

Is the Sum Greater than its Parts? Variations in Substance-Related Consequences by Conjoint Alcohol-Marijuana Use Patterns

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ABSTRACT

Alcohol and marijuana are the most commonly used substances for college-attending young adults. This study evaluated differences in substance-specific consequence attribution by alcohol-marijuana use patterns (concurrent alcohol and marijuana [CAM; use of both substances, not at same time] and simultaneous [SAM; use of both, at same time]) as well as alcohol-only (AO). First-year college students with prior alcohol use ($N = 610$, 50.9% women, 71% White, $M_{age} = 18$) completed an online assessment of past-three-month substance use, including SAM, and related consequences. Results indicated that polydrug (SAM and CAM) users reported greater alcohol involvement and earlier alcohol initiation than AO, and polydrug use was associated with more alcohol-related problems, including sexual risk taking and alcohol-related blackouts. When restricted to SAM/CAM users, logistic regressions indicated that SAM users reported an increased incidence in two marijuana-related problems relative to CAM (driving after using and academic difficulties), but lower rates of social problems. SAM users were also less likely to attribute substance-related social problems to alcohol. Overall, findings highlight variations that exist within alcohol-marijuana polydrug users and show areas to consider for intervention development and future research.

ARTICLE HISTORY

Received 7 June 2018

Accepted 1 February 2019

KEYWORDS

Alcohol; marijuana; college students; polydrug; conjoint; consequences

Individually, alcohol and marijuana are the most commonly used substances among young adults (Kann et al. 2016; Miech et al. 2016). However, individuals use both (Barrett, Darredeau, and Pihl 2006; Collins, Ellickson, and Bell 1998; Pape, Rossow, and Storrø 2009), with a growing number of studies linking polydrug use to more problematic consumption. For example, compared to peers who use alcohol only (AO), those who also use marijuana report greater alcohol consumption (Green et al. 2016; Magill et al. 2009; Shillington and Clapp 2001, 2006) and experience more alcohol-related consequences, including higher rates of cognitive and motor impairment while driving (Hartman et al. 2015; Robbe 1998) and risky sexual behavior (Metrik et al. 2016; Parks, Collins, and Derrick 2012).

Heterogeneity exists within alcohol-marijuana co-users, and a growing number of studies are examining variability that exists as a function of timing of use of each substance. For example, polydrug use may involve concurrent alcohol and marijuana use (CAM; use of both substances, not at same time), or simultaneous

alcohol and marijuana (SAM; of both, at same time, so the effects overlap) (Midanik, Tam, and Weisner 2007). There is mounting evidence that SAM use may be an additional risk factor for problematic consumption. Laboratory studies have shown that SAM produces interactive psychopharmacological effects that alter the $\Delta 9$ -tetrahydrocannabinol (THC) metabolism, producing stronger effects than if marijuana were used alone, contributing to the reinforcing properties of alcohol (Hansen et al. 2008; Pava and Woodward 2012). Convergent evidence comes from cross-sectional survey studies comparing drinking patterns between SAM and CAM users, with SAM users reporting greater drinking frequency and quantity, as well as greater alcohol-related problems (Brière et al. 2011; Haas et al. 2015; Midanik, Tam, and Weisner 2007; Subbaraman and Kerr 2015). Other comparative studies illustrate the likelihood of uniquely problematic links between SAM use and negative outcomes, including depressive symptoms, problems at school, impaired driving, and overall functional impairment (Norton and Collier 1988; Subbaraman and Kerr 2015; Terry-

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Portions of this study were used to fulfill dissertation requirements for Dr. Cummings. This research was supported in part by Grant Q184H090105 from the U.S. Department of Education Higher Education Center for the Prevention of Violence and High Risk drinking (PI: Haas). The Higher Education Center had no role in the study design, collection, data collection/analysis/interpretation, writing of the manuscript, or decision to submit this paper for publication.

McElrath, O'Malley, and Johnston 2013; Terry-McElrath, O'Malley, and Johnston 2014). However, the majority of studies focus on alcohol-related problem outcomes and have not extended investigations to examine differences in marijuana consequences.

