaging in this high-risk sexual activity (OR = .12, $p < .01$). In this sample, no female participants engaged in casual unprotected sex; thus, gender covariate was omitted from this model. In addition, the model carrying the interaction term between alcohol and marijuana use variables did not reach convergence. This failure to converge occurred because of sparseness in this data subset ($n = 45$ person-days) where there was a cell with zero counts, indicating zero days of marijuana nonuse and consuming 1–5 drinks (Table 3). To remedy this problem, supplementary GEE analyses were run with the alcohol variable collapsed into two sex-adjusted categories (0–5 drinks and 5+ drinks). Interaction terms were nonsignificant in these models (OR = 0.71, $p > .33$).

As shown in Table 4, only heavy alcohol use was significantly associated with the increased odds of having casual protected sex (OR = 1.47, $p = .01$). Female participants were much less likely than male participants (OR = 0.22, $p < .01$) to engage in casual protected sex. Main partner unprotected sex showed a synergistic effect for combined heavy drinking and marijuana use with almost 60% higher odds. In addition, the odds of having this type of sex increased with age (OR = 1.18, $p < .05$). Finally, in our lowest risk sexual activity type, main-partner protected sex, combined heavy drinking and marijuana use on a given day were associated with significantly lower odds of engaging in this type of sex (OR = 0.60, $p < .05$). Women were also more likely to engage in this type of sexual activity than men (OR = 3.0, $p = .01$). Moderate drinking alone or in combination with marijuana use was not associated with significant increases in the odds of engaging in either type of main partner sex (ps > .30).

Discussion

The results indicated that both alcohol (moderate and heavy) and marijuana were independently associated with greater odds of having sexual intercourse on a given day but were not associated with increased odds of unprotected sex with a casual partner. There was evidence that heavy drinking was associated with increased odds of protected sexual intercourse with casual partners on a given day, an association not observed with moderate drinking. Drinking heavily and using marijuana synergistically increased the likelihood of unprotected sex with a main partner and, conversely, decreased the odds of main-partner protected sex. Marijuana use did not independently increase the odds of any specific type of sexual activity besides having greater odds of sexual intercourse relative to no sex on any given day.

The finding that heavy alcohol use was not associated with unprotected casual sex may in part be explained by the very limited sample size for this sex type. Our subgroup of participants endorsing risky sex was small, only 10 participants. This limited the power to detect significant effect and may explain the lack of relationship between heavy use and this type of sexual activity. Although neither alcohol nor marijuana use predicted the most risky sexual behavior category (condomless sex with casual partners), all sexual intercourse infers an element of risk. Importantly, in this relatively low sex-risk sample, participants endorsing sexual

TABLE 4. Generalized estimating equations (GEE) from five models of Timeline Followback days of any marijuana and alcohol use (moderate or heavy drinking versus no drinking) predicting sexual intercourse activity

Predictors Dependent variable in 5 models:	Moderate alcohol		Heavy alcohol		Marijuana		Heavy Alcohol × Marijuana	
	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]
1. Any sex vs. no sex								
Main effects	1.95***	[1.58, 2.40]	1.90***	[1.51, 2.40]	1.74***	[1.39, 2.17]		
Main effects and interactions	2.25***	[1.70, 2.98]	2.44***	[1.76, 3.38]	1.93***	[1.48, 2.52]	0.67§	[0.45, 1.01]
Sexual activity days only:								
2. Casual partner unprotected								
Main effects	0.75	[0.54, 1.06]	1.63	[0.86, 3.09]	1.32	[0.92, 1.91]		
3. Casual partner protected								
Main effects	1.13	[0.91, 1.40]	1.47**	[1.18, 1.83]	0.99	[0.88, 1.12]		
Main effects and interactions	1.24	[0.97, 1.59]	1.59**	[1.22, 2.07]	1.06	[0.91, 1.23]	0.88	[0.65, 1.19]
4. Main partner unprotected								
Main effects	0.98	[0.86, 1.12]	0.98	[0.80, 1.20]	0.98	[0.92, 1.05]		
Main effects and interactions	0.92	[0.77, 1.11]	0.74*	[0.57, 0.97]	0.89*	[0.80, 0.99]	1.59**	[1.11, 2.26]
5. Main partner protected								
Main effects	0.98	[0.87, 1.09]	0.84	[0.64, 1.10]	1.01	[0.94, 1.08]		
Main effects and interactions	0.98	[0.86, 1.11]	1.13	[0.82, 1.56]	1.10§	[1.00, 1.20]	0.60*	[0.37, 0.98]

