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More drugs, more problems? Simultaneous use of alcohol and marijuana at parties among youth and young adults

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ABSTRACT

Background: Simultaneous alcohol and marijuana (SAM) use by youth and young adults often occurs at parties and may result in an increased risk of experiencing adverse consequences compared to use of either substance alone. This study sought to examine the relationship between SAM use by youth and young adults and consequences experienced at, or immediately following, parties.

Methods: We conducted a repeated cross-sectional survey of 15 to 20-year-olds residing in 24 communities across seven states within the United States in 2015 and 2016 (n = 2681). Logistic regression analyses were used to examine associations between SAM use and six consequences (e.g. hangover, sex without a condom, involved in a fight) among 834 youth and young adults (53.7% female, 78.3% White, mean age: 18.4 years) who reported using either alcohol or marijuana at the last party they attended.

Results: 72.3% consumed alcohol exclusively, 5.2% used marijuana exclusively, and 22.5% engaged in SAM use. In multivariable analyses, those who reported SAM use had significantly greater odds of experiencing any (AOR = 1.9; 95% CI: 1.3, 2.8) and 2 or more (AOR = 4.0; 95% CI: 2.0, 8.0) consequences compared to those who used only alcohol.

Conclusions: Our findings suggest that SAM use in a party context is associated with an increased risk of experiencing consequences among youth and young adults after controlling for the quantity of alcohol consumed. Policy and educational prevention strategies should target SAM at parties to reduce harms among youth and young adults.

1. Introduction

Alcohol and marijuana are two of the most commonly used substances among youth and young adults in the United States (US). In 2017, 33% of a nationally representative sample of 12th graders in the US reported past 30-day alcohol consumption and 23% reported past 30-day marijuana use (Miech et al., 2018). Among a similar sample of 12th graders who reported both alcohol or marijuana consumption within the past year, 22.5% endorsed simultaneous alcohol and marijuana (SAM; i.e., co-use during the same occasion) use (Patrick et al., 2019). Research is mixed on whether alcohol and marijuana are used together for the purpose of substitution (one drug can pharmacologically replace the other drug) or complementation (one drug enhances the effects of the drug) (Subbaraman, 2016). Regardless of the motivation, given that almost a quarter of 12th graders who consumed alcohol and marijuana in the past year used these substances simultaneously, it is critical that potential risks associated with this behavior are elucidated.

Current literature suggests that youth and young adults who use alcohol and marijuana simultaneously may be at higher risk of experiencing adverse consequences (Brière et al., 2011; Lipperman-Kreda et al., 2017; Terry-McElrath et al., 2014). SAM use in the 10th grade was associated with an increased risk of subsequent problems the following year among a sample of adolescents in Quebec (Canada) (Brière et al., 2011). Twelfth graders in the US who reported SAM use were more likely than past year concurrent users (i.e., used both substances within the same year but not during the same occasion) and those who only consumed alcohol to engage in unsafe driving (Terry-McElrath et al., 2014). While these studies did not examine risks immediately following SAM use, Lipperman-Kreda et al. (2017) studied the acute

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consequences of SAM use by means of ecological momentary assessment (EMA). In a sample of adolescents in California (US), they found that SAM use was related to an increased number of problems experienced, including perpetrating or being a victim of violence, driving under the influence or riding with a drunk driver, and being drunk, and that alcohol was a key contributor to experiencing these problems (Lipperman-Kreda et al., 2017).

SAM use among youth and young adults frequently occurs in a social context (Terry-McElrath et al., 2013). In a sample of 15–20 year olds residing in the US who had ever attended a party with alcohol, 24.9% reported that they had observed both alcohol consumption and marijuana use at the last party they attended (Egan et al., 2018). Parties where both alcohol and marijuana were used were more likely than parties with just alcohol consumption to occur in someone else's home, be larger in size with the majority of attendees under 21, and in a state where medical and recreational marijuana were legal (Egan et al., 2018). Another study found that individuals who engaged in SAM use were more likely to be at a party without adult supervision and to be with same-age peers consuming alcohol (Lipperman-Kreda et al., 2017). SAM use in a social context, such as a party with peers, may be especially troublesome if it permits access to alcohol and marijuana, contributes to or reinforces unhealthy norms about SAM use, and increases the likelihood of first- or second-hand consequences associated with substance use.

The objective of the study was to examine the relationship between simultaneous use of alcohol and marijuana at parties and adverse consequences experienced by youth and young adults while controlling for the context of the party, quantity of alcohol consumed, other substance use, and demographic characteristics. We hypothesized that youth and young adults who reported SAM use would be more likely to experience adverse consequences compared to their same-aged peers who used alcohol or marijuana alone. This study expands upon the current literature by examining the relationship between SAM use and consequences at a party setting in an US sample drawn from multiple states with varying cannabis laws.