Currently, it is unclear whether SAM use is a risk factor for increased marijuana-related consequences among alcohol-marijuana users. On first inspection, this could be examined via group-wise comparisons of DSM-type marijuana consequences (i.e., CAM vs. SAM). However, this may be complicated by user perceptions vis-à-vis whether their consequence was attributable to alcohol, marijuana, or both substances. Etiology can be more easily ascertained for consequences robustly associated with one substance (e.g., blackouts and alcohol). However, many consequence domains overlap, obscuring relationships between substance-specific etiologies to certain problems like driving under the influence, sexual risk taking, functional impairment (e.g., social, academic, or occupational), legal issues, and academic/cognitive/executive problems (Arria et al. 2013; Gilbert, Murphy, and Dennhardt 2014; Hingson et al. 2016; Homel, Thompson, and Leadbeater 2014; Lynskey and Hall 2000; Simons, Maisto, and Wray 2010; Suerken et al. 2016; Volkow et al. 2014). Ascertaining definitive causality for one drug or the other may not be possible; however, a tenable approach is to evaluate substance-specific consequences and investigate whether CAM and SAM users attribute consequences to a specific substance (i.e., alcohol or marijuana) or both. Such information would be valuable in intervention development efforts, particularly for high-risk populations such as college students.

Current study

This study extends current research on alcohol-marijuana use to look at differences in marijuana consequences and substance-specific problem attributions. First, we examined differences in alcohol-related problems as a function of use group (CAM, SAM, and alcohol only [AO]) to determine whether findings from comparable studies (Brière et al. 2011; Haas et al. 2015; Midanik, Tam, and Weisner 2007; Subbaraman and Kerr 2015) replicated to first-year college students. Second, we examined marijuana-related outcomes and substance-specific problem attributions within alcohol-marijuana users (CAM vs. SAM). Consistent with research on alcohol-related problems, we hypothesized that SAM users would report more marijuana-related problems compared to CAM users. Furthermore, among problem domains that

overlap between substances (e.g., unsafe sex, academic, legal, and social), CAM and SAM users would be more likely to attribute problems to alcohol compared to marijuana or both substances.

Method

Procedure and participants

Participants were recruited as part of a larger longitudinal study assessing substance use across the freshman year of college (for description of parent study, see Haas, Wickham, and Gibbs 2016). A subset of each entering class was selected at random for recruitment and attended a 20-minute recruitment/pre-college data collection session immediately before the start of the fall quarter. Data for this study were collected in the spring assessment, across two cohorts of first-year college students (2009–10 and 2010–11 entering classes). Participants were sent an individualized link to their university email to complete a 20-minute survey using a commercially available 128-bit encrypted program. Data collection was constrained to a two-week window each year (mid- to late May) to assess use patterns and consequences during a time in the academic year void of any events which may temporarily inflate alcohol or drug use (Greenbaum et al. 2005). Institutional Review Board approval was attained at Palo Alto University and Santa Clara University on an annual basis and participants received a \$10 gift card incentive upon completion of the survey.

For this study, data were collected from 817 students within the two-week window (66% of students recruited during the precollege session). Participants were excluded if they (1) reported no substance use in the preceding three months ($n = 180$); or (2) had missing alcohol or marijuana data ($n = 16$). The final sample consisted of 610 participants ($M_{age} = 18.09$, 50.9% women; 71% White, 16% Asian/Pacific Islander, 9% Latino/a, and 4% who did not specify their racial/ethnic identities).

Measures

Demographic measure included age, gender, height, weight, and ethnicity. Age of initiation for marijuana and alcohol was also collected.

Alcohol use

Past-month drinking was assessed using a modified version of the Quantity Frequency Index (Cahalan, Cisin, and Crossley 1969), with higher scores indicative of greater alcohol involvement. Items assessed

frequency of use on a 13-point Likert scale (e.g., “During the past spring, how often did you drink alcohol?”; response anchors ranged from 0 “never, I do not drink” to 12 “daily”) and typical quantity consumed per drinking event (open-ended).

