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High-intensity and simultaneous alcohol and marijuana use among high school seniors in the U.S.

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Abstract

Background—Simultaneous alcohol and marijuana (SAM) use poses threats to health, particularly among adolescents. These risks would be exacerbated to the extent that high-intensity drinking (e.g., 10+ drinks in a row) and marijuana use (e.g., 1+ joints per day) are associated with a higher likelihood of SAM use. The current study examines the extent to which the intensity of alcohol use and of marijuana use are associated with adolescent SAM use prevalence, and whether associations remain after controlling for key covariates known to associate with both alcohol and marijuana use; it identifies alcohol and marijuana use intensity levels associated with the highest risk of adolescent SAM use.

Methods—Data come from nationally representative samples of U.S. 12th graders who participated in the Monitoring the Future study from 2005 to 2014 (N=24,203 respondents; 48.4% boys, 51.6% girls).

Results—SAM use during the past year was reported by 20% of 12th graders overall. SAM use prevalence was strongly and positively associated with alcohol and marijuana use intensity even after controlling for covariates. High school seniors at highest risk for engaging in SAM use were those who reported 10+ drinks and those smoking at least 1 joint/day. Approximately 60% of those who had 10-14 or 15+ drinks in a row during the past two weeks and 76-80% of those who had 1 or 2+ joints per day on average during the past 30 days reported SAM use.

Conclusions—Results suggest that high school seniors who consume high quantities of alcohol and marijuana are very likely to consume these substances so that their effects overlap.

INTRODUCTION

Simultaneous alcohol and marijuana (SAM) use involves use of both substances at the same time, resulting in overlapping effects. SAM use is associated with serious public health problems including unsafe driving,^{1,2} depression,³ and substance dependence.³⁻⁵ Adolescent SAM use has been widely documented in North America^{2,6-8} and Europe,⁹ and is especially concerning due to deleterious effects of combined alcohol and marijuana use on adolescent neuropsychological development and cognitive functioning.¹⁰⁻¹² The National Center on

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AUTHOR CONTRIBUTIONS

Drs. Patrick and Veliz contributed to the manuscript with respect to concept, interpretation of data, and the write-up of results. Dr. Veliz conducted the data analysis. Ms. Terry-McElrath assisted with interpretation of data and write-up of results.

Addiction and Substance Abuse calls adolescent substance use one of the country's largest preventable and costly health problems, and recommends proactively seeking out opportunities to intervene.¹³ However, knowledge about which adolescents are most likely to engage in SAM use is limited.

SAM use among adults is independently associated with both alcohol use frequency (frequency measured at 5+ drinks per day) and intensity (average daily number of drinks).¹ Adolescent SAM use is positively associated with alcohol use frequency.⁸ For example, adolescents who reported using alcohol on only 1-2 occasions in the past year had lower probabilities of SAM use than did those who used on 40 or more occasions.⁸ While such frequency-related findings are important, they do not address associations between adolescent alcohol and marijuana use intensity (i.e., quantity) and SAM use. High-intensity drinking (10+ to 15+ drinks/occasion) is a problematic behavior among adolescents,¹⁴⁻¹⁶ posing risks to adolescent drinkers and the public.¹⁷⁻²¹ If SAM use is concentrated among adolescents who engage in high-intensity drinking (i.e., 10+ or 15+ drinks in a row), this knowledge can help direct prevention and intervention efforts to the primary group at risk for SAM-related harms. Similarly, increasing marijuana use intensity (number of joints) is strongly associated with increased dependence among adolescents.²² These risks would be exacerbated to the extent that high-intensity alcohol and/or marijuana use is associated with a higher likelihood of SAM use.

The current study used four research questions (RQs) to examine associations between adolescent alcohol and marijuana use intensity and SAM use: (1) How does the prevalence of adolescent SAM use vary across intensity levels of both alcohol use and marijuana use? (2) Do associations between alcohol and marijuana use intensity and SAM use remain significant after controlling for covariates known to be associated independently with the likelihood of high-intensity alcohol use and SAM use among adolescents?^{8,15,23,24} (3) Is there evidence that adolescent SAM use is associated primarily with high-intensity drinking versus high-intensity marijuana use? (4) Does adolescent SAM use appear to be associated with specific use intensity thresholds (i.e., 10-14 vs. 15+ drinks, or 1 vs. 2+ joints per day)?

