



Simultaneous alcohol and marijuana use among US high school seniors from 1976 to 2011: Trends, reasons, and situations



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ABSTRACT

Background: Simultaneous alcohol and marijuana (SAM) use raises significant concern due to the potential for additive or interactive psychopharmacological effects. However, no nationally representative studies are available that document prevalence, trends, or related factors in US youth SAM use.

Methods: Nationally representative cross-sectional samples of 12th grade students surveyed in the Monitoring the Future project from 1976 to 2011 provided data on SAM use. Analyses were conducted in 2012.

Results: In 2011, 23% of all US high school seniors reported any SAM use. Among seniors reporting any past 12-month marijuana use, 62% reported any SAM use and 13% reported SAM use most or every time they used marijuana. SAM use consistently followed trends for past 30-day alcohol use over time. SAM use showed significant variation by psychosocial and demographic characteristics and was strongly associated with higher substance use levels, but occurred across the substance use spectrum. Certain reasons for alcohol or marijuana use (to increase effects of another drug; I'm hooked) and situations of alcohol or marijuana use (park/beach, car, party) were strongly associated with SAM use.

Conclusions: A sizable proportion of US high school seniors reported SAM use, and it appeared to occur frequently in social use situations that could impact both the public as well as youth drug users. SAM use appears to be a complex behavior that is incidental to general substance use patterns as well as associated with (a) specific simultaneous reasons (or expectancies), and (b) heavy substance use and perceived dependence, especially on alcohol.

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1. Introduction

The use of alcohol together with one or more illegal substances at the same occasion (hereafter referred to as simultaneous drug use) raises significant concern due to the potential for additive or interactive psychopharmacological effects. Available studies indicate the most common form of simultaneous drug use involves alcohol and marijuana (Collins et al., 1998; Earleywine and Newcomb, 1997; Martin et al., 1996; Midanik et al., 2007; SAMHSA, 2009). Consequences of simultaneous alcohol and marijuana (SAM) use include additive effects on a variety of cognitive, perceptual and motor functions, with clearly increased risk for behaviors such as driving (Belgrave et al., 1979; Chesher et al., 1976, 1977; Kelly et al., 2004; Lamers and Ramaekers, 2001; Ramaekers et al., 2000; Robbe, 1998). SAM use has been significantly and positively associated with social consequences, alcohol dependence and depression, binge drinking, and other health problems (Brière et al., 2011; Martin et al., 1996; Midanik et al., 2007; SAMHSA, 2009).

Little is known about why or where SAM use typically occurs. Findings are mixed as to whether SAM use is incidental to general substance use (i.e., use prevalence of alcohol and marijuana are both high enough that it may be common for both substances to be used together; Hoffman et al., 2000) or relates to specific simultaneous use expectancies over and above drug-specific expectancies (i.e., the desire for a unique high; Barnwell and Earleywine, 2006). If SAM use is a general "by-product" of heavy use of both substances, then reducing or preventing heavy use should reduce or prevent simultaneous use. However, if SAM use is not fully explained by independent levels of alcohol and marijuana use, there may be specific risk factors that could help identify individuals most at risk for SAM use and associated consequences.

Adult SAM use may be especially related to negative emotional states and social contexts (Pakula et al., 2009). SAM use has been shown to vary by gender (Collins et al., 1998; Hoffman et al., 2000; Martin et al., 1992; Midanik et al., 2007; Pakula et al., 2009; SAMHSA, 2009), sensation seeking (Martin et al., 1992) and low educational attainment (Midanik et al., 2007). Results have been mixed for differences by race/ethnicity (Collins et al., 1998; Hoffman et al., 2000; Midanik et al., 2007; Norton and Colliver, 1988; SAMHSA, 2009). Available studies on youth SAM use are

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limited. In the 1982 National Household Survey on Drug Abuse, 7% of youth aged 12–17 reported at least occasional past 30-day SAM use (Norton and Colliver, 1988). In the National Surveys on Drug Use and Health of 2006 and 2007, 14% of 12–17 year olds reported past-month simultaneous illicit drug or alcohol use (SAM use specifically was not reported, but marijuana was the illicit drug most frequently used with alcohol (SAMHSA, 2009)). Past 6-month SAM use prevalence rates among New York 7th–12th graders for the years 1983, 1990, and 1994 were reported to be 25%, 12% and 21%, respectively (Hoffman et al., 2000). SAM use among Quebec high school students from disadvantaged areas averaged 30% from 2004 to 2008 (Brière et al., 2011). An additional study used 1990 data from the RAND Adolescent Panel Study of West Coast youth to report past 12-month SAM use prevalence rates of 28% (Collins et al., 1998). To our knowledge, no studies using nationally representative data have been published presenting youth SAM use trends over time, or that provide detailed information on the reasons, locations, and situations for substance use reported by adolescents who also report SAM use.

The current study used nationally representative data from US high school seniors to examine the following questions: (1) What percentage report SAM use, and has this percentage remained stable from 1976 to 2011? (2) How does SAM use associate with use frequency of both marijuana and alcohol? (3) What psychosocial and demographic characteristics are associated with SAM use? (4) What reasons for and situations of alcohol and marijuana use are frequently reported by students who also report frequent SAM use? (5) Do the answers to the above research questions support the conceptualization of SAM use as being incidental to general substance use or indicate specific correlates (in particular, simultaneous use reasons/expectancies)?

2. Methods

2.1. Sample

The analyses utilized data from nationally representative cross-sectional samples of 12th grade students in the coterminous US collected through the Monitoring the Future (MTF) study (detailed information on design and procedures can be found in Bachman et al. (2011) and Johnston et al. (2012)). Yearly sample selection included approximately 15,000 high school seniors from about 130 schools. In order to reduce respondent burden but still obtain a wide variety of measures, six different questionnaire forms were used in the full MTF study (randomly distributed within classroom); items on SAM use were included on only one form. Surveys were administered in classrooms by University of Michigan personnel; students self-completed questionnaires, usually during a normal class period. Student response rates averaged 83% for 12th graders from 1976 to 2011. Absenteeism was the primary reason for missing data; less than 1% of students were estimated to refuse participation. Appropriate consent was used, and the University of Michigan Behavioral Sciences Institutional Review Board approved the study.