Notes: Alcohol use was coded as 0 = *no drinking;* 1= *moderate drinking:* 1–5 standard drinks for men (1–4 for women); and 2 = *heavy drinking:* 5+ drinks for men (4+ drinks for women). The first GEE model tested the odds of having any sex (vs. no sex); GEE models 2–5 tested the odds of each sexual activity type versus all other activity types using only sex days. Each model presents steps with main effects only and steps with main effects with two interaction terms (heavy alcohol by marijuana shown for all models; moderate alcohol by marijuana not presented because not significant in all models). Casual partner unprotected sex model presents step with main effects only because model with the interaction terms did not reach convergence. Covariates (not shown in table) in all models included age, gender, race (White non-Hispanic vs. all other racial or ethnic groups), college status (currently attending vs. not attending), and sexual preference (predominantly heterosexual vs. all other sexual preference groups). OR = odds ratio; CI = confidence interval.
§*p* < .10; *p* < .05; **p* < .01; ***p* < .001.

intercourse with a main partner on the TLFB described their exclusive dating partner as someone they dated for an average of 9 weeks and endorsed more than one different sexual partner in the past 6 months on the CARE-R. This finding underscores the importance of examining unprotected relative to protected sexual intercourse as a risk behavior with greater clinical and public health implications than possibly more subjective categories of "casual" versus "main" partner type. Therefore, the association between heavy drinking and marijuana use with unprotected sexual intercourse with a main partner observed in this sample may still add valuable information on sexual transmission risk.

Significant findings concerning alcohol's association with specific sexual behaviors were explained by heavy (and not moderate) drinking that is known to place an individual at increased risk for alcohol-related problems (Dawson et al., 2005). These results are consistent with previous findings that sex risk may be more related to heavy drinking relative to moderate alcohol consumption (e.g., Hittner & Kennington, 2008; Kahler et al., 2015; Valera et al., 2009). Heavy drinking results also are consistent with findings from alcohol administration studies indicating that the impairing effects of alcohol are mostly present at heavy rather than moderate doses of alcohol (Caswell et al., 2013).

Drinking heavily and using marijuana synergistically increased the likelihood of unprotected sexual intercourse with a main partner on a given day. It thus appears that large quantities of alcohol in combination with marijuana may be associated with specific facets of sexual behavior,

providing some support for the suggestion that risk taking may be maximized by using the two drugs simultaneously (Li et al., 2012; Volkow et al., 2014). Alcohol consumption can increase willingness to engage in sexual risk behavior, for both men and women (e.g., Stoner et al., 2007; Testa et al., 2000). Reduced inhibitory control (de Wit, 2009) may be the putative mechanism for alcohol's association with risky sexual behavior. Alternatively, alcohol and marijuana outcome expectancies (Goldman et al., 1991; Reich et al., 2010), specifically beliefs related to sexual facilitation, may exert a strong disinhibiting effect on sex-related behavior (Fromme et al., 1997). Thus, alcohol and marijuana may be used intentionally by individuals with salient positive outcome expectancies as a means to facilitate sex and reduce sexual inhibitions (Leigh, 1990). Nevertheless, these association data do not permit causal inferences with respect to the use of alcohol and marijuana during the same episode or before sexual activity.