2. Methods

2.1. Procedures

As part of a prospective randomized community trial, The Study to Prevent Teen Drinking Parties (Wolfson et al., 2017), we conducted a repeated cross-sectional online survey of 15 to 20-year-olds residing in 24 communities in seven states within the US. Data collected in 2015 and 2016 were used for this manuscript. The survey assessed experiences at the last party attended with alcohol, including party characteristics (size, gender and age composition, location) and self-reported substance use and consequences. The survey took approximately 15 to 20 min to complete. Individuals who completed the survey received an electronic $15 Amazon gift card following survey submission. The protocol was approved by the Wake Forest School of Medicine Institutional Review Board (IRB). A Certificate of Confidentiality was obtained from the National Institutes of Health to provide additional security for the participants.

2.2. Community recruitment

We recruited 24 cities in seven states (California, Colorado, Georgia, Indiana, Iowa, New Mexico, and New York) to participate in the prospective community trial. Due to the focus of the parent study's objective to evaluate a comprehensive set of strategies, including social host ordinances, selected and implemented by community organizations, to be eligible, cities had to have a population between 25,000 and 300,000, a local law enforcement authority, and an active community substance abuse prevention coalition with leadership that was willing to participate in the trial. In addition, at the time of recruitment cities could not have a social host ordinance or be located within a state with a state-level social host law (Egan et al., 2018; Wolfson et al., 2017). Social host laws and ordinances hold property owners, or those who control the property, liable for underage drinking that occurs on the property (Wagoner et al., 2011).

2.3. Sample

An address-based sampling approach was utilized to invite households in the 24 communities expected to have at least one 15 to 20-year-old resident to participate in the online survey. Each year an age-targeted list sample was provided by Marketing Systems Group (Horsham, PA). A total of 37,385 mailed letter invitations with a link and a quick response (QR) code directing individuals to an online survey were sent out in 2015 and 2016; up to 4 postcard reminders were mailed to nonresponders. There were 2083 mailings returned as undeliverable, 1695 households reported that they were ineligible, 342 eligible households refused to participate, and 3344 individuals completed the survey in 2015 and 2016. It is often impossible to calculate a precise response rate for a survey that uses Address Based Sampling (ABS) to generate the sample. This is because it is not known whether any given nonrespondent was ineligible, or if she or he was eligible and did not respond (AAPOR, n.d.; also see Smith, 2009). A conservative estimate for the response rate is 13.1% (based on the proportional allocation method—see Smith, 2009).

In order to exclude duplicate responses from both 2015 and 2016, if participants completed the survey in both years, only the most recent data from 2016 was retained for analyses reported in this manuscript. To identify participants who may have participated in both years, we examined if they were from the same household, of the same gender, and if their ages aligned with the time elapsed between data collection waves. A total of 2681 15–20 year olds were retained for this study.

Of the 2681 participants, 1706 attended a party where alcohol was being consumed. At the last party they attended, 834 used alcohol or marijuana, 777 did not use a substance, and 95 could not be categorized due to missing data. Given that the intent of the study was to compare SAM use to the use of alcohol or marijuana alone, the analytical sample for this study was comprised of those who use alcohol or marijuana at the last party they attended (n = 834). Within this analytical sample, there were slightly more females than males (53.7% vs 46.3%), 78.3% were White, 89.1% were non-Hispanic (slightly higher than % within participating communities), and 71.9% had a mother with at least a college degree. The mean age was 18.4 (SD = 1.5) years of age (Table 1). There were 603 (72.3%) participants who reported consuming alcohol only, 43 (5.2%) reported marijuana only, and 188 (22.5%) reported SAM use at the last party they attended.

2.4. Measures

2.4.1. Independent variable – substance use classification

Substance use was categorized into the following three categories based on the substances used at the last party: alcohol only, marijuana only, and simultaneous alcohol and marijuana (SAM). Alcohol use was determined with a question on the number of drinks, defined as 12 ounces of beer, 8 ounces of malt liquor, 5 ounces of wine, or 1.5 ounces or a "shot" of liquor, consumed at the last party. Individuals who consumed one or more drink at the party was considered to use alcohol. The following question assessed marijuana use at the last party: "At the last party you attended where alcohol was being served, did you use any of the following at the party?." Response options included "marijuana (weed, pot, hash, hash oil)." If an individual reported both alcohol and marijuana use at the last party, they were categorized as using alcohol and marijuana simultaneously.

Individuals who did not report alcohol or marijuana use were not included in the analyses. We included individuals who reported using substances other than alcohol or marijuana (illicit, synthetic drugs, and

Table 1
Sample demographics, key variables, and consequences by type of substance(s) used at last party attended (N = 834 adolescents and young adults).