2.2. Measures

2.2.1. Past 12-month substance use. For alcohol, marijuana and hashish, students self-reported past 12-month use as 0 occasions, 1–2, 3–5, 6–9, 10–19, 20–39, 40 or more occasions (coded in analysis as 0, 1, 5, 4, 7, 5, 15, 30, 40); dichotomous any/none use measures also were created (responses for marijuana and hashish were combined into a single measure, hereafter referred to as marijuana). An additional dichotomy for any past 12-month use of illicit drugs other than marijuana (IOTM) was also created (including LSD, other psychedelics, cocaine, heroin, and any of the following not under doctor's orders: amphetamines, tranquilizers, barbiturates, and narcotics other than heroin).

2.2.2. Simultaneous use. Students who reported any past 12-month marijuana use were asked: "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 included not at all (1), a few of the times, some of the times, most of the time, every time (5). SAM use was coded in two ways: any simultaneous use (0,1); simultaneous use most or every time (0,1).

2.2.3. Reasons for and situations of substance use. Reasons for and situations of alcohol and marijuana use were asked only of students reporting past 12-month use of the specified substance. Respondents were asked, "What have been the most

important reasons for your using [substance]?" (See Table 1 for reason list.) Respondents were instructed to mark all that applied. For situations of use, respondents were asked: "When you used [substance] during the last year, how often did you use it in each of the following situations?" (See Table 1 for situation list.) Responses included not at all (1), a few of the times, some of the times, most of the time, every time (5). Situations were coded as continuous (1–5) and most/every time dichotomies. All reasons and situations focused on a single substance and did not refer to SAM use.

2.2.4. Psychosocial and demographic control variables. Self-reported gender, race/ethnicity, number of parents in the home, parental education, college plans, grades, evenings out during the week for recreation, truancy, and religious commitment were included in all multivariate models, as were measures of population density, region, and year. Race/ethnicity was coded as African American, Hispanic, White, or other. Parental education was utilized as a proxy for family socioeconomic status and was coded on an 11-point scale representing student-reported average parental educational attainment for father and mother (missing data for one parent allowed). College plans was a dichotomy indicating plans to probably or definitely graduate from a four-year college program. Grades were self-reported average grades in high school ranging from D (1) to A (9). Number of evenings out per week for fun and recreation was coded on a 6-point scale from less than one (0.5) to six or seven (6.5). Truancy was a mean of the frequency of skipping classes or whole days of school during the past 4 weeks. Religious commitment was a mean of two items assessing the importance of religion (ranging from not important to very important) and frequency of attendance at religious services (ranging from never to about once a week or more). Beginning in 1997, religious commitment items were not asked of students in California schools due to state regulations; all California students were assigned missing data on this measure and treated as a separate category. Population density was coded as large Metropolitan Statistical Area (MSA), other MSA, and non-MSA. For multivariate models, year was coded into individual dummy variables.

2.3. Data analysis

Survey commands in SAS 9.2 were used for all analyses to account for the complex MTF survey sampling design. All analyses included weights to adjust for differential probability of selection. Examination of SAM use trends was conducted using surveylogistic models with centered and quadratic year terms (without other control measures). Relationships between substance use frequency and SAM use were conducted with bivariate surveylogistic models with SAM use most/every time regressed on a single continuous substance use frequency measure per model. Surveylogistic models examining psychosocial and demographic characteristics associated with SAM use were conducted in three steps: (1) with each characteristic alone; (2) with all characteristics simultaneously other than substance use frequency; (3) simultaneously with all characteristics including substance use frequency. (Measures of both tolerance and variance inflation showed no indications of significant collinearity resulting from inclusion of substance use frequency in models.) Surveylogistic models examining reasons for and situations of using alcohol and marijuana and their associations with SAM use first simultaneously included all appropriate reasons or situations, and were then repeated including psychosocial and demographic controls and substance use frequency.

3. Results

A total of 103,129 unweighted cases were available from 1976 to 2011 from the questionnaire form with SAM use. Five percent of cases had missing data on past 12-month marijuana use; of the remaining 98,007 cases, 38% (37,566) reported any use of marijuana in the past year. SAM use was asked only of respondents indicating any past-year marijuana use; 36,107 respondents provided data (96% of past-year users). An additional 1257 cases with conflicting data on alcohol use and SAM use were removed leaving 34,850 cases for analyses.

3.1. SAM use prevalence and trends

Table 1 shows that among seniors reporting any past 12-month marijuana use, 70% reported any SAM use and 18% reported SAM use most/every time from 1976 to 2011. While not the focus of the current study, the respective percentages for all US high school seniors were 26% for any SAM use and 7% for SAM use most/every time. Fig. 1 presents prevalence trends for SAM use and past 30-day alcohol and marijuana use; SAM use trends generally followed those for past 30-day alcohol use. (After aggregating the data to the year level ($N = 36$), Pearson correlations were .803

Table 1
Sample characteristics (1976–2011, combined).