METHODS

The present study uses ten years of cross-sectional data from the Monitoring the Future (MTF) study.²⁵ Based on a three-stage sampling procedure, MTF surveys nationally representative samples of approximately 15,000 U.S. high school seniors annually (response rates ranging from 77% to 86%). Project design and sampling methods, including informed consent procedures, are described in detail elsewhere.²⁵ Measures for the current analysis were available on one of the six randomly distributed questionnaire forms for separate yearly 12th-grade samples from 2005 to 2014. The analytic sample included 24,203 respondents (48.4% boys; racial/ethnic distribution was 10.7% Black, 13.4% Hispanic, 56.4% White, and 19.6% other races). Approval for this study was obtained from the institutional review board.

Measures

Intensity of drinking—*Intensity of drinking* was based on three questions asking respondents to report the number of occasions during the last two weeks when they had (a) 5

or more, (b) 10 or more, and (c) 15 or more drinks in a row. Responses were combined to make a mutually exclusive 4-category variable reflecting a maximum number of drinks consumed in a row in the past two weeks: (1) 0 to 4 drinks, (2) 5 to 9 drinks, (3) 10 to 14 drinks, and (4) 15 or more drinks in a row. High-intensity drinking was operationalized as the intensity levels reported by the top ~10% of 12th-grade alcohol users, which has been shown to be 10+ drinks in a row in the past two weeks.¹⁵

Intensity of marijuana use—*Intensity of marijuana use* was based on one question about the number of “marijuana cigarettes (joints, reefers), or the equivalent” smoked per day, on average. A mutually exclusive 4-category variable was coded reflecting average per day use: (1) no use, (2) <1 joint/day, (3) 1 joint/day, and (4) 2+ joints/day. High-intensity marijuana use was operationalized as the intensity levels reported by the top ~10% of 12th-grade marijuana users in the current study, which is 1 or more joints per day in the past 30 days.

Simultaneous alcohol and marijuana (SAM) use—*Simultaneous alcohol and marijuana (SAM) use* was based on one question: “How many of the times when you used marijuana or hashish during the last year did you use it along with alcohol—that is, so that their effects overlapped?” Responses were coded into a binary measure indicating any SAM use in the past year versus no SAM use [no use included both (a) no marijuana use and/or no alcohol use in the past 12 months, and (b) marijuana use and alcohol use but no SAM use in the past 12 months].

Control variables—*Control variables* included in multivariable models were sex, race/ethnicity, truancy, average academic grades, parental education, and peer substance use.

Analysis

Stata 14.0²⁶ was used for analysis. All analyses used sampling weights to account for unequal sample selection probability and multiple imputation to account for missingness.²⁷ In particular, sequential regression imputation was used to impute missing values on all the variables in the current analysis (see Table 1 for a complete list); ten imputations with the full MTF sample used chained multinomial, logistic, and ordered logit models in STATA’s “mi impute chained” procedure (i.e., 10 imputations, 5 burn-in iterations each; the “augment” option was used in the presence of perfect prediction). Results from additional models (not shown) indicated findings were substantively unchanged when using either listwise deletion or imputing missing data on covariates but not on the dependent variable (i.e., SAM).

To address RQ1, logistic regression was used to estimate the unadjusted odds ratio of SAM use within specified intensity levels of alcohol and marijuana use separately (prevalence rates were also provided for descriptive purposes). To address RQ2, specified covariates were added to the logistic regression models to estimate the adjusted odds ratio of SAM use within specified intensity levels of alcohol and marijuana use separately. To address RQ3 and RQ4, logistic regression models were run simultaneously including alcohol use intensity, marijuana use intensity, and covariates. Using different intensity levels as the

referent, three separate models were run to examine the associations between key alcohol and marijuana use intensity thresholds and adolescent SAM use.