	Overall N = 834 n (%)	Alcohol-only N = 603 (72.3%) n (%)	Marijuana-only N = 43 (5.2%) n (%)	SAM N = 188 (22.5%) n (%)	p-value*
Sex					0.05
Male	385 (46.3)	263 (43.8)	19 (44.2)	103 (54.8)	
Female	447 (53.7)	338 (56.2)	24 (55.8)	85 (45.2)	
Race					0.57
White	647 (78.3)	468 (78.4)	31 (72.1)	148 (79.6)	
Non-White	179 (21.7)	129 (21.6)	12 (27.9)	38 (20.4)	
Ethnicity					0.89
Hispanic	89 (10.9)	62 (10.6)	5 (11.9)	22 (12.0)	
Non-Hispanic	724 (89.1)	525 (89.4)	37 (88.1)	162 (88.0)	
Mother's Education Level					0.54
Less than College Degree	229 (28.1)	165 (27.8)	15 (37.5)	49 (27.1)	
College Degree or More	586 (71.9)	429 (72.2)	25 (62.5)	132 (72.9)	
Age, *Mean (SD)*	18.4 (1.5)	18.4 (1.5)	17.9 (1.6)	18.4 (1.5)	0.16
# of Drinks Consumed at Party, *Mean (SD)*	4.3 (3.6)	4.1 (3.3)	0.0 (0.0)	6.0 (4.0)	< 0.001
Other Substance Use at Party					< 0.001
Yes	52 (6.4)	8 (1.4)	10 (23.3)	34 (18.3)	
No	760 (93.6)	575 (98.6)	33 (76.7)	152 (81.7)	
State Marijuana Law					0.004
Medical and Recreational	147 (17.6)	99 (16.4)	7 (16.3)	41 (21.8)	
Medical Only	455 (54.6)	336 (55.7)	17 (39.5)	102 (54.3)	
None	232 (27.8)	168 (27.9)	19 (44.2)	45 (23.9)	
Any Consequences					< 0.001
Yes	315 (38.7)	200 (34.0)	8 (18.6)	107 (58.5)	
No	499 (61.3)	388 (66.0)	35 (81.4)	76 (41.5)	
Number of Consequences					< 0.001
0	499 (62.2)	388 (67.0)	35 (81.4)	76 (42.2)	
1	235 (29.3)	161 (27.8)	5 (11.6)	69 (38.3)	
2+	68 (8.5)	30 (5.2)	3 (7.0)	35 (19.4)	
Type of Consequences Hangover					< 0.001
Yes	274 (33.0)	175 (29.1)	4 (9.3)	95 (50.8)	
No	557 (67.0)	426 (70.9)	39 (90.7)	92 (49.2)	
Punished by parents					< 0.001
Yes	46 (5.6)	23 (3.9)	5 (11.6)	18 (9.7)	
No	780 (94.4)	575 (96.2)	38 (88.4)	167 (90.3)	
Sex without condom					< 0.001
Yes	42 (5.1)	18 (3.0)	3 (7.0)	21 (11.2)	
No	787 (94.9)	581 (97.0)	40 (93.0)	166 (88.8)	
Car crash					0.12
Yes	4 (0.5)	2 (0.3)	1 (2.3)	1 (0.6)	
No	819 (99.5)	595 (99.7)	42 (97.7)	182 (99.5)	
Physical fight					0.49
Yes	18 (2.2)	12 (2.0)	0 (0.0)	6 (3.2)	
No	811 (97.8)	587 (98.0)	43 (100)	181 (96.8)	
Victim of sexual assault					< 0.001
Yes	21 (2.5)	8 (1.3)	0 (0.0)	13 (7.0)	
No	807 (97.5)	591 (98.7)	43 (100)	173 (93.0)	

Due to missing data, some percentage denominators may differ from the totals in the column headers.
* p-value for Chi-Square comparisons between alcohol only, marijuana only, and SAM use.

nonmedical over-the-counter (OTC) or prescription drugs). Substance use other than alcohol or marijuana was reported by 6.4% of the full sample, 1.4% of individuals who used alcohol-only, 23.3% of individuals who used marijuana-only, and 18.3% of individuals who reported SAM use. We controlled for other substance use in the multivariable/multinomial models and conducted a sensitivity analysis (not reported) that excluded participants who reported other substances. Results from the sensitivity analysis did not differ from the reported results.

2.4.2. Dependent variable – consequences experienced

Consequences experienced at or after the last party were assessed with the following questions: "Did you have any of the following experiences at the last party you attended where alcohol was present, or after the party was over? - Had a headache or hangover; Punished by your parent(s) or guardian(s); Had sex without using a condom; Someone tried to have sex with you or actually had sex with you against your will; Were in a motor vehicle crash after leaving the party; and Were involved in a fight." Due to the distribution of the consequences experienced by participants (62.2% report zero consequences, 29.3% report experiencing one consequence, and only 8.5% of the analytical sample report experiencing two or more consequences), consequences were coded based on experiencing any consequence and by the number of consequences experienced (0/1/2+).