Our finding that marijuana use approximately doubled the odds of engaging in sexual activity on a given day relative to not having sexual intercourse is consistent with prior reports (e.g., Anderson & Stein, 2011). Beyond the observed increase in likelihood of general sexual activity, it appears that for the most part, marijuana use may not be considered an independent risk factor for sexual activity that incurs increased probability of sexually transmitted infections and HIV. Inconsistencies with several previous studies that indicated an association between marijuana use and risky sex (Anderson & Stein, 2011; Drumright et al., 2006) may

be largely explained by other drug use (Drumright et al., 2006) or by different samples (e.g., all females in Anderson & Stein, 2011; or adjudicated youth in Kingree et al., 2000).

Women in this study were more likely than men to engage in the safest category of sex (protected sex with a main partner) and were much less likely than men to engage in casual protected sex. Women were not represented in the casual unprotected sex category in this sample. Gender differences in sexual behavior and attitudes are known to influence risky sexual behavior, with men reporting engaging in more casual sex and more permissive attitudes about casual and premarital sex (Petersen & Hyde, 2010; Regan & Berscheid, 1999) and women emphasizing sex as part of a committed relationship more than men do (Regan & Berscheid, 1999). We have shown that these same participants in a marijuana placebo-controlled administration study, when expecting marijuana, relative to expecting placebo, rated negative consequences from coercive sex as more likely (Metrik et al., 2012). This suggests increased awareness of sexual risk in women when they smoke marijuana. Thus, risky sexual behavior when under the influence of alcohol and marijuana may differ across genders. Because of low power to detect such an effect in our limited subsample of women, we were unable to test whether the association between alcohol or marijuana use with sexual risk outcomes differed by gender.

Limitations

Although this study has a number of important strengths, including detailed day-level analysis of a sample of regular marijuana users of both genders, it is not without limitations. Despite the TLFB method's established reliability and validity, this retrospective reporting method may carry recall bias that could have influenced substance use and sexual behavior outcomes. This bias may be particularly pronounced in day-level analysis of assessment windows covering longer time intervals such as 60 days (Hoeppner et al., 2010) and in day-level association of behaviors with varying base-rate frequency. Temporal order between use of substances and sexual intercourse cannot be established with this type of assessment. Low count of days with condomless sexual intercourse with casual partners precluded us from testing the synergistic effect of marijuana and alcohol on this sexual risk outcome and generally limited the power to detect an effect of alcohol or marijuana use on this behavior.

Furthermore, no women engaged in casual unprotected sex in this sample, further limiting our ability to generalize conclusions about this high-risk sexual activity to both sexes. Limited MSM composition of this sample precluded us from exploring any sexual orientation subgroup differences in sexual risk. This was a study of associations, rather than one testing a specific theory of how substance use affects sexual risk. Future studies should consider a more comprehensive analysis of alcohol and marijuana's impact on sexual risk outcomes in the context of partner type as well as environmental factors including proximal time between use of a drug and sexual encounter.

Conclusions

These findings add important information to the small body of literature on day-level associations between marijuana use, alcohol use, and sexual risk behavior among regular marijuana users of both genders. Results suggest that sexual risk behaviors are more likely to occur on days when alcohol is consumed at high levels and, in some instances, when marijuana is also used on the same day. Differentiating heavy from moderate drinking levels, as well as examining synergistic effects of marijuana use, helped explicate mixed findings from previous studies that failed to consider variability in alcohol use levels. Marijuana users appear to be at greatest sexual risk on days when their alcohol consumption exceeds moderate drinking limits.

An important question for future research to address is whether heavy drinking and/or marijuana use increase the odds of condomless intercourse with non-exclusive sexual partners in a sample where this type of risk behavior is more prevalent among both men and women. Interventions designed to reduce sexual risk behaviors may need to specifically target heavy drinking alone or when combined with marijuana use. Brief interventions targeting alcohol-related risky sexual behavior in young adults appear to be efficacious (e.g., Lewis et al., 2014) and more effective when focused on multiple health risk behaviors such as substance misuse and sexual risk (Hale et al., 2014; Jackson et al., 2012).

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