	Range	Past 12-Month Marijuana Users	
		Mean or proportion	(SE)
<u>Simultaneous alcohol and marijuana (SAM) use^a</u>			
SAM use frequency	1–5	2.332	(0.009)
Any SAM use	0,1	0.697	(0.003)
SAM use most or every time	0,1	0.184	(0.003)
<u>Substance use</u>			
Past 12-month alcohol use			
Frequency of use	0–40	21.925	(0.146)
Any use	0,1	0.984	(0.001)
Past 12-month marijuana use			
Frequency of use	0–40	17.530	(0.130)
Any use	0,1	1.000	(0.000)
Any past 12-month IOTM use ^b	0,1	0.414	(0.004)
Any past 30-day substance use			
Alcohol use	0,1	0.850	(0.003)
Marijuana use	0,1	0.644	(0.001)
IOTM use	0,1	0.224	(0.004)
<u>Socio-demographic characteristics</u>			
Male	0,1	0.525	(0.004)
<u>Race/ethnicity</u>			
African American	0,1	0.076	(0.004)
Hispanic	0,1	0.060	(0.003)
White	0,1	0.734	(0.006)
Other	0,1	0.129	(0.003)
Two-parent household	0,1	0.710	(0.004)
Parental education ^c	10–60	37.407	(0.159)
Grades ^d	1–9	5.615	(0.019)
College plans ^e	0,1	0.671	(0.006)
Evenings out per week for fun/recreation ^f	0.5–6.5	3.117	(0.013)
Truancy ^g	1–5	2.044	(0.013)
<u>Religious commitment</u>			
Low	0,1	0.420	(0.005)
Medium	0,1	0.323	(0.004)
High	0,1	0.213	(0.004)
California data	0,1	0.110	(0.006)
<u>Population density</u>			
Large Metropolitan Statistical Area (MSA)	0,1	0.288	(0.010)
Other MSA	0,1	0.471	(0.011)
Non-MSA	0,1	0.241	(0.008)
<u>Region</u>			
Northeast	0,1	0.245	(0.008)
Midwest	0,1	0.279	(0.008)
South	0,1	0.286	(0.008)
West	0,1	0.190	(0.007)
<u>Reasons for substance use</u>			
<u>Alcohol</u>			
To experiment—to see what it's like	0,1	0.382	(0.004)
To relax or relieve tension	0,1	0.502	(0.004)
To feel good or get high	0,1	0.666	(0.004)
To seek deeper insights and understanding	0,1	0.068	(0.002)
To have a good time with my friends	0,1	0.821	(0.003)
To fit in with a group I like	0,1	0.092	(0.002)
To get away from my problems or troubles	0,1	0.270	(0.003)
Because of boredom, nothing else to do	0,1	0.299	(0.003)
Because of anger or frustration	0,1	0.215	(0.003)
To get through the day	0,1	0.034	(0.001)
To increase the effects of some other drug(s)	0,1	0.129	(0.002)
To decrease (offset) the effects of some other drug(s)	0,1	0.019	(0.001)
To get to sleep	0, 1	0.082	(0.002)
Because it tastes good	0, 1	0.488	(0.004)
Because I am 'hooked'—I feel I have to drink	0, 1	0.021	(0.001)
<u>Marijuana</u>			
To experiment—to see what it's like	0,1	0.638	(0.003)
To relax or relieve tension	0,1	0.500	(0.004)
To feel good or get high	0,1	0.759	(0.003)
To seek deeper insights and understanding	0,1	0.172	(0.003)
To have a good time with friends	0,1	0.669	(0.003)
To fit in with a group I like	0,1	0.105	(0.002)
To get away from my problems or troubles	0,1	0.234	(0.003)
Because of boredom, nothing else to do	0,1	0.291	(0.003)
Because of anger or frustration	0,1	0.169	(0.003)
To get through the day	0,1	0.090	(0.002)
To increase the effects of some other drug(s)	0,1	0.134	(0.002)
To decrease (offset) the effects of some other drug(s)	0,1	0.026	(0.001)
Because I'm 'hooked'—I have to have it	0,1	0.037	(0.001)

Table 1 (Continued)

Situations of substance use	Range	Past 12-Month Marijuana Users	
		Mean or proportion	(SE)
Situations of substance use			
Alcohol			
When you were alone	1–5	1.432	(0.005)
With just 1 or 2 other people	1–5	2.802	(0.010)
At a party	1–5	3.669	(0.009)
When your date or spouse was present	1–5	2.478	(0.011)
When people over age 30 were present	1–5	2.105	(0.007)
At your home (or apartment or dorm)	1–5	2.122	(0.007)
At school	1–5	1.235	(0.005)
In a car	1–5	2.230	(0.015)
At a park or beach ^h	1–5	1.742	(0.017)
At a bar or restaurant ^h	1–5	1.601	(0.017)
Marijuana			
When you were alone	1–5	1.541	(0.006)
With just 1 or 2 other people	1–5	3.102	(0.008)
At a party	1–5	2.821	(0.010)
When your date or spouse was present	1–5	2.058	(0.009)
When people over age 30 were present	1–5	1.539	(0.007)
At your home (or apartment or dorm)	1–5	1.882	(0.008)
At school	1–5	1.527	(0.010)
In a car	1–5	2.592	(0.011)
At a park or beach ^h	1–5	1.926	(0.017)

Notes: Total possible unweighted sample size was 34,850.

- ^a Any past 12-month use of marijuana along with alcohol so that the effects overlapped.
- ^b IOTM = illicit drugs other than marijuana; includes LSD, other psychedelics, cocaine, amphetamines, tranquilizers, heroin, barbiturates and narcotics other than heroin.
- ^c Coded on an 11-point scale representing student-reported average parental educational attainment for father and mother (missing data for one parent allowed).
- ^d Self-reported average grades in high school ranging from D to A.
- ^e A dichotomous measure indicating plans to probably or definitely graduate from a four-year college program.
- ^f Coded on a 6-point scale of 0.5 (less than one), 1, 2, 3, 4.5 (four to five), 6.5 (six to seven).
- ^g Mean of the frequency of skipping classes or whole days of school during the past 4 weeks.
- ^h Items asked from 1999 onwards.

($p < .0001$) between any SAM use and past 30-day alcohol use and .810 ($p < .0001$) between SAM use most/every time and past 30-day alcohol use. Respective correlations with past 30-day marijuana use were .461 and .435 ($p < .01$.) Any SAM use decreased from a high of 74% in 1980–1982 to 62% in 2011 (a significant and linear decrease; OR 0.99, $p < .0001$). SAM use most or every time remained generally stable at around 20% from 1976 through the mid-1990s, but then decreased significantly through 2011 when only 13% of past 12-month marijuana users reported such use (linear year term OR 0.981, $p < .0001$; quadratic term OR 0.999, $p = .0051$).

3.2. Substance use and SAM use among past 12-month marijuana users

Fig. 2 presents the percentage of past 12-month marijuana users who reported SAM use most/every time based on alcohol and marijuana use frequency; results show a clearly ordinal relationship. Estimates from bivariate models using 1976–2011 data with SAM use most/every time as outcome for alcohol were OR 1.064 (95% CI 1.061–1.067, $p < .0001$) and for marijuana were OR 1.032 (95% CI 1.030–1.034, $p < .0001$). Any IOTM use was also strongly associated