RESULTS

Descriptive statistics for all variables (including controls) are provided in Table 1. During the past year, 20% of 12th graders reported SAM use. Regarding high-intensity drinking, in the last two weeks, 5% of respondents had a maximum of 10–14 and 5% had 15+ drinks in a row. Regarding high-intensity marijuana use, 3% had 1 joint a day and 7% had 2+ joints a day, on average, in the last 30 days.

Prevalence of adolescent SAM use by alcohol and marijuana use intensity (RQ1)

SAM use prevalence by intensity of alcohol and marijuana use is shown in Table 2. Past 12-month SAM use was greater among those who reported higher-intensity drinking in the past 2 weeks, with SAM use reported by 12% who had 0–4 drinks, 50% who had 5–9 drinks, and 60–61% who had 10–14 or 15+ drinks. SAM use was also greater among those who reported higher-intensity marijuana use in the past 30 days, with SAM use reported by 9% who did not use in the past month, 69% who had <1 joint/day, and 76–80% who had 1 or 2+ joints/day.

Before controlling for covariates, compared to students who drank 0–4 drinks/occasion, the odds of SAM use were approximately 7 times higher among respondents reporting 5–9 drinks, and 11 times higher for those reporting 10–14 or 15+ drinks (Table 2, Model 1). Compared to students with no past 30-day marijuana use, the bivariate odds of SAM use were 23 times higher for <1 joint/day, 32 times higher for 1 joint/day, and 40 times higher for 2+ joints/day (Table 2, Model 2).

Associations between adolescent alcohol/marijuana use intensity and SAM use controlling for covariates (RQ2)

After including control variables, associations remained highly significant but were reduced in magnitude by approximately one-third. Compared to students who drank 0–4 drinks/occasion, the multivariable odds of SAM use were approximately 5 times higher among respondents reporting 5–9 drinks, and 7 to 8 times higher for those reporting 10–14 or 15+ drinks (Table 2, Model 3). Compared to students with no past 30-day marijuana use, the multivariable odds of SAM use were 15 times higher for <1 joint/day, 20 times higher for 1 joint/day, and 23 times higher for 2+ joints/day (Table 2, Model 4).

Comparison of association strength for alcohol use intensity vs. marijuana use intensity with adolescent SAM use (RQ3)

When simultaneously including alcohol use intensity, marijuana use intensity, and covariates, both use intensity measures remained strongly associated with adolescent SAM use (Table 2, Model 5a). The magnitude of associations for alcohol use intensity were roughly 30% lower: the odds of SAM use were 4 to 6 times higher for those who had 5+ drinks compared to those having 0–4 drinks. After controlling for alcohol use intensity, the magnitude of associations for marijuana use intensity were approximately 20% lower: the

odds of SAM use were 12 times higher for <1 joint/day and 17 to 18 times higher for 1 joint/day or more compared to those reporting no past 30-day use. (See Supplement Table 1 for full Model 5a results, including covariates.)

Threshold differences in association strength with adolescent SAM use (RQ4)

Adolescents who reported 10-14 drinks were significantly more likely to report SAM use than those reporting either 5-9 or 15+ drinks (Table 2, Models 5b and 5c). Adolescents who reported either 1 or 2+ joints/day were significantly more likely to report SAM use than those who reported <1 joint/day (Table 2, Model 5b). No significant difference in the odds of SAM use were observed between adolescents who reported 1 joint/day vs. 2+ joints/day (Table 2, Model 5c).

DISCUSSION

Alcohol and marijuana use intensity were strongly associated with SAM use among U.S. high school seniors, even after controlling for key covariates known to be associated with the likelihood of high-intensity alcohol and drug use. High school students at highest risk for engaging in SAM use were those who reported high-intensity use of either substance. Any SAM use in the past 12 months was reported by approximately 6 out of 10 students who reported high-intensity drinking in the past two weeks, and roughly 8 out of 10 students who reported high-intensity marijuana use in the last 30 days.

These findings should be considered within their limitations. The cross-sectional data structure precludes causal inference. All data were based on self-reports, which have been found to be reasonably reliable and valid under appropriate conditions provided by MTF.^{25,28,29} Results may not generalize to individuals who drop out of high school prior to their senior year. As lower educational attainment is associated with higher marijuana use,³⁰ the findings here may be conservative with respect to SAM use prevalence. Limitations notwithstanding, the results of the current study were based on large nationally representative samples of U.S. 12th-grade students, spanning 10 years and permitting robust analysis of the prevalence of SAM use within the older adolescent population.