2.4.3. Covariates

Demographic characteristics included age, sex (male or female), ethnicity (Hispanic or Non-Hispanic), race (White or non-White (Black/African American, American Indian/Native American, Asian/Pacific Islander, Multiracial, or Other), and mother's completed education level (dichotomized as 'college degree or more' or 'less than college degree'). The following party contexts were assessed: party location (coded as my home, other's home, or other location), party size (due to the skewed distribution we used the natural log of party size), sex composition of the party (coded as majority male, majority female, or mixed-sex), and age composition (coded as majority under 21 or majority over 21). The specific survey items are described in Egan et al., 2018. The presence of a medical and/or recreational state level medical marijuana law was

determined by examining the National Conference of State Legislatures' website (National Conference of State Legislatures, 2017). States that had both a medical and recreational law as of June 1, 2016 were coded as "medical and recreational" and states with only a medical law as of June 1, 2016 were coded as "medical-only." The reference category was "no medical or recreational law" and "no medical law," respectively. Participants reported the number of drinks, defined as 12 ounces of beer, 8 ounces of malt liquor, 5 ounces of wine, or 1.5 ounces or a "shot" of liquor, they consumed at the last party, with an integer between 0 and 20. Use of illicit, synthetic drugs, and nonmedical over-the-counter (OTC) or prescription drugs was also included as a covariate (coded as yes or no to 'other substance use).

2.5. Statistical analysis

All analyses were restricted to participants who reported alcohol or marijuana use at the last party they attended. Descriptive statistics were calculated to describe the demographic characteristics and consequences experienced by the overall sample and by category of substance use (alcohol only, marijuana only, SAM). Chi-square tests were conducted to test differences in covariates and consequences based on whether the individual used alcohol only, marijuana only, or SAM at the last party; continuous variables were analyzed using an ANOVA F test (Table 1). Multivariable logistic regression was used to assess the relationship between SAM use, compared to alcohol only, and experiencing any consequence (Table 2, Model 1). Multinomial logistic regression was conducted to assess the relationship between SAM use, compared to alcohol only, and the number of consequences experienced at the last party (Table 2, Model 2). Marijuana only use was included in the bivariate (Table 1) but not the multivariable and multinomial models (Table 2) due to small cell sizes for consequences experienced by those who used only marijuana at the last party. Thus, the analytical sample for the multivariable models presented in Table 2 (n = 700) exclude those who only used marijuana and individuals with missing data. To examine the impact of missing data on our findings, we performed bivariate analyses to examine differences between the analysis sample (n = 700) and the sample with missing data (n = 91). The only statistically significant difference between the analytic sample and the sample with missing data was the age composition of the party. All models were adjusted for within-state and community clustering by treating state and community as random effects using PROC GLIMMIX with a logit link function for logistic models and a generalized logit link for multinomial models in SAS version 9.4 (Cary, NC). Adjusted odds ratios and 95% confidence intervals are presented.

3. Results

3.1. Bivariate analysis

As shown in Table 1, experiencing any and more consequences varied by alcohol, marijuana, and SAM use ($p < 0.001$). In the bivariate analyses, individuals who reported SAM use were significantly more likely to experience any adverse consequence compared to those who used alcohol only ($p < 0.001$) or marijuana only ($p < 0.001$). Compared to those who used alcohol only, those who used marijuana only were less likely to experience any adverse consequences ($p < 0.05$). The types of consequences experienced by those who used alcohol only, marijuana only, and alcohol and marijuana simultaneously are presented in Table 1. The most common consequence experienced by those who consumed only alcohol or engaged in SAM use was a hangover (29.1% and 50.8%, respectively). Being punished by parents was the most common consequence reported for those who used marijuana only (11.6%). Being punished by parent(s), experiencing a hangover, having sex without a condom, and experiencing an attempted or actual sexual assault differed by substance use group ($p < 0.001$ for all consequences). There was not a statistically significant difference in getting into a physical fight or car crash based on substance use categorization at the last party.

Table 2
Association between SAM use and negative consequences adjusted for covariates (N = 700 who reported alcohol-consumption or SAM use at the last party attended).