Alcohol-related consequences

Participants self-reported the occurrence of 26 developmentally appropriate consequences using a 4-point scale ranging from 0 “never” to 3 “happened frequently.” Problems were assessed across multiple domains, including: Physiological (e.g., *had a hangover, blackout, vomiting, coordination/balance problems, shakiness day after drinking*; six items; sample $\alpha = .78$); Legal/Delinquent (e.g., *was convicted of an alcohol-related legal offense, received a campus alcohol policy violation, property destruction, physical altercations, driving after drinking*; eight items; $\alpha = .86$); Social (e.g., *had disagreements with your friends/partner/parent regarding how much or how often you drink, embarrassed self, verbal altercations*; five items; $\alpha = .73$); Academic (e.g., *missed class due to drinking and/or hangover, received poor grade due to drinking*; three items; $\alpha = .72$); and Sexual (*engaged in unplanned, unsafe, or regretted sexual activity*; three items; $\alpha = .81$). A total problem score was calculated by dummy-coding item responses and summing to create an overall problem score ($\alpha = .92$). This measure has been validated in college samples and has good convergent validity with the RAPI and AUDIT (Haas et al. 2013).

Marijuana and SAM use

Participants were asked if they had consumed marijuana in the past 90 days and, if yes, the number of days used. Consistent with measures used in previous studies (Lee, Cadigan, and Patrick 2017; Patrick, Veliz, and Terry-McElrath 2017), a separate, dichotomous item assessed simultaneous alcohol-marijuana use: “Do you use marijuana when you are also consuming alcohol?”

Marijuana-related consequences

Participants reported the incidence of 16 problems using a measure that assessed DSM-IV-TR comparable abuse/dependency symptoms (APA 2000), including items that paralleled domains on the alcohol consequence measure, including: Legal/Delinquent (e.g., *was arrested due to marijuana, drove after using*); Social (e.g., *had disagreements with your significant other regarding how much or how often you consume marijuana*; three items, $\alpha = .87$); and Academic (e.g., *missed class due to being stoned*; two items; $\alpha = .78$). Other items assessed DSM-IV-TR compatible symptoms of dependency (e.g., *had withdrawal symptoms*;

four items, $\alpha = .81$). A single item asked about unsafe sex while using marijuana. Items representing content that overlapped with alcohol consequence items were worded in mirror format for direct comparison. Items were dummy-coded (occurred/did not occur) and summed to create an overall problem quantity score (sample $\alpha = .94$).

Data analyses

Preliminary analyses evaluated normality of distribution, with variables exhibiting significant skew and/or kurtosis (i.e., quantity-frequency index: QFI) square-root transformed per recommendations of Tabachnick and Fidell (2007). Scale scores were calculated for alcohol- and marijuana-related consequences in the following domains: Legal/Delinquent (all items except driving after using/drinking, which were used as an independent indicators), Social, Academic, and Sexual. Driving after drinking (or using) and alcohol-related blackout were measured with single-item indicators. Frequency analyses indicated zero-inflated distributions for all consequence scores and these indicators were dummy-coded (0 “did not occur”; 1 “occurred”) for use in subsequent analyses.

Participants were stratified into three groups based on self-report: (1) CAM ($n = 209$); (2) SAM ($n = 139$); and (3) AO ($n = 262$). Logistic regressions evaluated group differences for specific consequences while controlling for overall use (alcohol or marijuana, depending upon consequence domains being assessed). Analyses examining differences in marijuana-specific use and outcomes among polydrug users were constrained to CAM and SAM users, while analyses examining alcohol-related differences among polydrug users included the AO users as a reference group.

Results

Differences by use category (AO, CAM, and SAM)

As shown in Table 1, subtle demographic differences were noted between groups. Specifically, SAM users had a higher representation of males and earliest ages of initiation for both alcohol (compared to AO and CAM) and marijuana (compared to CAM). Omnibus ethnic differences were found but largely attributable to a modest overrepresentation of CAM and AO students identifying as “other.”

Current alcohol use. Consistent with our first objective, group differences in recent alcohol use were observed, with AO students reporting less frequent alcohol use relative to CAM and SAM users, particularly for

Table 1. Demographic and substance use characteristics by group.

