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A latent class analysis of poly-marijuana use among young adults

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Abstract

Introduction: With more states legalizing marijuana use, the marijuana industry has grown, introducing a variety of marijuana products. Our study explores the use of multiple marijuana products (poly-marijuana use) and the characteristics associated with this behavior.

Methods: Past-month marijuana users aged 18-34 years were surveyed online via an existing online panel (n=2,444). Participants answered questions about past-month use of three types of marijuana (plant-based, concentrates, edibles), marijuana use patterns, and driving after use. Latent class analysis was used to identify subgroups of marijuana users.

Results: Four classes of marijuana users were identified: Light plant users, who used only plant-based products infrequently and were unlikely to drive after use (32%); Heavy plant users, who used mainly plant-based products frequently, multiple times per day, and were likely to drive after use (37%); Plant and concentrates users, who used plant-based products heavily and concentrates at least infrequently, used multiple times per day, and were likely to drive after use (20%); Light plant and edibles users, who used both products infrequently and were unlikely to drive after use (10%). Those in legal marijuana states were more likely to belong to the poly-marijuana groups.

Discussion: Our findings reflect the increase in popularity of new marijuana products in legal states and suggest that heavy user groups, including concentrates users, are associated with driving after use. As various forms of marijuana use increases, monitoring and surveillance of the use of multiple types of marijuana will be important for determining potential varying impacts on physiological and social consequences.

Keywords: marijuana; substance use; marijuana legalization; drugged driving

1. Introduction

Social perception of marijuana has become more lenient in the United States in the past decade. As of the 2016 election, 28 states had passed laws legalizing medicinal use, and eight states had passed measures legalizing recreational use (NORML, 2017; Procon.org, 2016). These more lenient policies reflect the general public's perception that marijuana use is not harmful (Johnston et al., 2014). In fact, over half of Americans (52%) now favor legalizing marijuana for recreational use (Pew Research Center, 2013).

As policies have evolved, the marijuana consumer market has grown along with the availability and demand for a variety of marijuana products. Traditional, plant-based products (dried and crushed marijuana flowers) are usually smoked (Schauer et al., 2016), and average around 13% THC (tetrahydrocannabinol; the main psychoactive component of marijuana) (US Department of Justice Drug Enforcement Administration [DEA], 2014). Novel, highly concentrated forms of marijuana, sometimes containing up to 70-90% THC, have been growing in popularity (Colorado Department of Revenue, 2014; Marijuana Business Daily, 2016). Marijuana concentrates (hereafter concentrates) are a processed form of marijuana whereby solvents (e.g., butane) are passed through the dried marijuana plant. The resulting oils or wax substances are then vaporized and inhaled (Schauer, et al., 2016). Because of the high THC concentrations, concentrates users are more likely to experience intense effects following use (e.g., loss of consciousness) (Stogner & Miller, 2015). Edibles, or marijuana infused in food, have also surged in use (Colorado Department of Revenue, 2014; Marijuana Business Daily, 2016) and have a delayed onset and longer duration of effects compared to smoked marijuana (Williams, 2016). Epidemiological surveys of substance use do not yet ask young adults about use of multiple forms of marijuana, and surveillance of these behaviors is timely.

While combustible plant-based marijuana is the most commonly ingested form (Oregon Public Health Division, 2016; Schauer, et al., 2016), frequent users are more likely to use more than one form of marijuana (i.e. poly-marijuana user) (Oregon Public Health Division, 2016). As the public experiments with multiple marijuana forms, there is a need for additional research examining the characteristics of different types of users. As such, in the present study, we take the first step towards delineating marijuana user profiles in the context of poly-marijuana use, employing latent class analysis to describe subgroups of marijuana users based on types of marijuana used and associated risky behaviors.

We examine young adult marijuana users across the U.S. to examine whether residence in a legal marijuana state is associated with specific marijuana use subgroups. Given that the legal marijuana industry is one the fastest growing industries in the U.S. and emerging evidence suggesting an influx of novel marijuana products (ArcView Market Research, 2017), we use the availability proneness theory of drug abuse to guide our study. The availability proneness theory stresses the relationship between increased accessibility and likelihood for substance use among prone individuals (Smart, 1980). We hypothesize that poly-marijuana users will be more likely to live in legal marijuana states given the increase in accessibility of these products (ArcView Market Research, 2017; Borodovsky et al., 2016; Lamy et al., 2016; National Institute on Drug Abuse, 2016; Zhang et al., 2016). We also hypothesize that a cluster of our participants will be prone to problematic behaviors such as driving after use, heavy use, and/or poly-marijuana use. In consideration that the risk of a vehicle crash increases progressively with the dose and frequency of marijuana use (Li et al., 2013; Li et al., 2012), our study that considers driving following use across different types of marijuana users represents a novel and timely area of study.