	Model 1 any consequence	Model 2 number of consequences		
	AOR (95% CI)	1 vs. 0 AOR (95% CI)	2+ vs. 0 AOR (95% CI)	2+ vs. 1 AOR (95% CI)
SAM vs. Alcohol-only (ref)	1.9 (1.3, 2.8)**	1.7 (1.1, 2.6)*	4.0 (2.0, 8.0)***	1.8 (0.9, 3.6)
Sex				
Female vs. Male (ref)	1.1 (0.8, 1.6)	1.0 (0.7, 1.5)	1.7 (0.8, 3.3)	1.8 (0.9, 3.6)
Race				
Non-White vs. White (ref)	1.1 (0.7, 1.8)	1.1 (0.7, 1.7)	1.5 (0.7, 3.3)	1.6 (0.7, 3.6)
Ethnicity				
Hispanic vs. Non-Hispanic (ref)	1.0 (0.6, 1.8)	1.2 (0.7, 2.2)	0.7 (0.2, 2.1)	0.6 (0.2, 2.0)
Mother's Education Level				
College Degree + vs. < College Degree (ref)	0.9 (0.6, 1.3)	1.0 (0.7, 1.6)	0.4 (0.2, 0.9)*	0.4 (0.2, 0.8)**
Age	1.0 (0.9, 1.2)	1.1 (1.0, 1.2)	0.9 (0.7, 1.2)	0.8 (0.7, 1.0)
Party Location				
Other's home vs. My home (ref)	0.7 (0.4, 1.1)	0.7 (0.4, 1.4)	0.6 (0.2, 1.8)	0.9 (0.3, 2.9)
Other place vs. My home (ref)	0.7 (0.3, 1.4)	0.8 (0.3, 1.7)	0.5 (0.1, 2.1)	0.7 (0.2, 3.1)
Party Size	1.2 (1.0, 1.5)	1.2 (1.0, 1.5)	1.3 (0.9, 2.0)	1.1 (0.7, 1.7)
Party Sex Composition	1.0			
Majority Males vs. Mixed-sex (ref)	0.8 (0.5, 1.3)	0.8 (0.5, 1.4)	1.0 (0.3, 2.9)	1.1 (0.4, 3.1)
Majority Females vs. Mixed-sex (ref)	1.0 (0.6, 1.7)	0.9 (0.5, 1.6)	1.6 (0.6, 3.8)	2.5 (1.0, 6.7)
Party Age Composition				
Mostly Over 21 vs. Mostly Under 21 (ref)	0.7 (0.5, 1.0)	0.8 (0.5, 1.1)	0.6 (0.3, 1.2)	0.8 (0.4, 1.6)
# of Drinks Consumed at Party	1.2 (1.1, 1.2)***	1.2 (1.1, 1.2)***	1.2 (1.1, 1.3)***	1.0 (0.9, 1.1)
Other Substance Use at Party				
Yes (vs No)	4.2 (1.7, 10.6)**	2.4 (0.8, 6.8)	9.6 (3.1, 29.2)***	4.2 (1.6, 11.1)***
State Marijuana Law				
Medical and Recreational (vs None)	1.4 (0.8, 2.3)	1.6 (1.0, 2.7)	0.6 (0.2, 2.2)	0.3 (0.1, 1.0)
Medical Only (vs None)	0.8 (0.6, 1.2)	0.9 (0.6, 1.3)	1.0 (0.5, 2.1)	0.8 (0.4, 1.7)

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Number of drinks consumed and other substances used at the last party varied by substance use category; SAM users consumed the highest mean number of alcohol beverages and the marijuana-only category had the highest percentage of other substance use. State-level marijuana policies varied by substance use category; 76.1% of SAM users lived in a state where medical and recreational use of marijuana has been legalized compared to 71.4% of alcohol-only users and 55.8% of marijuana-only users.

3.2. Multivariate analysis

After controlling for demographics, party context, quantity of alcohol consumed, other substance use, and state marijuana policy in the multivariable model (Table 2), SAM use at the last party attended was significantly and positively associated with experiencing any (AOR = 1.9; 95% CI: 1.3, 2.8) and 2 or more consequences (AOR = 4.0; 95% CI: 2.0, 8.0). The odds of experiencing 2 or more consequences (vs. 0 consequences) were lower for individuals whose mother obtained at least a college degree compared to individuals whose mother did not obtain a college degree (AOR = 0.4; 95% CI: 0.2, 0.9). Other substance use at the last party was significantly and positively associated with reporting any (AOR = 4.2; 95% CI: 1.7, 10.6) and two or more consequences (vs. 0 consequences - AOR = 9.6; 95% CI: 3.1, 29.2 and vs. 1 consequence - AOR = 4.2; 95% CI: 1.6, 11.1).

4. Discussion

Just under a quarter of youth and young adults who used either alcohol or marijuana at the last party they attended used both alcohol and marijuana during the same occasion. We found that, after controlling for the amount of alcohol they consumed and context of the party setting, SAM use was significantly and positively related to experiencing adverse consequences. Our study expands upon the current literature by accounting for the quantity of alcohol consumption and context of the setting in a sample of youth and young adults from multiple US states with varying state-level marijuana policies.