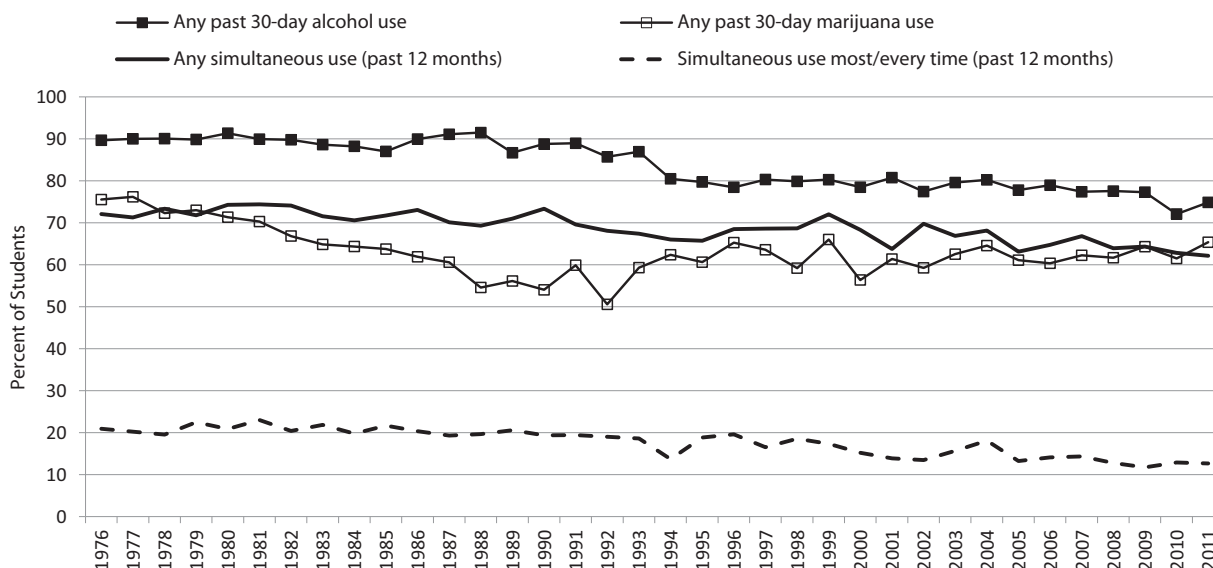


Fig. 1. Trends in past 30-day alcohol and marijuana use prevalence and simultaneous use of both substances among high school seniors reporting any past 12-month marijuana use, 1976–2011. Notes: “Simultaneous use” indicates simultaneous use of alcohol and marijuana in the past 12 months.

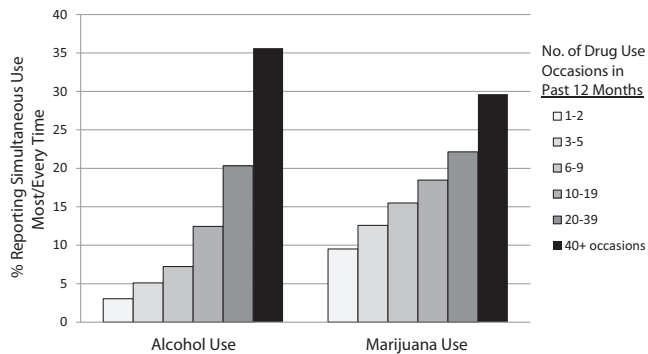


Fig. 2. Relationship between past 12-month substance use frequency and simultaneous alcohol and marijuana use most/every time among high school seniors reporting any past 12-month marijuana use, 1976–2011. Notes: *N* (unweighted) = 34,850.

with increased likelihood of frequent SAM use: 13% of seniors who reported past 12-month marijuana use but no past 12-month IOTM use reported SAM use most/every time versus 26% with any IOTM use (bivariate OR 2.379, 95% CI 2.218–2.552, $p < .0001$).

3.3. Characteristics associated with SAM use

Table 2 presents results of bivariate (that is, one independent and one dependent variable) and multivariate (that is, multiple independent variables and one dependent variable) models associating psychosocial and demographic characteristics and substance use frequency with SAM use. Given the very large analytical sample, models were limited to the most recent 10 years of data (2002–2011) to reduce the likelihood of obtaining statistically significant effects that would be too small to be of substantive importance.

3.3.1. Characteristics associated with any SAM use. Bivariate associations showed substance use frequency, gender, race/ethnicity, average parental education, evenings out, truancy, religious commitment, and region were all significantly associated with any SAM use. In multivariate models (both with and without substance use frequency), the majority of associations continued to be significant. Use frequency of both alcohol and marijuana were significantly and positively associated with the likelihood of any SAM use. Any SAM use was significantly more likely among White high school seniors than among African American or Hispanic seniors. Any SAM use was also significantly associated with more evenings out and truancy. High religious commitment was associated with significantly lower odds of SAM use than medium religious commitment. In multivariate models without controlling for substance use frequency, male gender, higher average parental education and residence in the Northeast or Midwest (vs. South) were associated with higher odds of any SAM use. After controlling for substance use frequency, four changes were observed: (1) females showed higher odds of any SAM use than males; (2) the association with average parental education became nonsignificant; (3) the positive association between higher GPA and any SAM use reached significance; and (4) no significance for either the Northeast or Midwest was observed; instead, residence in the West was associated with higher odds of any SAM use.

3.3.2. Characteristics associated with SAM use most or every time. Models for SAM use most or every time showed bivariate associations generally similar to those obtained for any SAM use for substance use frequency, gender, African American race/ethnicity, evenings out, and truancy. However, multivariate models controlling for all psychosocial, demographic and substance use measures

indicated that only substance use frequency and higher truancy significantly associated with odds of frequent SAM use. While both alcohol and marijuana use frequency positively associated with the likelihood of frequent SAM use, alcohol use frequency had a significantly stronger association than marijuana use frequency.

3.4. Use situations and SAM use most or every time

Situations were dichotomized into most/every time vs. other, and were then grouped by physical locations (bar/restaurant, car, home, park/beach, school) and social situations (adults, alone, date/spouse, party, one or two other people). Only 1% of past 12-month marijuana users reported both frequent SAM use and using alcohol at school most/every time; thus, this situation was dropped from further analyses.

Table 3 reports the percentages of past 12-month marijuana users reporting SAM use most/every time based on reported physical location of either alcohol or marijuana use. In order to compare the relative strength of associations between each location and frequent SAM use, all alcohol use locations were entered simultaneously (a separate model regressed frequent SAM use on marijuana use locations). All other psychosocial, demographic, and substance use measures were then added. Results are presented in decreasing order of effect size based on models including all covariates. In models with all substance-specific physical locations entered simultaneously and controlling for psychosocial, demographic, and substance use measures (models with simultaneous inclusion of all physical locations include data from 1999 to 2011 only, because situations of park/beach and bar/restaurant were not asked until 1999), primarily using alcohol in a park as well as a car remained strongly and significantly associated with increased odds of frequent SAM use ($p < .001$). For marijuana, primarily using in a park, school, or home all remained strongly and significantly associated with increased odds of frequent SAM use ($p < .001$).

