Understanding Heterogeneity Among Simultaneous Alcohol and Marijuana Users: Latent Classes Derived From Daily Diary Data

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ABSTRACT. **Objective:** Simultaneous use of alcohol and marijuana (SAM) is common among U.S. college students, but little research has examined specific substance use behaviors during SAM use episodes. This study identified latent classes of SAM users based on their SAM, alcohol-only, and marijuana-only use episodes. **Method:** College student SAM users ($N = 284$; 50.7% female; M age = 19.8 years) completed up to five surveys each day across two 4-week bursts. Latent class analysis (LCA) was used to characterize SAM users based on seven latent class indicators of use behavior. Sex was examined in relation to latent class membership. **Results:** Five unique classes emerged: Frequent Marijuana-Focused SAM users (21%); Frequent Alcohol-Initiating SAM users (29%); Heavy-Drinking Infrequent SAM users (12%); Moderate SAM users (29%); and Light Infrequent SAM users (9%). These groups were differentiated primarily by their frequency of SAM use, form of marijuana, whether marijuana was used on non-SAM occasions, and whether consequences were experienced. Groups differed significantly by sex. **Conclusions:** College student SAM users are heterogeneous with respect not only to their degree of SAM use but also in their pattern of drinking, type of marijuana use, relative focus on alcohol versus marijuana, and risk of experiencing acute negative consequences. Describing this heterogeneity is an important step toward developing interventions for different types of users. (*J. Stud. Alcohol Drugs, 83,* 358–363, 2022)

ALCOHOL AND MARIJUANA are the most commonly used regulated substances among young adults in the United States (Schulenberg et al., 2020). Increasingly, 19- to 22-year-olds report engaging in simultaneous alcohol and marijuana (SAM) use, such that the effects of both substances overlap (Terry-McElrath & Patrick, 2018). Although young adult SAM users report positive effects from combining alcohol and marijuana (i.e., "cross-faded"; Patrick et al., 2020; Patrick & Lee, 2018), SAM use is linked with excessive substance use and related harms, including academic/occupational problems, social–interpersonal issues, and passing out (e.g., Jackson et al., 2020; Linden-Carmichael et al., 2019; Subbaraman & Kerr, 2015; Yurasek et al., 2017).

Research examining SAM-related risk has compared individuals who engage in SAM use over a period (typically past month, past year) with single-substance users (e.g., Subbaraman & Kerr, 2015). These comparisons yield important information for identifying broad subgroups of users at increased risk for harms but ignore heterogeneity among SAM users. To identify subgroups of individuals based on features of their SAM use, several studies have used latent class analysis (LCA; Collins & Lanza, 2010) to characterize underlying patterns of behavior according to features such as frequency and recency of use, typical quantity used, and heavy episodic drinking (HED; Arterberry et al., 2017; Cadigan et al., 2019; Davis et al., 2019; Patrick et al., 2018). One study has used LCA to characterize substance use behaviors among SAM users (Linden-Carmichael & Allen, 2021). Separate models identified latent classes based on patterns of typical alcohol use and marijuana use behaviors. They found considerable heterogeneity among SAM users in both alcohol and marijuana use behaviors but did not explore heterogeneity in SAM use behaviors.

Emerging evidence suggests that the frequency and manner of SAM use can confer risk for negative outcomes among young adults. Daily diary work assessing alcohol and marijuana use patterns over multiple weeks showed that days with reported SAM use (vs. only alcohol or only marijuana) were associated with heavier use (Lee et al., 2020) and more negative consequences (e.g., Linden-Carmichael et al., 2020; Sokolovsky et al., 2020). Further, order of marijuana and alcohol use within a SAM use episode was associated with amount consumed (Gunn et al., 2021). In addition, mixing

multiple marijuana and/or alcohol products increased risk for heavier use and harms (Stevens et al., 2021).

Most research has focused on identifying individuals as "SAM users" or "non–SAM users," ignoring heterogeneity among SAM users. Recent interventions to reduce SAM use have been unsuccessful (Stein et al., 2018); explicating the nuances of SAM use behavior (e.g., intensity, product used, ordering of use) may inform targets for prevention and intervention efforts. We aimed to identify latent classes of young adult SAM users based on detailed information about their behavior across 54 days, considering features of use on days with alcohol-only, marijuana-only, and SAM use. Further, given sex differences in frequency of engaging in SAM use (White et al., 2019), we described latent classes as a function of sex to determine whether interventions based on these latent classes may need to vary by sex.