Characteristic	Conjoint Use Category			<i>F</i> or χ^2	Effect Size†
	AO (<i>n</i> = 262)	CAM (<i>n</i> = 230)	SAM (<i>n</i> = 134)		
Demographics					
Gender				12.95**	.14
% Male	40.6 ^a	52.4 ^b	58.2 ^b		
Ethnicity				20.29**	.13
% Asian/Pacific Islander	19.8 ^a	10.4 ^a	11.2 ^a		
% Latino/a	9.2 ^a	7.8 ^a	9.0 ^a		
% White	61.8 ^a	65.7 ^a	73.9 ^a		
% Other	9.2 ^{a,b}	16.1 ^a	6.0 ^b		
Age of Initiation (<i>M, SD</i>)					
Marijuana	n/a	16.60 (1.23)	16.03 (1.48)	6.38**	.04
Alcohol	16.52 ^a (1.74)	15.70 ^b (1.73)	14.74 ^c (1.59)	48.85**	.14
Alcohol Use					
Frequency				116.82**	.31
< Monthly	43.9 ^a	14.3 ^b	9.0 ^b		
1–3 Times/Month	16.4 ^a	17.0 ^a	10.4 ^a		
1–2 Times/Week	32.1 ^a	43.9 ^a	39.6 ^a		
3 or More Times/Week	7.6 ^a	24.8 ^b	41.0 ^c		
Typical Quantity/Occasion (<i>M, SD</i>)	4.34 ^a (2.32)	6.30 ^b (2.82)	7.13 ^c (2.93)	59.99**	.16
Typical BAC/Drinking Event (<i>M,SD</i>)	0.08 ^a (0.06)	0.12 ^b (0.06)	0.13 ^b (0.07)	35.01**	.13
Marijuana Use					
# Days Used/Past 90 Days (<i>M,SD</i>)	n/a	5.19 (7.39)	9.20 (9.96)	44.53**	.17

Note. AO = Alcohol only; CAM = concurrent alcohol-marijuana; SAM = simultaneous alcohol-marijuana. †Effect size calculated by Cramer's V for χ^2 and η^2 for F tests. Within each characteristic means and percentages followed by different letter superscripts (^{a,b,c}) signifying significant group differences based on Bonferroni-adjusted z -tests ($p < .05$).

* $p < .05$; ** $p < .01$.

frequent drinking (i.e., 3+ days/per week), which was reported by less than 10% of the AO compared to 24.8% of CAM and 41% of SAM users. Differences in typical quantity were also observed, with SAM and CAM users consuming significantly more drinks per occasion than AO (post-hoc Bonferroni tests $p < .05$).

Alcohol-related consequences. After controlling for overall drinking (QFI), AO users reported significantly fewer alcohol-related consequences ($M = 3.00$, $SD = 3.87$), followed by CAM ($M = 6.02$, $SD = 5.46$) and SAM ($M = 6.92$, $SD = 4.81$) users, $F(2, 621) = 9.45$, $p < .01$, $\eta^2_p = .03$. Comparison of specific consequence domains (driving after drinking, risky sex, blackout, social, legal, and academic/school) were analyzed using six logistic regressions, one for each consequence domain. Overall alcohol use (QFI) was entered as a covariate, followed by use category. The CAM group was used as a reference to enable direct comparison with SAM users as well as lower-risk AO students.

Results are summarized in Table 2. Most robust differences were seen for alcohol-induced blackouts. Frequency analyses indicated about 20% of AO users reported a blackout; however, incidence was considerably higher for CAM and SAM (47% and 63% of group, respectively). Even after controlling for QFI, blackout rates were considerably lower for

AO ($OR = 0.49$), and higher for SAM ($OR = 1.68$), relative to CAM users ($ps < .01$). Differences were also seen for risky sexual activity, with higher rates for CAM and SAM users compared to AO (28.3%, 32.1%, and 9.5%, respectively). A different pattern emerged for social problems, with CAM reporting more social problems relative to AO and SAM groups (14.4% compared to 4.3% and 5.2%, respectively). After controlling for QFI, no significant group differences were observed for legal issues, driving after drinking, or academic/school consequences.