The odds of experiencing any and more consequences were significantly higher for youth and young adults who engaged in SAM use at the last party they attended compared to same age peers who consumed alcohol only. We examined six consequences that varied in severity experienced at, or immediately following, the last party attended. Physical fights and car crashes following use of alcohol, marijuana, or SAM use were relatively rare occurrences and did not differ among the three substance use categories. The most common consequence experienced following both alcohol and SAM use was having a hangover. Experiencing a hangover was likely due to physiologically effects of alcohol consumption given that only 9.3% of marijuana users reported experiencing a hangover compared to 29.1% who consumed alcohol only and 50.8% who reported SAM use. Additionally, individuals who reported SAM use consumed more drinks than those who consumed alcohol only. Next, only 5.6% of participants reported being punished by their parents. Given that a higher percentage of individuals who used marijuana only or marijuana simultaneously with alcohol reported that they were punished by their parents compared to those who used alcohol only, parents may have less favorable perceptions of- or greater concerns about legal implications of marijuana use compared to alcohol consumption. The more concerning, although relatively rare, consequences experienced by individuals who endorsed SAM use were sex without a condom and being a victim of sexual assault. Prevention efforts should consider the use of protective behavioral strategies to minimize the likelihood of these adverse consequences (Bravo et al., 2017; Palmer et al., 2010).

Given previous findings pertaining to the frequency of alcohol consumption during SAM use (Lipperman-Kreda et al., 2017), we explored if the number of drinks consumed was a contributing factor to the relationship between SAM use and adverse consequences. In the bivariate results, youth and young adults who were using alcohol and marijuana simultaneously consumed the highest mean number of drinks during the party. After controlling for the number of drinks consumed at the last party in the multivariable and multinomial models, SAM use was significantly related to experiencing any and more consequences. It is important to note that, in the multivariable model, quantity of alcohol consumed was independently associated with experiencing a greater number of consequences. Taken together, these findings suggest that both SAM use and quantity of alcohol consumption contribute to experiencing adverse consequences. In addition, we examined the impact of co-use of substances of other than alcohol or marijuana at the party. Although individuals who reported using substances other than marijuana and alcohol at the last party they attended had greater odds of sustaining adverse consequences, SAM use was still significantly related to experiencing more consequences after controlling for other substance use. These findings suggest that there is something unique about the combination of alcohol and marijuana, or those who engage in this behavior, that heightens the risk of experiencing adverse consequences.

One potential explanation for the observed association between SAM use and adverse consequences is these youth and young adults may have personality traits, such as higher levels of impulsivity and sensation seeking (Stautz and Cooper, 2013), that predispose them to both SAM use and experiencing adverse consequences. Youth and young adults who are more impulsive or higher sensation seekers may gravitate towards novel experiences, such as SAM use, and be more willing to participate in risky behaviors (Horvath and Zuckerman, 1993; O'Brien et al., 2013) such as having unprotected sex and driving or riding with someone under the influence. Another potential explanation is that the pharmacological combination of alcohol and marijuana may have heightened intoxicating impacts due to the additive effects of alcohol and marijuana (Bramness et al., 2010; Chait and Perry, 1994; Ramaekers et al., 2000) that increase adverse physiological effects such as experiencing a hangover or responsible decision making. A third potential explanation is that individuals may have different expectancies about the effects of (Barnwell and Earleywine, 2006) and motivations for (Terry-McElrath et al., 2013) using alcohol and marijuana in isolation or in combination. Youth and young adults who hold strong positive and weak negative expectancies for SAM use may be more likely to engage in this behavior and experience adverse consequences. Youth and young adults who report SAM use to increase the effects of both drugs and to get high (Terry-McElrath et al., 2013) may be at heightened risk of experiencing consequences due to their recreational motives. Further research is needed to better understand why youth and young adults who use alcohol and marijuana simultaneously are at higher risk of experiencing consequences.

There is a need for prevention strategies that address SAM use among youth and young adults. Our findings, consistent with those of Lipperman-Kreda et al. (2017), suggest that SAM use occurs in a social context with same age peers. Strategies that target alcohol or marijuana use in social contexts with same age peers, such as social host ordinances (Paschall et al., 2014; Wagoner et al., 2011; Wolfson et al., 2017), may be promising strategies to reduce SAM use and associated harms. Social host ordinances hold property owners, or those who control the property, liable for underage drinking that occurs on the property. Traditionally, social host ordinances have targeted alcohol, but as legalization of recreational and medical marijuana expands to more and more states, more communities may implement or modify existing social host ordinances to include marijuana (e.g., Fort Collins, CA, Municipal Code Ord. No. 047 § 3, 2016; Redding, CA, Municipal Code. Ord. No. 2537 § 1, 2015). School-based and community education campaigns could also publicize the enhanced risk of parties involving both alcohol and marijuana, although care should be taken to avoid conveying a message that either one, consumed in isolation, is a safe alternative for youth and young adults. Protective behavioral strategies that minimize the likelihood of experiencing adverse

consequences should be included within prevention efforts (Bravo et al., 2017; Pearson, 2013). Future research on prevention strategies to prevent SAM use and associated consequences is needed and should take into account the co-use of alcohol and marijuana as well as the potential separate alcohol or marijuana use disorders (Baggio et al., 2018; Yurasek et al., 2017).