Table 4 reports frequent SAM use based on social situation of either alcohol or marijuana use. As before, alcohol and marijuana social situations were modeled separately, and results are presented in decreasing order of effect size based on models including all covariates. Other than using alcohol with adults, all alcohol and marijuana social use situations remained independently and strongly significantly associated with an increased likelihood of SAM use most/every time ($p < .001$). For marijuana, primarily using at a party was more strongly associated with frequent SAM use than all other social use situations.

3.5. Reasons for use and SAM use most or every time

Table 5 presents the percentage of past 12-month marijuana users reporting frequent SAM use by reported substance-specific use reason. As before, alcohol and marijuana use reasons were modeled separately, and results are presented in decreasing order of effect size based on models including all covariates. In the alcohol use reasons model, increase effects, hooked, get high, bored, and taste were independently and significantly related to higher odds of frequent SAM use ($p < .001$). In the marijuana use reasons model, increase effects, hooked, fit in, and get high were independently and significantly related to higher odds of frequent SAM use ($p < .001$). In both the alcohol and marijuana use reasons models, using to experiment was independently and significantly related to decreased frequent SAM use ($p < .001$). Both using alcohol to increase the effects of another drug and because the respondent reported being hooked showed significantly stronger relationships with frequent SAM use than all other alcohol use reasons. Using marijuana to increase the effects of another drug

Table 2
 Characteristics associated with any simultaneous alcohol and marijuana use among high school seniors reporting any past 12-month marijuana use, 2002–2011.

	Bivariate Results				Multivariate Without Substance Use			Multivariate With Substance Use		
	%	OR	(95% CI)	<i>p</i>	OR	(95% CI)	<i>p</i>	OR	(95% CI)	<i>p</i>
Any SAM use										
Past 12-month substance use frequency										
Alcohol		1.07	(1.06–1.08)	<.0001	–			1.05	(1.05–1.06)	<.0001
Marijuana		1.06	(1.06–1.07)	<.0001	–			1.05	(1.05–1.06)	<.0001
Gender										
Female	61.1	(ref)			(ref)			(ref)		
Male	67.3	1.31	(1.16–1.47)	<.0001	1.24	(1.09–1.40)	0.0009	0.81	(0.70–0.93)	0.0022
Race/ethnicity										
White	68.5	(ref)			(ref)			(ref)		
African American	47.6	0.42	(0.35–0.50)	<.0001	0.48	(0.39–0.58)	<.0001	0.63	(0.51–0.78)	<.0001
Hispanic	56.3	0.59	(0.49–0.72)	<.0001	0.67	(0.54–0.83)	0.0003	0.74	(0.59–0.94)	0.0113
Other	66.8	0.92	(0.79–1.09)	0.3353	0.73	(0.61–0.88)	0.0011	0.78	(0.64–0.96)	0.0160
Number of parents in the home										
Less than two	63.0	(ref)			(ref)			(ref)		
Two	65.2	1.10	(0.97–1.25)	0.1306	0.97	(0.86–1.11)	0.6928	1.11	(0.96–1.28)	0.1543
Average parental education										
		1.01	(1.00–1.01)	0.0003	1.01	(1.00–1.01)	0.0289	1.00	(1.00–1.01)	0.3712
Plans to graduate from a four-year college program										
Other	65.8	(ref)			(ref)			(ref)		
Probably/definitely	63.3	0.90	(0.77–1.04)	0.1582	0.89	(0.75–1.05)	0.1562	1.02	(0.84–1.24)	0.8433
Grades										
		1.00	(0.97–1.03)	0.9013	1.02	(0.98–1.06)	0.3338	1.04	(1.00–1.09)	0.0335
Evenings out										
		1.23	(1.18–1.27)	<.0001	1.18	(1.13–1.23)	<.0001	1.05	(1.01–1.10)	0.0224
Truancy										
		1.23	(1.18–1.28)	<.0001	1.21	(1.15–1.26)	<.0001	1.07	(1.01–1.13)	0.0150
Religious commitment										
High	55.6	(ref)			(ref)			(ref)		
Medium	66.1	1.56	(1.32–1.83)	<.0001	1.47	(1.24–1.73)	<.0001	1.21	(1.01–1.46)	0.0437
Low	66.5	1.58	(1.35–1.85)	<.0001	1.34	(1.15–1.58)	0.0003	1.02	(0.85–1.23)	0.8012
CA	62.3	1.32	(1.02–1.70)	0.0317	1.31	(0.99–1.73)	0.0602	0.97	(0.72–1.30)	0.8134
Population density ^a										
Non-MSA	65.4	(ref)			(ref)			(ref)		
Other MSA	66.5	1.05	(0.89–1.25)	0.5481	1.01	(0.86–1.20)	0.8883	0.97	(0.80–1.17)	0.7321
Large MSA	63.1	0.91	(0.76–1.09)	0.2961	0.93	(0.77–1.12)	0.4425	0.90	(0.73–1.10)	0.3001
Region										
South	62.5	(ref)			(ref)			(ref)		
Northeast	68.5	1.31	(1.10–1.57)	0.0031	1.10	(0.92–1.33)	0.3026	1.09	(0.88–1.35)	0.4220
Midwest	67.5	1.25	(1.06–1.47)	0.0092	1.13	(0.96–1.34)	0.1354	1.14	(0.95–1.36)	0.1587
West	63.4	1.04	(0.87–1.25)	0.6766	1.04	(0.84–1.30)	0.7140	1.31	(1.03–1.67)	0.0286
SAM use most/all the time										
Past 12-month substance use frequency										
Alcohol		1.06	(1.05–1.07)	<.0001	–			1.06	(1.05–1.06)	<.0001
Marijuana		1.03	(1.03–1.03)	<.0001	–			1.01	(1.01–1.02)	<.0001
Gender										
Female	11.4	(ref)			(ref)			(ref)		
Male	15.0	1.38	(1.15–1.66)	0.0005	1.33	(1.10–1.60)	0.0032	0.97	(0.79–1.18)	0.7496
Race/ethnicity										
White	13.8	(ref)			(ref)			(ref)		
African American	10.2	0.71	(0.52–0.97)	0.0315	0.67	(0.48–0.93)	0.0180	1.03	(0.74–1.43)	0.8586
Hispanic	11.8	0.84	(0.64–1.10)	0.1987	0.94	(0.71–1.25)	0.6776	1.05	(0.78–1.41)	0.7523
Other	17.3	1.30	(1.08–1.58)	0.0068	1.12	(0.86–1.45)	0.4213	1.25	(0.95–1.64)	0.1102
Number of parents in the home										
Less than two	14.5	(ref)			(ref)			(ref)		
Two	12.8	0.86	(0.73–1.01)	0.0736	0.83	(0.70–0.99)	0.0423	0.88	(0.73–1.06)	0.1626
Average parental education										
		1.00	(0.99–1.01)	0.9424	1.00	(0.99–1.01)	0.8858	1.00	(0.99–1.01)	0.4245
Plans to graduate from a four-year college program										
Other	15.1	(ref)			(ref)			(ref)		
Probably/definitely	12.7	0.82	(0.66–1.01)	0.0567	0.90	(0.72–1.12)	0.3454	0.95	(0.75–1.19)	0.6428
Grades										
		0.95	(0.91–0.99)	0.0099	0.98	(0.94–1.03)	0.4205	0.98	(0.94–1.03)	0.4036
Evenings out										
		1.14	(1.09–1.19)	<.0001	1.10	(1.05–1.15)	0.0002	1.00	(0.95–1.06)	0.9352
Truancy										
		1.19	(1.13–1.26)	<.0001	1.16	(1.10–1.23)	<.0001	1.07	(1.00–1.14)	0.0382
Religious commitment										
High	12.3	(ref)			(ref)			(ref)		
Medium	14.3	1.19	(0.93–1.51)	0.1643	1.13	(0.88–1.45)	0.3378	0.97	(0.74–1.27)	0.8306
Low	13.8	1.14	(0.91–1.43)	0.2695	1.02	(0.79–1.31)	0.9101	0.85	(0.65–1.12)	0.2541
CA	9.9	0.78	(0.55–1.12)	0.1814	0.86	(0.57–1.30)	0.4634	0.62	(0.40–0.96)	0.0301
Population density ^a										
Non-MSA	13.4	(ref)			(ref)			(ref)		
Other MSA	14.4	1.09	(0.88–1.34)	0.4508	1.12	(0.90–1.39)	0.3079	1.11	(0.89–1.39)	0.3473
Large MSA	13.6	1.01	(0.80–1.28)	0.9193	1.10	(0.86–1.42)	0.4509	1.10	(0.85–1.41)	0.4777
Region										
South	14.5	(ref)			(ref)			(ref)		
Northeast	14.5	1.00	(0.82–1.23)	0.9952	0.95	(0.77–1.17)	0.6219	0.92	(0.74–1.14)	0.4620
Midwest	15.2	1.06	(0.85–1.30)	0.6204	1.05	(0.85–1.31)	0.6425	1.01	(0.82–1.25)	0.9278
West	11.1	0.74	(0.59–0.92)	0.0083	0.79	(0.60–1.04)	0.0884	0.93	(0.70–1.23)	0.6067