Method

Participants and procedure

Participants were college students enrolled in a multi-site study of SAM use (see Sokolovsky et al., 2020; White et al., 2019, for recruitment details). Phase 1 (61% response rate) comprised 1,390 full-time college students ages 18–24 indicating past-year alcohol and marijuana use from one of three universities in states with different laws regarding marijuana possession. They completed web-based surveys at two waves, 3 months apart. A subsample with past-month SAM use (Stevens et al., 2020) was invited to participate in Phase 2, which involved five surveys per day across two 4-week bursts following each wave (89% participated). We retained data from 54 study days due to technical difficulties that occurred during the first 2 study days. The present study includes data from 284 participants who reported any SAM days.[1] Mean age was 19.8 years (SD = 1.35); 49.3% were male; 24.6% self-identified as non-White; 8.8% Hispanic/Latinx.

Measures

If any alcohol and/or marijuana was endorsed, participants were presented with a timeline overlaid on a grid with time (in minutes) anchored between the times of the previous and current surveys. Participants were to indicate time of use

(Jackson et al., 2021).[2] Day-level alcohol and marijuana use quantity were indexed as the sum of the number of drinks and marijuana uses across all surveys that day. Day-level SAM use was computed as occurring when at least one drink and one marijuana use were recorded. Temporal ordering was defined as the substance used first each day. Participants indicated the form of marijuana used (i.e., dry leaf, concentrate, edible). Alcohol and marijuana use measures from all surveys within a day were used to construct latent class indicators. Consequences, assessed each morning about the day before, included hangover, nausea/vomiting, hurt self, drove car drunk/high, blackout, rude/aggressive, and unwanted sex.

Seven latent class indicators of SAM-relevant behavior were computed at the person level based on an individual's daily data. Categorical indicators were computed based on interpretation and original variable distributions[3] (Table 1). Maximum estimated blood-alcohol content (eBAC) was coded 2 if students achieved .20% or higher on any day; 1 otherwise.[4] Students who ever used two or more forms of marijuana within a day were coded 2; 1 otherwise. Maximum number of substance use consequences in a given day was coded as 0, 1, or 2+ consequences. Temporal ordering of alcohol and marijuana on SAM days was coded 1 for students who typically initiated with marijuana, 2 for students who initiated equally with either substance, and 3 for those who typically initiated with alcohol. Number of SAM days during the study was coded 1 for 1–2 days and 2 for 3+ days. Those reporting using marijuana on a non-SAM day were coded 2; 1 otherwise. Similarly, those reporting HED (4+/5+ drinks for women/men) on a non-SAM day were coded 2; 1 otherwise.[5]

A covariate indicating participant's sex (1 = *male*, 0 = *female*) was examined in relation to latent class membership.

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[1]We operationalized a SAM day as any self-reported use of alcohol and cannabis, regardless of the timeframe of use within that day. Prior work with this sample (Sokolovsky et al., 2020) found that the cumulative proportion of days with co-use occurring at given intervals were 19.6% within 1 minute, 52.0% within 10 minutes, 78.2% within 2 hours, 86.4% within 3 hours, and 94.1% within 4 hours. It also found that there was little additional risk from using alcohol and cannabis simultaneously versus concurrently, regardless of the timeframe used to differentiate simultaneous versus concurrent use.

[2]If a daily survey was missed, the coverage of the subsequent survey was expanded to include the coverage period of the prior survey. If the subsequent daily survey was also missed, the coverage of the next daily survey would include only the immediate prior survey, not the first missed survey. Thus, only two subsequent missed daily surveys resulted in day-level missing data. See Stevens et al. (2020) for more details on missing data.

[3]Continuous indicators are assumed to be normally distributed within classes; otherwise, over-extraction can occur. Given the severe nonnormality and skew in our variables, categorical indicators were constructed.

[4]Point estimates of BAC after each self-reported drink and assuming instantaneous absorption were computed based on the updated Widmark formula presented in Seidl et al. (2000). U.S. mean heights for men and women were used. Maximum daily eBAC was used to create a binary variable indicating participants exceeded .20% on any day to help identify subgroups characterized by extreme use. Adjusting the threshold to .16% based on NIAAA's definition of severe impairment (https://www.niaaa.nih.gov/publications/brochures-and-fact-sheets/understanding-dangers-of-alcohol-overdose) did not alter findings in any substantial way.

[5]Any alcohol use on non-SAM days was extremely common; thus, we focused on HED (which occurred on non-SAM days for 68.3% of participants) to better discriminate latent classes.