The current study extends prior research identifying alcohol and marijuana use frequency as correlates of adolescent SAM use,⁸ clearly indicating that use intensity (particularly high-intensity use) of both substances is a significant correlate of SAM use. Adolescents engaging in high-intensity marijuana use are particularly likely to report simultaneous use and thus experience negative consequences associated with SAM use. These findings have implications for both prevention and treatment. A particular challenge for prevention programs is to effectively communicate the risks associated with SAM use to high-intensity- and non-using adolescents; young adult research shows that SAM use decreases as perceived risks of SAM use increase.³¹ Screening and intervention efforts addressing SAM use are needed among high-intensity adolescent drug users.^{1,2,8} These combined risks—of high-intensity drinking, high-intensity marijuana use, and SAM use—are likely to exacerbate risks of using other substances and pose particular threats to adolescent health. Additional research on the particular effects of engaging in high-intensity drinking and high-intensity marijuana use both separately and simultaneously among adolescents is needed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Sample Characteristics

Table 1

Dependent Variable	Missing		Multiple Imputation (10 imputations)		Full Sample	
	%	SE	%	SE	%	SE
Simultaneous alcohol and marijuana (SAM) use (past 12 months)	2.80					
No SAM use			79.6	0.003	79.7	0.003
Any SAM use			20.4	0.003	20.3	0.003
Independent Variables						
Intensity of alcohol use (past 2 weeks)	6.18					
No binge drinking (i.e., 0 to 4 drinks in a row)			80.4	0.003	80.5	0.003
5 to 9 drinks in a row			9.5	0.002	9.5	0.002
10 to 14 drinks in a row			4.8	0.002	4.8	0.002
15 or more drinks in a row			5.3	0.002	5.3	0.002
Intensity of marijuana use (past 30 days)	5.40					
No marijuana use			82.1	0.003	82.2	0.003
Less than 1 joint a day			8.7	0.002	8.7	0.002
1 joint a day			2.5	0.001	2.5	0.001
2 or more joints a day			6.7	0.002	6.6	0.002
Control Variables						
Sex						
Male	8.90					
Female			48.4	0.004	48.1	0.004
Race/ethnicity			51.6	0.004	51.9	0.004
White	0.00					
Black			56.4	0.004	56.4	0.004
Hispanic			10.7	0.002	10.7	0.002
Other race			13.4	0.003	13.4	0.003
Truancy			19.6	0.003	19.6	0.003
Did not skip class during the past month	10.70					
			69.2	0.004	69.7	0.004

Dependent Variable	Missing %	Multiple Imputation (10 imputations)		Full Sample	
		%	SE	%	SE
Skipped class during the past month		30.8	0.004	30.3	0.004
Average academic grades	11.00				
Average grade is a B- or higher		83.1	0.003	83.2	0.003
Average grade is a C+ or lower		16.9	0.003	16.8	0.003
Parental Education	9.00				
No parent has a college degree		49.9	0.004	50.0	0.004
At least one parent has a college degree		50.1	0.004	50.0	0.004
Peer alcohol use	8.10				
None/a few/some friends get drunk at least once a week		79.7	0.003	80.0	0.003
Most/all friends get drunk at least once a week		20.3	0.003	20.0	0.003
Peer marijuana use	7.90				
None/a few/some friends smoke marijuana		76.1	0.004	76.5	0.003
Most/all friends smoke marijuana		23.9	0.004	23.5	0.003
Cohort (academic year)	0.00				
2005-06		20.9	0.003	20.9	0.003
2007-08		20.6	0.003	20.6	0.003
2009-10		20.3	0.003	20.3	0.003
2011-12		20.0	0.003	20.0	0.003
2013-14		18.2	0.003	18.2	0.003

Notes: Unweighted n = 24,203. Weighted estimates are provided.