Notes: *N* (unweighted) = 7590. Multivariate models also controlled for year using dummy terms (data not shown). Missing data handled by imputing means (for continuous measures) together with the use of missing data indicators; no substantive differences were found when compared with results from complete-case analysis. Estimates for missing data indicators not shown.

^aMSA = metropolitan statistical area.

Table 3

Physical locations of alcohol and marijuana use: associations with simultaneous alcohol and marijuana (SAM) use most/every time among high school seniors reporting any past 12-month marijuana use, 1999–2011.

		% Reporting frequent SAM use:		Multivariate: locations only ^a			Multivariate: locations and all other covariates ^b		
		Non-frequent use of location	Frequent use of location	OR	(95% CI)	<i>p</i>	OR	(95% CI)	<i>p</i>
Location of alcohol use:									
Park	12		44	3.31	(2.61–4.20)	<.0001	2.57	(2.00–3.29)	<.0001
Car	13		47	2.99	(2.21–4.04)	<.0001	2.08	(1.55–2.79)	<.0001
Bar	13		36	1.85	(1.44–2.39)	<.0001	1.49	(1.16–1.92)	0.0021
Home	14		22	1.21	(0.99–1.48)	0.0609	1.12	(0.91–1.38)	0.2807
Location of marijuana use:									
Park	11		36	2.53	(2.06–3.12)	<.0001	2.48	(1.99–3.09)	<.0001
School	13		48	2.18	(1.62–2.93)	<.0001	2.15	(1.57–2.95)	<.0001
Home	12		26	1.52	(1.27–1.81)	<.0001	1.53	(1.26–1.86)	<.0001
Car	11		25	1.66	(1.41–1.96)	<.0001	1.32	(1.09–1.58)	0.0035

Notes: Ns (unweighted): alcohol use locations 9447; marijuana use locations 9757. Results are presented in decreasing order of effect size based on models including all covariates.

^a Includes simultaneous inclusion of all substance-specific use locations listed.

^b Includes simultaneous inclusion of all substance-specific use locations listed, as well as the following: past 12-month alcohol use frequency, past 12-month marijuana use frequency, gender, race/ethnicity, number of parents in the home, average parental education, college plans, academic grade point average, evenings out, truancy, religious commitment, population density, region, and year. Missing data handled by imputing means (for continuous measures) together with the use of missing data indicators; no substantive differences were found when compared with results from complete-case analysis.

Table 4

Social situations of alcohol and marijuana use: associations with simultaneous alcohol and marijuana (SAM) use most/every time among high school seniors reporting any past 12-month marijuana use, 1976–2011.

		% Reporting frequent SAM use:		Multivariate: situations only ^a			Multivariate: situations and all other covariates ^b		
		Non-frequent use of situation	Frequent use of situation	OR	(95% CI)	<i>p</i>	OR	(95% CI)	<i>p</i>
Alcohol social situations									
Alone	19		42	2.23	(1.77–2.81)	<.0001	1.93	(1.52–2.45)	<.0001
Party	11		23	2.41	(2.23–2.60)	<.0001	1.68	(1.55–1.82)	<.0001
Date/spouse	15		30	1.91	(1.78–2.05)	<.0001	1.58	(1.47–1.71)	<.0001
1–2 people	16		26	1.84	(1.70–1.98)	<.0001	1.40	(1.30–1.52)	<.0001
Adults	18		27	1.16	(1.04–1.30)	0.0064	1.12	(1.00–1.25)	0.0583
Marijuana social situations									
Party	10		34	3.81	(3.55–4.09)	<.0001	3.19	(2.94–3.45)	<.0001
Adults	17		41	1.56	(1.35–1.80)	<.0001	1.61	(1.38–1.88)	<.0001
Alone	18		40	1.45	(1.24–1.70)	<.0001	1.45	(1.23–1.72)	<.0001
Date/spouse	16		31	1.41	(1.29–1.53)	<.0001	1.42	(1.29–1.56)	<.0001
1–2 people	15		23	1.39	(1.29–1.49)	<.0001	1.27	(1.18–1.38)	<.0001

Notes: Ns (unweighted): alcohol use social situations 33,336; marijuana use social situations 34,107. Results are presented in decreasing order of effect size based on models including all covariates.