TABLE 1. Five latent classes of college student simultaneous alcohol and marijuana (SAM) users

Latent class indicator	Overall proportion	SAM user latent class				
		Frequent Marijuana-Focused SAM (21%)	Frequent Alcohol-Initiating SAM (29%)	Heavy-Drinking Infrequent SAM (12%)	Moderate SAM (29%)	Light Infrequent SAM (9%)
eBAC ≥.20% on ≥1 days						
No	.465	.284	.131	.073	**.985**	**.827**
Yes	.535	**.716**	**.869**	**.927**	.015	.173
Multiple forms of marijuana						
No	.472	.045	.364	**.995**	**.501**	**.994**
Yes	.528	**.955**	**.636**	.005	.499	.006
Max. number of consequences						
0	.166	.120	.001	.174	.165	**.774**
1	.377	.293	.324	.195	**.623**	.210
2 or more	.458	**.587**	**.675**	**.631**	.213	.016
Most likely ordering						
Marijuana first	.345	**.784**	.160	.004	.361	.346
Either substance	.106	.048	.076	.178	.141	.125
Alcohol first	.549	.168	**.764**	**.819**	.498	**.530**
Frequency of SAM use						
1–2 times	.306	.003	.056	**.817**	.402	**.817**
3 or more times	.694	**.997**	**.944**	.183	**.598**	.183
Marijuana on non-SAM days						
No	.109	.000	.000	.493	.000	**.534**
Yes	.891	**1.000**	**1.000**	**.507**	**1.000**	.466
HED on non-SAM days						
No	.317	**.763**	.005	.003	.444	.327
Yes	.683	.237	**.995**	**.997**	**.556**	**.673**
Covariate:						
% male[a]	49.3%	62.7%	38.0%	25.6%	62.6%	44.8%

Notes: Item-response probabilities >.5 in **bold** to facilitate interpretation. eBAC = estimated blood-alcohol content; max. = maximum; HED = heavy episodic drinking. [a]Significant class differences between Classes 1 & 2, Classes 1 & 3, Classes 2 & 4, and Classes 3 & 4 (overall Wald statistic = 14.72, 4 *df*, *p* = .005).

Analytic strategy

Latent classes were identified using seven indicators of specific behaviors. Models with different numbers of classes were compared in terms of information criteria and interpretation. Model identification was assessed using 1,000 random starting value sets, and the covariate was examined using the BCH approach[6] (Bolck et al., 2004). All models were fit using SAS PROC LCA (Lanza et al., 2013).

Results

About half of students who engaged in SAM use on at least one study day (53.5%) achieved an eBAC of .20% or higher on one or more study days, and about half (52.8%) used multiple forms of marijuana on the same day (Table 1

and Supplemental Figure 1). (Supplemental material appears as an online-only addendum to this article on the journal's website.) Nearly half (45.8%) experienced 2+ same-day consequences of substance use. More typically initiated SAM days with alcohol (54.9%) than marijuana (34.5%); 10.6% showed no typical order. SAM use was frequent: 69.4% engaged in SAM use on 3+ study days. Nearly all (89.1%) used marijuana, and 68.3% engaged in HED on at least one non-SAM day.

Models with 1 through 6 classes were well identified; information criteria and interpretability of the classes suggested a five-class model as optimal. Table 1 shows the percentage of students in each class and the corresponding item-response probabilities, which are used to define and label the classes.

Five-class model of SAM users

The Frequent Marijuana-Focused SAM class (21%) was characterized by high eBAC (≥.20%) during the study and reported multiple forms of marijuana within a day, 2+ same-day consequences, marijuana on non-SAM days, and SAM

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[6]A flexible approach to a regression-based outcome analysis involving a latent class variable is a 3-step approach proposed by Bolck et al. (2004; "BCH approach"): fit a latent class model with no covariates, retain specially designed weights, and estimate the outcome model treating latent class membership as observed, adjusting with the weights.

use on 3+ days. This is the only class likely to begin a SAM day with marijuana. They were unlikely to drink heavily on non-SAM days but did drink heavily on SAM days.

The Frequent Alcohol-Initiating SAM class (29%) was similar: They had high eBAC, used multiple forms of marijuana, reported multiple same-day consequences, engaged in frequent SAM use, and used marijuana on non-SAM days. However, they typically began a SAM day with alcohol and drank heavily on non-SAM days.

The Heavy-Drinking Infrequent SAM class (12%) had a high eBAC and reported multiple same-day consequences, initiating SAM episodes with alcohol, and heavy drinking on non-SAM days; they likely engaged in SAM use 1–2 times.