2. Methods

2.1. Participants

An online survey was conducted with members of SurveyMonkey® Audience, a proprietary panel of participants recruited from over 30 million people who complete SurveyMonkey surveys. SurveyMonkey asks people who complete a survey whether they would like to be a member of the online panel. Panel participants are offered donations to a charity or entry in sweepstakes in exchange for surveys taken. Detailed background information is stored in a profile for each Audience member. SurveyMonkey maintains high quality responses by limiting the number of surveys that can be taken per week and using incentives that are not based on monetary rewards. SurveyMonkey also runs panel benchmarking surveys to ensure that the demographic characteristics are similar to that of the U.S. population.

The survey was conducted in June-September of 2015. For the present study, participants were 18-34 years old, lived in the United States, and reported using marijuana in the past month. Marijuana use is not part of an Audience member's profile; thus, SurveyMonkey targeted our age group of U.S. residents with an invitation to the survey, both by email invitation and by "routing" people who visit their website to take a survey for which they qualify. Eligibility items were used to ensure the respondent was in the age group of interest and met marijuana use criteria. We restricted our study to past month marijuana users to focus on current marijuana use behaviors (in the past 30 days) among non-sporadic users. Each participant provided informed consent online, and the Washington University Institutional Review Board reviewed and approved this study.

Because SurveyMonkey Audience is not nationally representative, we applied weights to our survey data so that marginal totals of our survey matched that of past-month marijuana users

in the 2014 National Survey on Drug Use and Health (NSDUH) on age, gender, and race/ethnicity. The NSDUH, sponsored by the Substance Abuse and Mental Health Services Administration, is conducted annually in the U.S. and provides national data on substance use and mental health (United States Department of Health and Human Services et al., 2014).

Weights were applied using a raking technique with the SAS rake and trim macro (AbtAssociates, n.d.). The weights were then normalized so that the sum of the weights equaled the sample size of our survey data ($n=2,444$).

2.2. Marijuana use behaviors (used as latent class indicators)

In addition to traditional plant/flower-based marijuana, we assessed use of two increasingly popular forms of marijuana: edibles and concentrates (Loflin & Earleywine, 2014, Schauer et al., 2016). The survey queried past-month use of these three types of marijuana with the following three parallel questions: “How many days did you _____ in the past 30 days?”: a) “smoke marijuana in its plant or bud form”, b) “dab marijuana concentrates/extracts” (concentrates were defined as including shatter, wax, oil, and any other THC-concentrated form of marijuana), and c) “consume marijuana edibles.” Responses included 0 days, 1-2 days, 3-5 days, 6-9 days, 10-19 days, 20-29 days, and 30 days. Responses were recoded into no use (0 days) and relatively equal frequency categories of use (1-9 days, 10-19 days, and 20-30 days).

To identify what may be considered ‘problematic’ or ‘risky’ marijuana use behaviors, we assessed whether participants normally used marijuana multiple times per day with the item “On a typical day when you use marijuana, how many times a day do you use (i.e., number of sessions)?”. We dichotomized responses to reflect those who used multiple times (i.e., at least twice) per day versus those who only used once per day. We also used an item modified from the Cannabis Use Disorders Identification Test (CUDIT) (Adamon & Sellman, 2003) inquiring

“How often are you “high” for 6 or more hours?” Response options were dichotomized to contrast those who were “high” for 6 or more hours at least once a month versus those who were not. Finally, we also assessed the risky behavior of driving after marijuana use with an item from Monitoring the Future: “During the last two weeks, how many times have you driven a car, truck or motorcycle after smoking marijuana?” (Johnston et al., 2015). Responses were dichotomized to represent any engagement in this behavior versus not at all in the last two weeks.

2.3. Potential predictors of marijuana use classes

Guided by the availability proneness theory of drug abuse (Smart, 1980) we believed that those living in legal marijuana states would be more likely to use multiple product types. Legal status of marijuana at the time of the survey was coded based on the participant’s state of residence. Prior research indicates that medical users tend to use more frequently (Roy-Byrne et al., 2015; Woodruff & Shillington, 2016), and being a medical patient may increase access to a variety of marijuana products. Therefore, we inquired whether participants had a medical marijuana card or doctor’s prescription.