4.1. Strengths and limitations

A strength of this study is its inclusion of youth and young adults residing in 24 communities across seven states in most regions of the United States. However, the results may not be generalizable to all 15 to 20-year-olds in the US, especially given the slightly higher percentage of non-Hispanic Whites in the sample compared to the demographics of the participating communities. This may be particularly true for larger urban areas or smaller communities than those in our study and states with different marijuana policy provisions. Also, state marijuana legalization was assessed in 2016 whereas self-reported data was collected in 2015 and 2016. Thus, our findings likely reflect societal norms around the use of marijuana prior to and during changes in state policy rather than increased access via dispensaries.

An additional strength of the study is that substance use and consequences were assessed for the same occasion—specifically, at the last party. However, we do not know the length of the party and when use of alcohol and marijuana occurred. If there was a substantial gap in time between when the substances were used, the pharmacological effects of alcohol and marijuana may have been attenuated. Also, while we assessed the quantity of alcohol consumed, we did not assess the quantity of marijuana used or the route of administration. Our findings likely underestimate SAM use, since our survey asked only about the last party attended. Self-reported alcohol and marijuana use is subject to social desirability bias, although this is likely to have been minimized through our use of an online survey (McCabe et al., 2006). Also, the survey asked about substance at an earlier date, which may have resulted in recall bias. Use of real-time methods, such as ecological momentary assessment, can minimize recall biases associated with retrospective recall.

5. Conclusion

One in five youth and young adults who consumed alcohol or used marijuana at the last party they attended used both substances at the same occasion. Even after controlling for quantity of alcohol consumption, other substance use, and party context, there was a significant and positive association between SAM use and experiencing acute adverse consequences. Our findings suggest that the unique combination of alcohol and marijuana is associated with a heightened risk of experiencing problems following use. Prevention efforts that target both substances, including both policy and education, may be necessary to reduce SAM use and associated consequences.

Contributors

Kathleen Egan conceptualized and composed the manuscript. Melissa Cox assisted with the conceptualization of the manuscript. Cynthia Suerken conducted the data analysis. Beth Reboussin, Eunyoung Song, Kimberly Wagoner, and Mark Wolfson assisted with the conceptualization of the manuscript, designed the larger study, and were involved with the data collection. All authors provided critical feedback and helped shape the research, analysis, and manuscript. All authors have approved the final article.

Declaration of Competing Interest

No conflicts to declare.

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References

AAPOR. (n.d.). Response Rates - An Overview. Retrieved March 22, 2017, from http://www.aapor.org/Education-Resources/For-Researchers/Poll-Survey-FAQ/Response-RatesAn-Overview.aspx.

Baggio, S., Sapin, M., Khazaal, Y., Studer, J., Wolff, H., Gmel, G., 2018. Comorbidity of symptoms of alcohol and cannabis use disorders among a population-based sample of simultaneous users. Insight from a network perspective. Int. J. Environ. Res. Public Health 15, 2893. https://doi.org/10.3390/ijerph15122893.

Barnwell, S.S., Earleywine, M., 2006. Simultaneous alcohol and cannabis expectancies predict simultaneous use. Subst. Abuse Treat. Prev. Policy 1, 29. https://doi.org/10.1186/1747-597X-1-29.

Bramness, J.G., Khiabani, H.Z., Mørland, J., 2010. Impairment due to cannabis and ethanol: clinical signs and additive effects. Addiction 105, 1080–1087. https://doi.org/10.1111/j.1360-0443.2010.02911.x.

Bravo, A.J., Anthenien, A.M., Prince, M.A., Pearson, M.R., 2017. Marijuana protective behavioral strategies as a moderator of the effects of risk/protective factors on marijuana-related outcomes. Addict. Behav. 69, 14–21. https://doi.org/10.1016/j.addbeh.2017.01.007.

Brière, F.N., Fallu, J.-S., Descheneaux, A., Janosz, M., 2011. Predictors and consequences of simultaneous alcohol and cannabis use in adolescents. Addict. Behav. 36, 785–788. https://doi.org/10.1016/j.addbeh.2011.02.012.

Chait, L.D., Perry, J.L., 1994. Acute and residual effects of alcohol and marijuana, alone and in combination, on mood and performance. Psychopharmacology (Berl.) 115, 340–349. https://doi.org/10.1007/BF02245075.

Egan, K.L., Suerken, C., Debinski, B., Reboussin, B.A., Wagoner, K.G., Sutfin, E.L., Wolfson, M., 2018. More than just alcohol: marijuana and illicit drug use at parties attended by 15–20 year olds. Subst. Use Misuse 1–10. https://doi.org/10.1080/10826084.2018.1517798.

Horvath, P., Zuckerman, M., 1993. Sensation seeking, risk appraisal, and risky behavior. Personal. Individ. Differ. 14, 41–52. https://doi.org/10.1016/0191-8869(93)90173-Z.