^a Includes simultaneous inclusion of all substance-specific use social situations listed.

^b Includes simultaneous inclusion of all substance-specific use social situations listed, as well as the following: past 12-month alcohol use frequency, past 12-month marijuana use frequency, gender, race/ethnicity, number of parents in the home, average parental education, college plans, academic grade point average, evenings out, truancy, religious commitment, population density, region, and year. Missing data handled by imputing means (for continuous measures) together with the use of missing data indicators; no substantive differences were found when compared with results from complete-case analysis.

showed a significantly stronger relationship with frequent SAM use than all other marijuana use reasons, including hooked.

4. Discussion

In 2011, about three-fifths of US high school seniors who reported past 12-month marijuana use reported any SAM use (approximately one-fourth of all seniors) and more than 10% of past 12-month marijuana users reported SAM use most/every time (7% of all seniors). These rates are comparable to prior research (Brière et al., 2011; Hoffman et al., 2000; SAMHSA, 2009) and indicate SAM use affects a significant proportion of American youth. The similarity between SAM and alcohol use trends (a discussion of the trends in alcohol use can be found in Johnston et al., 2012) implies that SAM use appears to be incidental to general substance use (especially alcohol). That is, a generally consistent proportion of alcohol users can be expected to engage in SAM use. Any SAM use occurred across use frequencies of both alcohol and marijuana with equal strength of association. Frequent SAM use was more strongly associated with past 12-month alcohol use frequency than

marijuana use frequency (although the likelihood of frequent SAM use increased with use frequency of both substances). Adolescents who engage in frequent alcohol use are most likely to engage in frequent SAM use. Yet, some degree of SAM use was observed at each level of alcohol and marijuana use, and not all heavy alcohol and marijuana users reported SAM use. Thus, given that SAM use appears across the spectrum of both alcohol and marijuana use, it does not appear merely to be a by-product of heavy use.

After controlling for substance use frequency, a broad set of psychosocial and demographic characteristics were associated with any SAM use; a more limited set were associated with frequent SAM use. Results indicate students with higher truancy records and higher substance use (especially alcohol use) have the strongest risk for frequent SAM use. However, the constellation of characteristics associated with any SAM use (being White, having higher grades, more evenings out, higher truancy, and higher substance use frequency) includes both “protective” factors (higher grades), and factors traditionally associated with higher substance use (White, evenings out, truancy, substance use frequency). Prior to controlling for substance use frequency, average parental education was

Table 5
Reasons for alcohol and marijuana use: associations with simultaneous alcohol and marijuana (SAM) use most/every time among high school seniors reporting any past 12-month marijuana use, 1976–2011.

	% Reporting frequent SAM use:		Multivariate: reasons only ^a			Multivariate: reasons and all other covariates ^b		
	No to reason	Yes to reason	OR	(95% CI)	p	OR	(95% CI)	p
Alcohol use reasons								
Increase effects	16	40	2.51	(2.31–2.74)	<.0001	1.90	(1.74–2.08)	<.0001
Hooked	18	51	2.37	(1.92–2.92)	<.0001	1.88	(1.53–2.29)	<.0001
Get high	11	23	1.87	(1.73–2.04)	<.0001	1.46	(1.34–1.59)	<.0001
Get thru day	18	40	1.32	(1.12–1.56)	0.0010	1.25	(1.06–1.48)	0.0089
Good time	13	20	1.19	(1.08–1.31)	0.0004	1.17	(1.06–1.30)	0.0022
Bored	16	25	1.26	(1.17–1.35)	<.0001	1.16	(1.08–1.25)	<.0001
Taste	15	23	1.44	(1.35–1.54)	<.0001	1.15	(1.07–1.24)	<.0001
Decrease effects	18	43	1.20	(0.97–1.50)	0.0979	1.12	(0.90–1.40)	0.2956
Problems	17	24	1.06	(0.97–1.16)	0.1752	1.10	(1.00–1.20)	0.0468
Anger	17	25	1.14	(1.04–1.24)	0.0044	1.07	(0.97–1.17)	0.1791
Fit in	19	23	1.04	(0.93–1.17)	0.4884	1.06	(0.94–1.20)	0.3631
Relax	15	22	1.12	(1.04–1.20)	0.0018	1.03	(0.96–1.11)	0.3720
Sleep	18	28	1.01	(0.89–1.14)	0.9331	0.98	(0.87–1.11)	0.7622
Insights	18	27	1.01	(0.89–1.15)	0.9112	0.95	(0.83–1.09)	0.4647
Experiment	20	16	0.67	(0.63–0.72)	<.0001	0.87	(0.81–0.94)	0.0003
Marijuana use reasons								
Increase effects	15	43	3.75	(3.44–4.08)	<.0001	2.89	(2.65–3.16)	<.0001
Hooked	18	39	1.51	(1.28–1.78)	<.0001	1.37	(1.16–1.62)	0.0002
Fit in	18	23	1.28	(1.15–1.43)	<.0001	1.25	(1.12–1.41)	0.0001
Get high	11	21	1.48	(1.35–1.63)	<.0001	1.20	(1.08–1.33)	0.0006
Get thru day	17	32	1.15	(1.02–1.31)	0.0239	1.12	(0.99–1.27)	0.0710
Good time	14	21	1.16	(1.07–1.25)	0.0002	1.12	(1.03–1.21)	0.0087
Problems	17	24	1.04	(0.95–1.15)	0.3994	1.12	(1.01–1.23)	0.0321
Decrease effects	18	39	1.07	(0.89–1.29)	0.4969	0.98	(0.82–1.18)	0.8571
Anger	17	24	0.96	(0.87–1.07)	0.4642	0.97	(0.87–1.08)	0.6075
Bored	16	23	1.00	(0.92–1.07)	0.9147	0.93	(0.86–1.00)	0.0480
Relax	16	21	0.96	(0.89–1.03)	0.2489	0.92	(0.84–0.99)	0.0338
Insights	18	23	0.89	(0.81–0.98)	0.0141	0.86	(0.78–0.95)	0.0019
Experiment	22	16	0.70	(0.66–0.75)	<.0001	0.84	(0.78–0.90)	<.0001