Variations in marijuana consequences between polydrug users (CAM vs. SAM)

The sample was restricted to participants with prior marijuana use (CAM and SAM; $n = 364$). Four additional logistic regressions examined differences in marijuana-related problem domains (legal, risky sex, academic, and social), with CAM as the reference group. Frequency of past-90-day marijuana use was entered as a covariate, followed by group membership. As shown in Table 3, there were no significant group differences after controlling for past-90-day use ($ps > .20$).

Table 2. Logistic regression analyses predicting alcohol-related consequences controlling for alcohol involvement.

Variable	B	S.E.	Wald	p-value	OR	OR 95% CI	Nagelkerke R^2	χ^2	% Classified
<i>Driving after Drinking</i>									
Covariate: QFI	.01	.00	7.55	<.01	1.01	[1.00, 1.01]			
Block 1: Use Category			3.52	.17					
CAM (ref)									
AO	-.96	.61	2.45	.12	0.38	[0.12, 1.27]			
SAM	.18	.44	0.17	.68	1.20	[0.51, 2.83]			
Model Fit							.10	4.11	93.8
<i>Risky Sexual Activity</i>									
Covariate: QFI	.01	.00	19.11	<.01	1.01	[1.01, 1.02]			
Block 1: Use Category			6.76	.03					
CAM (ref)									
AO	-.70	.31	5.21	.02	0.50	[0.27, 0.91]			
SAM	.06	.27	0.05	.82	1.06	[0.62, 1.82]			
Model Fit							.24	31.42**	77.7
<i>Alcohol-Induced Blackout</i>									
Covariate: QFI	.02	.00	38.91	< .01	1.02	[1.01, 1.02]			
Block 1: Use Category			20.24	<.01					
CAM (ref)									
AO	-.71	.26	7.60	<.01	0.49	[0.30, .81]			
SAM	1.67	.26	3.93	<.01	1.68	[1.00, 2.80]			
Model Fit							.28	20.75**	70.7
<i>Social Consequences</i>									
Covariate: QFI	.01	.00	11.57	<.01	1.01	[1.01, 1.02]			
Block 1: Use Category			10.90	<.01					
CAM (ref)									
AO	-.99	.45	4.86	.03	0.37	[0.16, 0.90]			
SAM	-1.37	.48	8.22	<.01	0.26	[0.10, 0.65]			
Model Fit							.12	11.35**	92.1
<i>Legal Issue Due to Alcohol Consumption†</i>									
Covariate: QFI	.01	.00	16.59	<.01	1.01	[1.00, 1.02]			
Block 1: Use Category			3.48	.18					
CAM (ref)									
AO	-.75	.71	1.09	.30	0.48	[0.12, 1.92]			
SAM	-.43	.55	0.59	.44	0.65	[0.22, 1.93]			
Model Fit							.08	3.59	86.1
<i>Academic/School Consequences</i>									
Covariate: QFI	.02	.00	39.77		1.02	[1.01, 1.02]			
Block 1: Use Category			2.45	.30					
CAM (ref)									
AO	-.22	.30	0.57	.45	0.80	[0.45, 1.46]			
SAM	.25	.28	0.79	.37	1.28	[0.74, 2.21]			
Model Fit							.20	2.43	76.4

Note. CAM = concurrent alcohol-marijuana; AO = Alcohol only; SAM = simultaneous alcohol-marijuana; QFI = overall alcohol use as measured by square-root corrected Quantity-Frequency Index. Concurrent alcohol-marijuana (CAM) group used as reference group for the categorical comparisons; OR = odds ratio based on reference group; CI = confidence intervals for odds ratios. ** $p < .01$. † Includes receiving a campus alcohol policy violation as an alcohol-related legal issue.

Table 3. Regression analyses predicting marijuana-related consequences controlling for past-90-day frequency of marijuana use.