Lipperman-Kreda, S., Gruenewald, P.J., Grube, J.W., Bersamin, M., 2017. Adolescents, alcohol, and marijuana: context characteristics and problems associated with simultaneous use. Drug Alcohol Depend. 179, 55–60. https://doi.org/10.1016/j.drugalcdep.2017.06.023.

McCabe, S.E., Diez, A., Boyd, C.J., Nelson, T.F., Weitzman, E.R., 2006. Comparing web and mail responses in a mixed mode survey in college alcohol use research. Addict. Behav. 31, 1619–1627. https://doi.org/10.1016/j.addbeh.2005.12.009.

Miech, R., Johnston, L., O'Malley, P., Bachman, J., Schulenberg, J., Patrick, M., 2018. Monitoring the Future National Survey Results on Drug Use, 1975-2017 Vol. 1 Secondary school students. Institute for Social Research, University of Michigan, Ann Arbor.

National Conference of State Legislatures, 2017. State Medical Marijuana Laws [WWW Document]. URL http://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx (Accessed 22 March 2017). .

O'Brien, M.C., McCoy, T.P., Egan, K.L., Goldin, S., Rhodes, S.D., Wolfson, M., 2013. Caffeinated alcohol, sensation seeking, and injury risk. J. Caffeine Res. 3, 59–66. https://doi.org/10.1089/jcr.2013.0004.

Palmer, R.S., McMahon, T.J., Rounsaville, B.J., Ball, S.A., 2010. Coercive sexual experiences, protective behavioral strategies, alcohol expectancies and consumption among male and female college students. J. Interpers. Violence 25, 1563–1578. https://doi.org/10.1177/0886260509354581.

Paschall, M.J., Lipperman-Kreda, S., Grube, J.W., Thomas, S., 2014. Relationships between social host laws and underage drinking: findings from a study of 50 California cities. J. Stud. Alcohol Drugs 75, 901–907.

Patrick, M.E., Terry-McElrath, Y.M., Lee, C.M., Schulenberg, J.E., 2019. Simultaneous alcohol and marijuana use among underage young adults in the United States. Addict. Behav. 88, 77–81. https://doi.org/10.1016/j.addbeh.2018.08.015.

Pearson, M.R., 2013. Use of alcohol protective behavioral strategies among college students: a critical review. Clin. Psychol. Rev. 33, 1025–1040. https://doi.org/10.1016/j.cpr.2013.08.006.

Ramaekers, J.G., Robbe, H.W.J., O'Hanlon, J.F., 2000. Marijuana, alcohol and actual driving performance. Hum. Psychopharmacol. Clin. Exp. 15, 551–558. https://doi.org/10.1002/1099-1077(200010)15:7<551::AID-HUP236>3.0.CO;2-P.

Smith, T.W., 2009. A Revised Review of Methods to Estimate the Status of Cases with Unknown Eligibility. https://www.aapor.org/AAPOR_Main/media/MainSiteFiles/FindingE.pdf.

Stautz, K., Cooper, A., 2013. Impulsivity-related personality traits and adolescent alcohol use: a meta-analytic review. Clin. Psychol. Rev. 33, 574–592. https://doi.org/10.1016/j.cpr.2013.03.003.

Subbaraman, M.S., 2016. Substitution and complementarity of alcohol and cannabis: a review of the literature. Subst. Use Misuse 51, 1399–1414. https://doi.org/10.3109/10826084.2016.1170145.

Terry-McElrath, Y.M., O'Malley, P.M., Johnston, L.D., 2014. Alcohol and marijuana use patterns associated with unsafe driving among U.S. High school seniors: high use

frequency, concurrent use, and simultaneous use. J. Stud. Alcohol Drugs 75, 378–389.
Terry-McElrath, Y.M., O'Malley, P.M., Johnston, L.D., 2013. Simultaneous alcohol and marijuana use among US high school seniors from 1976 to 2011: trends, reasons, and situations. Drug Alcohol Depend. 133, 71–79. https://doi.org/10.1016/j.drugalcdep.2013.05.031.
Wagoner, K.G., Francisco, V.T., Sparks, M., Wyrick, D., Nichols, T., Wolfson, M., 2011. A review of social host policies focused on underage drinking parties: suggestions for future research. J. Drug Educ. 42, 99–117. https://doi.org/10.2190/DE.42.1.f.
Wolfson, M., Wagoner, K.G., Rhodes, S.D., Egan, K.L., Sparks, M., Ellerbee, D., Song, E.Y., Debinski, B., Terrillion, A., Vining, J., Yang, E., 2017. Coproduction of research questions and research evidence in public health: the study to prevent teen drinking parties [WWW document]. Biomed Res. Int. 2017, 10. https://doi.org/10.1155/2017/3639596. 3639596.
Yurasek, A.M., Aston, E.R., Metrik, J., 2017. Co-use of alcohol and Cannabis: a review. Curr. Addict. Rep. 4, 184–193. https://doi.org/10.1007/s40429-017-0149-8.