Important demographic variables known to be associated with marijuana use (Arria et al., 2012; Brook et al., 2013; Compton et al., 2004; Center for Behavioral Health Statistics and Quality, 2015; Fergusson & Boden, 2008; Johnston et al., 2014) including gender, age, race, education (i.e., highest level of school completed), and employment status, were also assessed in the survey or provided by SurveyMonkey as part of the participant’s Audience Profile (i.e., gender).

2.4. Statistical analysis

We used SAS PROC LCA to perform a latent class analysis (LCA) to examine the underlying subgroups, or classes, of marijuana users in our sample (Lanza, Collins, Lemon, & Schafer, 2007). Our latent class model was derived from the six indicators of type and frequency of marijuana use and risky marijuana behaviors described above. The LCA model provides two parameters: 1) latent class membership probabilities, or the proportion of the sample that belong to each class of marijuana users, and 2) item response probabilities conditional on class membership, which are the probabilities of endorsing a marijuana behavior given membership in a specific class.

We first fit a baseline model including the six indicators of marijuana-related behaviors, but did not include any covariates (Lanza, Collins, Lemon, & Schafer, 2007). We ran a series of successive models with one class (which assumes that marijuana use behaviors were the same for all participants) to 6 latent classes to identify an optimal model that was parsimonious and had good fit to the data and model interpretability. Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) were used to compare the fit of successive models. The 4-class model had the lowest BIC, and the drop in AIC for successive models was much less substantial after 4 classes. The 4-class model also appeared to have distinguishable classes that were not trivial in size; thus we present the 4-class LCA model.

After selecting the 4-class model, we included covariates to predict probability of class membership. We used multinomial logistic regression, within the PROC LCA procedure, with latent class membership as the dependent variable. We first added each covariate separately to examine bivariable associations. Then all covariates were included in the model simultaneously. Due to small categories of responses for some covariates, response categories were collapsed to obtain stable parameter estimates (i.e., race, age, employment status). Descriptive analyses were

conducted using survey procedures in SAS version 9.4 for Windows (SAS Institute, Cary, NC).

Survey weights were applied in all analyses.

3. Results

3.1. Participant characteristics

Demographic characteristics of the marijuana users in our sample are shown in Table 1. Nearly 2/3 were male and White, and 31% were 18-21 years old, 27% were 22-25 years old, and 41% were 26-34 years old. Over 1/4 (28%) earned a Bachelor's degree or higher, and nearly 3/4 were employed. Over half lived in a state where either medical and/or recreational use was legal, and 9% reported having a medical card or prescription.

Table 1. Demographic characteristics of marijuana users (Total weighted N=2,444 unless otherwise noted)

Variable	Unweighted n	Weighted n (%)
Gender ^a		
Male	1239	1513 (62)
Female	1205	931 (38)
Age ^a		
18-19 years	179	368 (15)
20-21 years	325	402 (16)
22-23 years	313	377 (15)
24-25 years	369	301 (12)
26-29 years	593	503 (21)
30-34 years	665	494 (20)
Race ^a		
White	1686	1538 (63)
Black	151	391 (16)
Hispanic	346	357 (15)
Other	261	158 (6)
Education (n=2443)		
< Bachelor's degree	1594	1761 (72)
≥ Bachelor's degree	849	682 (28)
Employment (n=2414)		
Employed	1810	1733 (72)
Unemployed	197	226 (9)
Other (e.g., student, homemaker)	408	455 (19)
Region of country (n=2407)		
Northeast	434	440 (18)
Midwest	487	489 (20)
South	659	690 (29)
West	828	787 (33)
Legal status of marijuana in state (n=2407)		
Both recreational and medical use are legal	313	297 (12)
Only medical use is legal	1082	1082 (45)
Use is not legal	1013	1027 (43)
Medical marijuana patient (i.e., has medical card or prescription)	231	227 (9)

^a Weights were applied to match age, gender, and race/ethnicity distributions of past-month marijuana users from the 2014 National Survey on Drug Use and Health (NSDUH): 38% female, 62% male; 15% 18-19 years, 16% 20-21 years, 15% 22-23 years, 12% 24-25 years, 21% 26-29 years, 20% 30-34 years; 63% White, 16% Black, 15% Hispanic, 6% other race.