Variable	B	S.E.	Wald	p-value	OR	OR 95% CI	Nagelkerke R^2	χ^2	% Classified
<i>Legal</i>									
Covariate: Days Used	.11	.06	3.83	.05	1.12	[1.00, 1.22]			
Block 1: Use Category	-1.39	1.35	1.06	.30	0.25	[0.18, 3.47]			
Model Fit							.13	3.93	98.8
<i>Risky Sex</i>									
Covariate: Days Used	.08	.03	6.70	.01	1.08	[1.02, 1.15]			
Block 1: Use Category	.05	.71	0.01	.95	1.05	[0.26, 4.21]			
Model Fit							.10	7.03*	96.1
<i>Academic</i>									
Covariate: Days Used	.13	.02	42.50	< .01	1.13	[1.09, 1.18]			
Block 1: Use Category	.02	.34	0.02	.96	1.01	[0.53, 1.97]			
Model Fit							.29	57.32**	80.6
<i>Social</i>									
Covariate: Days Used	.08	.02	14.98	<.01	1.09	[1.04, 1.13]			
Block 1: Use Category	-.56	.47	1.46	.23	0.57	[0.29, 1.42]			
Model Fit							.11	14.54**	89.9

Note. $n = 364$. CAM participants used as reference group for use category. OR = odds ratio based on reference group; CI = confidence intervals for odds ratios.

* $p < .05$; ** $p < .01$.

Variations in substance-specific problems between polydrug users (CAM vs. SAM)

Domains with item overlap (driving after using, legal, academic, social, and unsafe sex) were crossed to create four categories: (1) no problem reported for either substance; (2) problem attributed to alcohol only; (3) problem attributed to marijuana only; and (4) problem attributed to both substances. Chi square tests examined SAM/CAM differences across these categories (Table 4). Comparable rates of problems and substance attributions were found for driving after drinking/using, legal issues, and unsafe sexual activity. Academic problems were more frequent among SAM users (54% compared to 40% of CAM), who were more likely to attribute difficulties to use of both substances than CAM users. Differences were also seen for social problems (CAM: 21% vs. SAM: 13%), with CAM users more likely to attribute social issues to alcohol consumption compared to SAM.

Discussion

Perceptions, practices, and legislation about marijuana are rapidly changing in the U.S., making it essential to better understand use with other substances, like alcohol, and how polydrug consumption and consequences differ vis-a-vis concurrent or simultaneous co-

administration. Our findings add to the existing evidence that polydrug alcohol and marijuana users experience more alcohol-related consequences than their peers who use alcohol only, even when controlling for level of overall alcohol involvement (Earlywine and Newcomb 1997; Primack et al. 2012; Suerken et al. 2014; Terry-McElrath, O'Malley, and Johnston 2013). In general, CAM and SAM users in the current study reported comparable marijuana-attributed problems, engagement in risky sex while drinking, and substance-specific problem attributions for driving after using, legal issues, and unsafe sex.

However, subtle but significant differences were seen for some problems with implications for assessment and intervention development. CAM users reported a higher incidence of social (i.e., peer, partner, and family) concerns about their drinking and marijuana use relative to SAM and AO. One possible explanation is that heavier substance users, in this case students who engage in SAM use, may affiliate with social networks where alcohol and drug use is more prevalent and/or accepted (Ennett et al. 2006; Galea, Nandi, and Vlahov 2004; Meisel et al. 2015), and experience fewer social problems because of broader affiliation with individuals who are more accepting of substance use. Another contributing factor may be use history. SAM users initiated alcohol and marijuana use earlier than the other two groups. It is possible that that additional experience with substances served as a protective factor. This could occur through several mechanisms like increased functional tolerance, experiences where they have learned to navigate away from events that may lead to social consequences, or that they have a more liberal acceptance of what could be perceived as negative social consequences. Simultaneous marijuana consumption may also attenuate disinhibition that can occur with alcohol use. Future research should explore this issue, either through a more thorough investigation of social networks (e.g., through approaches like the "important people" interview; Zywiak et al. 2009) and/or injunctive norm differences about marijuana (LaBrie et al. 2011) that may exist between CAM and SAM users.

One important difference between CAM and SAM users was the increased incidence of alcohol-related blackouts. Blackouts are one of the most common alcohol-related consequences in college students (Wetherill and Fromme 2016), and can have severe negative repercussions that extend beyond the drinking and blackout event (Hingson et al. 2016; White et al. 2004). In a blackout, individuals appear conscious and functional (Goodwin 1995). However, short-term memory stores are not transferred to long-term due

Table 4. Differences in problem attribution between use categories.