The Moderate SAM class (29%) was equally likely to use single or multiple forms of marijuana within a day. They reported at most one same-day consequence and marijuana use on non-SAM days and were likely to use alcohol on non-SAM days, but not have a high eBAC.

The Light Infrequent SAM class (9%) typically reported 1–2 SAM days and no consequences of use.

Sex was significantly associated with types of SAM use (Wald statistic = 14.72, $df = 4$, $p = .005$). Men were more likely to be in the Frequent Marijuana-Focused and Moderate SAM classes, compared with the Frequent Alcohol-Initiating SAM and the Heavy-Drinking Infrequent SAM classes (Table 1).

Discussion

This study expands prior work characterizing SAM users on heaviness of use (Jackson et al., 2020) and typical alcohol or marijuana use patterns (Linden-Carmichael & Allen, 2021). By deriving individual characteristics from intensive assessment of alcohol and marijuana use on SAM and non-SAM days, we captured nuanced information about SAM users, such as frequency and heaviness of use, form of marijuana use, consequences, and ordering of use.

Four classes were clearly distinguished by frequency of SAM use: two frequent and two infrequent classes (with Moderate SAM class in between). In addition, form of marijuana, marijuana use on non-SAM days, and consequences experienced also differentiated classes. Neither temporal ordering nor HED on non-SAM days separated classes, except the two classes characterized by frequent SAM use, using multiple forms of marijuana, using marijuana on non-SAM occasions, and high eBAC. These two frequent SAM classes were separated by ordering and HED on non-SAM occasions, with one class more marijuana-focused (marijuana used first on SAM days, alcohol used less frequently on non-SAM days) and more likely to contain men and the other class more alcohol-focused (alcohol used first, alcohol consumed on non-SAM days) and primarily comprising women.

Two infrequent SAM classes were differentiated primarily by alcohol use. The Heavy-Drinking Infrequent SAM class tended to attain an eBAC of .20% or greater, experience 2+ same-day consequences, and initiate episodes with alcohol; the Light Infrequent SAM class was unlikely to attain a high eBAC or experience consequences. These classes comprised heavy- and light-drinking students, respectively, who likely experiment with one form of marijuana. The Moderate SAM class was differentiated from the Light Infrequent SAM class by their tendency to report one consequence, moderate frequency of SAM use, and marijuana use on non-SAM days. Among these infrequent/moderate SAM classes, women comprised the majority of the Heavy-Drinking Infrequent class (~75% female) and were least likely to be in the Moderate SAM class (<40%).

Half of this sample evinced an alarming pattern of heavy drinking with frequent SAM use. This was true both on SAM days and alcohol-only days, suggesting the need to address SAM use in college student drinking interventions (Cole et al., 2018). These higher-risk SAM users were likely to use multiple forms of marijuana in a day and experience multiple consequences; this may inform a harm-reduction strategy. About 20% of the sample were infrequent or experimental SAM users—perhaps drinkers who "dabble" in SAM use and may use marijuana on non-SAM days. For them, programs targeting contexts conducive to opportunistic use might be effective.

Several limitations merit mention. Our findings may not generalize beyond college students, although students comprise a large portion of young adult SAM users (Patrick et al., 2019). The majority of study participants were White, limiting generalizability to non-White students. The Moderate SAM class is large and somewhat nondescript; a longitudinal study may elucidate transitions to more problematic patterns. We defined SAM use as any day with self-reported use of alcohol and marijuana, given that the substances tended to be used relatively close in time; future research that provides greater detail on features of a use episode would be informative. Finally, person-level aggregation of intensive assessments may obscure differences in missing data. A sensitivity analysis removing 26 individuals without complete data on at least one SAM day revealed slightly higher prevalence of marijuana-related behaviors, suggesting that our estimates may be conservative, although the latent class structure was identical.

College student SAM users are heterogeneous, differing in their degree of SAM use, pattern of drinking, type of marijuana use, focus on alcohol versus marijuana, and risk of acute negative consequences. Describing heterogeneity among college students engaging in SAM use in daily life is important for developing new or modifying existing interventions tailored to be relevant and effective for different types of users. Distinguishing between "alcohol-focused" versus "marijuana-focused" SAM users would help explicate the etiology and consequences of SAM use and inform inter-

vention content. Given this study's findings, alcohol-oriented content may be particularly important to address SAM use among women, whereas marijuana-oriented content may be more important for addressing SAM use among men. Future work to reduce harms associated with SAM use in real time and context could identify proximal predictors of the higher-risk SAM use patterns identified herein.

Acknowledgment

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