Notes: Ns (unweighted); alcohol use reasons 33,780; marijuana use reasons 34,498. Results are presented in decreasing order of effect size based on models including all covariates. Full definitions of the above reasons were as follows: to increase the effects of some other drug(s); because I am ‘hooked’—I feel I have to drink [alcohol]/I have to have it [marijuana]; to feel good or get high; to get through the day; to have a good time with my friends; because of boredom, nothing else to do; because it tastes good; to decrease (offset) the effects of some other drug(s); to get away from my problems or troubles; because of anger or frustration; to fit in with a group I like; to relax or relieve tension; to get to sleep; to seek deeper insights and understanding; to experiment—to see what it’s like.

^a Includes simultaneous inclusion of all substance-specific use reasons listed.
^b Includes simultaneous inclusion of all substance-specific use reasons listed, as well as the following: past 12-month alcohol use frequency, past 12-month marijuana use frequency, gender, race/ethnicity, number of parents in the home, average parental education, college plans, academic grade point average, evenings out, truancy, religious commitment, population density, region, and year. Missing data handled by imputing means (for continuous measures) together with the use of missing data indicators; no substantive differences were found when compared with results from complete-case analysis.

significantly and positively associated with any SAM use, while grades were positively but non-significantly associated. After substance use frequency was included, associations were reversed. Higher family socioeconomic standing has been associated with increased adolescent alcohol use (Humensky, 2010; Melotti et al., 2011) and adolescent academic achievement (Sirin, 2005). One interpretation of the current study’s findings is that individuals at risk for any SAM use exhibit both “expected” risk characteristics as well as characteristics indicative of higher socioeconomic standing and socially active lifestyles (higher grades, higher evenings out).

A strong social context to SAM use has been observed in prior studies of adults. Data from the 2000 National Alcohol Survey indicated that individuals reporting SAM use were more likely to frequently attend parties than individuals who reported concurrent alcohol and marijuana use, or who reported alcohol but no marijuana use (Midanik et al., 2007). Midanik and colleagues theorized that a party’s social context, where both alcohol and marijuana may be highly available, may facilitate SAM use. Pakula et al. (2009) also reported that social contexts such as “home with friends” and “bars/taverns/parties” were strongly associated with adult SAM use. The current study’s findings related to the physical and social contexts of alcohol or marijuana use support a social context connection. Physical locations (at a park/beach and in a car for alcohol; at a park/beach for marijuana) and social situations (at

a party for marijuana) most strongly associated with frequent SAM use indicate the social nature of SAM use. Importantly, the results from the current study also indicate that SAM use is not limited to social contexts. Using alcohol alone showed the strongest association with frequent SAM use of the listed alcohol social situations, and the strength of association between having a good time and frequent SAM use was weaker than several other reasons (increase effects, hooked, get high, get through the day) for both alcohol and marijuana. Prevention efforts may be aided by discussing the likelihood of increased pressure to engage in SAM use in social contexts and the corresponding dangers of simultaneous drug use. The social context of SAM use raises the likelihood that such use is likely to occur in situations in which the general public could suffer consequences. As noted in the introduction, SAM use has been shown to have an additive effect on cognitive, perceptual and motor functions, especially in relation to driving. The strong association between frequently using alcohol in a car and frequent SAM use raises serious concerns for public safety. Importantly, Pakula et al. (2009) also found that SAM use was highly associated with driving in a car.

While the social context of SAM use may suggest that the behavior is at least in part incidental to substance use (i.e., both alcohol and marijuana may be highly available in some social contexts, and thus simple co-occurring availability may facilitate SAM use), the reasons given by users themselves for alcohol use and

marijuana use indicate that some individuals regularly seek specific simultaneous use “highs”. Readers are reminded that respondents provided answers to use reasons (as well as use situations) for each substance separately and were not asked to say why they engaged in SAM use specifically. Using alcohol to increase the effects of another drug, as well as because the respondent reported they were hooked, were more strongly associated with frequent SAM use than all other use reasons. Correspondingly, using marijuana to increase the effects of another drug was more strongly associated with frequent SAM use than all other use reasons (although perceived dependence on marijuana was also strongly associated with frequent SAM use). The association between perceived dependence on both alcohol and marijuana and frequent SAM use raises significant concerns. SAM use has been found to be strongly associated with alcohol dependence and abuse (Martin et al., 1996; Midanik et al., 2007) and to predict subsequent substance-related problems (Brière et al., 2011). SAM use appears to be a complex behavior that is incidental of general substance use patterns as well as associated with specific simultaneous reasons (or expectancies), combined with strong associations with heavy substance use and perceived dependence, especially on alcohol (a finding supported by Hoffman et al., 2000).

These findings should be considered within their limitations. Analyses used self-report measures of deviant behaviors, but available evidence suggests that MTF self-report measures have a high degree of reliability (O'Malley et al., 1983) and validity (Johnston et al., 2012). Further, substance use expectancy measures focused on alcohol and marijuana use separately, and were not directly focused on SAM use. Data were cross-sectional and cannot be used to draw causal conclusions. Limitations notwithstanding, this study's use of a representative national sample and consistent measures over time contribute significantly to the field's understanding of adolescent SAM use.

SAM use affected a sizable proportion of US high school seniors, and frequently occurred in locations that might affect the safety of both the public and SAM users. SAM use was also closely tied to simultaneous drug use reasons (or expectancies) and perceived substance dependence. Efforts to reduce youth SAM use should include carefully providing accurate and targeted information about the dangers of simultaneous drug use to at-risk populations in the general school environment as well as among treatment populations.

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Contributors

Johnston co-designed the study and wrote the protocol. O'Malley helped conduct the study and assisted with planning and guiding the statistical analysis. Terry-McElrath managed literature searches and summaries of previous work, conducted analyses, and drafted the first version of the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of interest

All authors declare they have no conflicts of interest.

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