Problem Domain/ Substance Attribution	Use Category		χ^2	<i>p</i>	Cramers V
	CAM N= 230	SAM N= 134			
Driving after Drinking			6.23	.10	.13
Never	89.7	84.1			
Alcohol Only	5.8	4.5			
Marijuana Only	2.7	6.1			
Both	1.8	5.3			
Legal Issues			2.02	.56	.07
Never	92.2	94.0			
Alcohol Only	5.2	5.2			
Marijuana Only	1.3	0.7			
Both	1.3	0.0			
Academic Problems					
Never	59.6	45.5	8.08	.04	.17
Alcohol Only	21.3	24.6			
Marijuana Only	11.7	16.4			
Both	7.4	13.4			
Unsafe Sexual Activity			2.28	.51	.08
Never	71.3	67.9			
Alcohol Only	26.1	27.6			
Marijuana Only	0.4	0.0			
Both	2.2	4.5			
Social Problems			7.90	.04	.17
Never	79.1	87.3			
Alcohol Only	11.8	3.0			
Marijuana Only	6.5	7.5			
Both	2.6	2.2			

Note. CAM = concurrent alcohol-marijuana; SAM = simultaneous alcohol-marijuana. **Bold** text indicates where column proportions significantly differ from each other based on Bonferroni-adjusted tests of column proportion ($p < .05$).

to disruptions in encoding (White 2003), making individuals unaware of processes that contributed to events and behaviors during the blackout. There is evidence that memory impairments associated with THC operate on the same neural circuitry impaired during alcohol-related blackouts (Bossong et al. 2014). Blackout risk has been associated with several risky styles of drinking, including pregameing, drinking game participation, and chugging drinks (LaBrie et al. 2011; Ray et al. 2014), and this study suggests that polydrug use, particularly SAM, also elevates risk.

Limitations and future directions

Measures used in this study were limited to use and consequences. However, recent studies emphasize the importance of examining conjoint use motives (Patrick, Fairlie, and Lee 2018), sequencing issues (SAM/CAM, as well as which drug is used first), and whether marijuana is used as a substitute for other drugs (like alcohol) or a means to complement the pharmacological effects (Guttmannova et al. 2016; O'Hara, Armeli, and Tennen 2016; Pape, Rossow, and Storvoll 2009). Future studies would benefit from more intensive exploration of these issues, including event-level measurement that can delineate discrete events. Likewise, recent consequences were assessed for both substances and parallel items were present to examine reporting of problems. However, items were not included that assessed consequences resulting from simultaneous use. Measures exist which ask participants to report problems occurring as a function of alcohol or marijuana (e.g., the Risk and Consequence Questionnaire; Stein et al. 2010), but have not been normed on college students and/or contain items assessing consequences unique to simultaneous use. Development of a SAM problem scale, or adaptation of existing alcohol or marijuana consequences questionnaires to include SAM-specific problems, would add to the literature. This study included a less widely used alcohol consequence measure developed by the lead investigator (Haas et al. 2013). Though the measure has been validated and used in other studies, the authors would like to note that other measures are more widely used (e.g., YAAPST or YAACQ; Hurlbut and Sher 1992; Read et al. 2006) and may be more appropriate for use in future studies. In addition, data were collected in a state where decriminalization and medicalization legislation was passed, but recreational use was still illegal at the time of data collection. As such, replication in regions with different marijuana laws is indicated, not only to look at differences in prevalence, but to examine how

other influences (e.g., religious background/affiliation, conservative beliefs) may impact consequences.

Concluding remarks

These results provide additional support that polydrug alcohol and marijuana is a deleterious behavior, and that SAM use poses additional risk, particularly for experiencing alcohol-related blackouts. Currently, most existing college student interventions focus on alcohol, which may have limited information transfer to marijuana consumption or polydrug use (Yurasek et al. 2017; White et al. 2015). Additional research is indicated to better understand nuances of SAM use that exacerbate risk and can be used in the development of targeted interventions, as well as better measurement of nuances of CAM and SAM use that can be integrated into these tailored programs.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Higher Education Center for the Prevention of Violence and High Risk Drinking [Q184H090105].

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