Table 2

Associations between Alcohol and Marijuana Use Intensity and Any Past 12-Month Simultaneous Alcohol and Marijuana Use: US High School Seniors, 2005-2014

		Any Simultaneous Alcohol and Marijuana (SAM) Use During the Past 12 Months			
		SAM Prevalence by Intensity Level ^a	Bivariate Analysis (separate)	Multivariable Analysis (separate)	
			%	OR ^b (95% CI)	AOR ^c (95% CI)
Intensity of alcohol use (past 2 weeks)			Model 1	Model 3	
0 to 4 drinks in one sitting	11.8	(ref)	(ref)		
5 to 9 drinks in one sitting	49.6	7.36 ^{***} (6.60, 8.21)	5.43 ^{***} (4.76, 6.19)		
10 to 14 drinks in one sitting	61.2	11.8 ^{***} (10.1, 13.8)	7.84 ^{***} (6.52, 9.41)		
15 or more drinks in one sitting	60.4	11.2 ^{***} (9.68, 12.9)	7.14 ^{***} (5.98, 8.52)		
Intensity of marijuana use (past 30 days)			Model 2	Model 4	
No marijuana use	8.8	(ref)	(ref)		
Less than 1 joint a day	68.8	22.8 ^{***} (20.1, 25.9)	15.0 ^{***} (13.1, 17.2)		
1 joint a day	75.5	31.9 ^{***} (25.0, 40.9)	20.1 ^{***} (15.1, 26.7)		
2 or more joints a day	79.5	40.1 ^{***} (34.1, 47.1)	23.3 ^{***} (19.3, 28.2)		
		Multivariable Analysis (combined)	Multivariable Analysis (combined)	Multivariate Analysis (combined)	
		AOR^d (95% CI)	AOR (95% CI)	AOR (95% CI)	
Intensity of alcohol use (past 2 weeks)			Model 5a	Model 5b	Model 5c
0 to 4 drinks in one sitting	11.8	(ref)	(ref)	0.25 ^{***} (0.22, 0.29)	0.17 ^{***} (0.14, 0.21)
5 to 9 drinks in one sitting	49.6	3.99 ^{***} (3.45, 4.63)	(ref)	(ref)	0.69 ^{**} (0.55, 0.87)
10 to 14 drinks in one sitting	61.2	5.75 ^{***} (4.69, 7.06)	1.43 ^{**} (1.14, 1.81)		(ref)
15 or more drinks in one sitting	60.4	4.34 ^{***} (3.50, 5.39)	1.08 (0.85, 1.39)		0.76 [*] (0.58, 0.99)
Intensity of marijuana use (past 30 days)					
No marijuana use	8.8	(ref)	(ref)	0.08 ^{***} (0.07, 0.10)	0.06 ^{***} (0.04, 0.08)
Less than 1 joint a day	68.8	12.0 ^{***} (10.4, 14.0)	(ref)	(ref)	0.72 [*] (0.52, 0.99)

	Any Simultaneous Alcohol and Marijuana (SAM) Use During the Past 12 Months			
	SAM Prevalence by Intensity Level ^a	Bivariate Analysis (separate)	Multivariable Analysis (separate)	
	%	OR ^b (95% CI)	AOR ^c (95% CI)	
1 joint a day	75.5	16.8*** (12.4, 22.8)	1.39* (1.01, 1.92)	(ref)
2 or more joints a day	79.5	18.4*** (15.1, 22.4)	1.52*** (1.22, 1.89)	1.09 (0.77, 1.54)

Notes: Unweighted n = 24,203.

* p<.05;

** p<.01;

*** p<.001.

^a Weighted percentage of respondents in each noted alcohol or marijuana use intensity level that also reported SAM use.

^b Bivariate odds ratio.

^c Adjusted odds ratio from multivariable models run separately for (a) alcohol intensity, and (b) marijuana intensity, controlling for sex, race/ethnicity, truancy, average academic grades, parental education, peer alcohol and marijuana use, and cohort.

^d Adjusted odds ratio from multivariate model simultaneously including both alcohol and marijuana use intensity measures, as well as controlling for sex, race/ethnicity, truancy, average academic grades, parental education, peer alcohol and marijuana use, and cohort. Reference groups across Models 5a, 5b, and 5c allow for statistical comparisons across all thresholds of use.