3.2. Marijuana use behaviors

The prevalence of specific marijuana-related behaviors are shown in Table 2. Almost all participants (96%) had used plant-based marijuana in the past month and 48% reported using this form of marijuana between 1 and 9 days, while 34% reported using nearly every day (20-30 days). About 30% of the sample reported using marijuana edibles in the past month; 27% reported using 1-9 days and very few reported more frequent use. Similarly, about 30% of participants reported using marijuana concentrates in the past month; 24% reported using concentrates 1-9 days. The majority reported using marijuana multiple times per day (59%) and nearly as many reported being “high” for ≥ 6 hours at least once per month (54%). Over a third (39%) reported driving after using marijuana in the past two weeks.

Table 2. Prevalence of marijuana use behaviors (weighted n = 2,444 unless otherwise noted)

Marijuana use behaviors	Unweighted n	Weighted n (%)
Frequency used plant-based marijuana in past 30 days (n=2441)		
0 days	106	92 (4)
1-9 days	1173	1183 (48)
10-19 days	324	338 (14)
20-30 days	837	828 (34)
Frequency used marijuana edibles in past 30 days (n=2388)		
0 days	1691	1669 (70)
1-9 days	628	633 (27)
10-19 days	30	7 (1)
20-30 days	47	7 (2)
Frequency used marijuana concentrates/extracts in past 30 days (n=2386)		
0 days	1691	1652 (69)
1-9 days	531	564 (24)
10-19 days	60	65 (3)
20-30 days	107	105 (4)
Use marijuana more than once on a typical day when using (n=2437)	1371	1446 (59)
“High” for 6 or more hours at least once per month (n=2440)	1231	1313 (54)
Drove after using marijuana in the past two weeks (n=2439)	914	951 (39)

3.3. Latent class model

The 4-class LCA model parameters, including class membership probabilities and item response probabilities, are presented in Table 3. In addition, a visual depiction of the 4 distinct classes is shown in Figure 1. The “light plant” user class (32%) was characterized by infrequent plant-based marijuana use (1-9 days), low likelihood for using other types of marijuana and low likelihood of using several times per day, being high for a long period of time, or driving after use. The “heavy plant” user class (37%) was characterized by using plant-based products much more frequently (10-19 or 20-30 days), a low likelihood of using other products, and a high

likelihood of using multiple times per day, spending more time high, and driving after use. The remaining two groups were poly-marijuana groups. The “plant and concentrates” user class (20%) was likely to use plant-based products frequently and to also use concentrates at least infrequently (1-9 days). This group also had a medium likelihood of using edibles 1-9 days/month. In addition, this group had a high likelihood of using multiple times per day, being high for long periods of time, and driving after use. The “light plant and edibles” user class (10%) tended to use edibles and plant-based marijuana infrequently (1-9 days). This group had a low likelihood of using multiple times per day, being high for a long period of time, or driving following their use.

Table 3. Item response probabilities for a four class model of marijuana use

	Light plant-based product users	Heavy plant-based product users	Plant-based product and concentrates users	Light plant-based products and edibles users
<i>Class membership probabilities γ (se)</i>	0.323 (0.019)	0.373 (0.040)	0.202 (0.039)	0.102 (0.010)
<i>Item response probabilities ρ (se)</i>				
Frequency used plant-based marijuana in past 30 days				
1-9 days	0.885 (0.020)	0.249 (0.032)	0.210 (0.034)	0.625 (0.039)
10-19 days	0.081 (0.016)	0.191 (0.021)	0.170 (0.028)	0.064 (0.021)
20-30 days	0.034 (0.011)	0.561 (0.035)	0.567 (0.039)	0.041 (0.020)
Frequency used marijuana edibles in past 30 days				
1-9 days	0.003 (0.004)	0.233 (0.022)	0.452 (0.038)	0.839 (0.048)
10-19 days	0.000 (0.000)	0.008 (0.004)	0.046 (0.013)	0.020 (0.011)
20-30 days	0.001 (0.004)	0.014 (0.006)	0.072 (0.023)	0.013 (0.012)
Frequency used marijuana concentrates in past 30 days				
1-9 days	0.082 (0.014)	0.119 (0.084)	0.677 (0.061)	0.277 (0.041)
10-19 days	0.000 (0.000)	0.015 (0.020)	0.107 (0.037)	0.000 (0.000)
20-30 days	0.005 (0.003)	0.000 (0.000)	0.209 (0.046)	0.000 (0.001)
Used marijuana more than once on a typical day when using	0.208 (0.029)	0.887 (0.024)	0.918 (0.021)	0.099 (0.031)
“High” for 6 or more hours at least once per month	0.182 (0.026)	0.773 (0.025)	0.837 (0.023)	0.212 (0.039)
Drove after using marijuana in the past two weeks	0.150 (0.019)	0.520 (0.028)	0.656 (0.031)	0.144 (0.037)

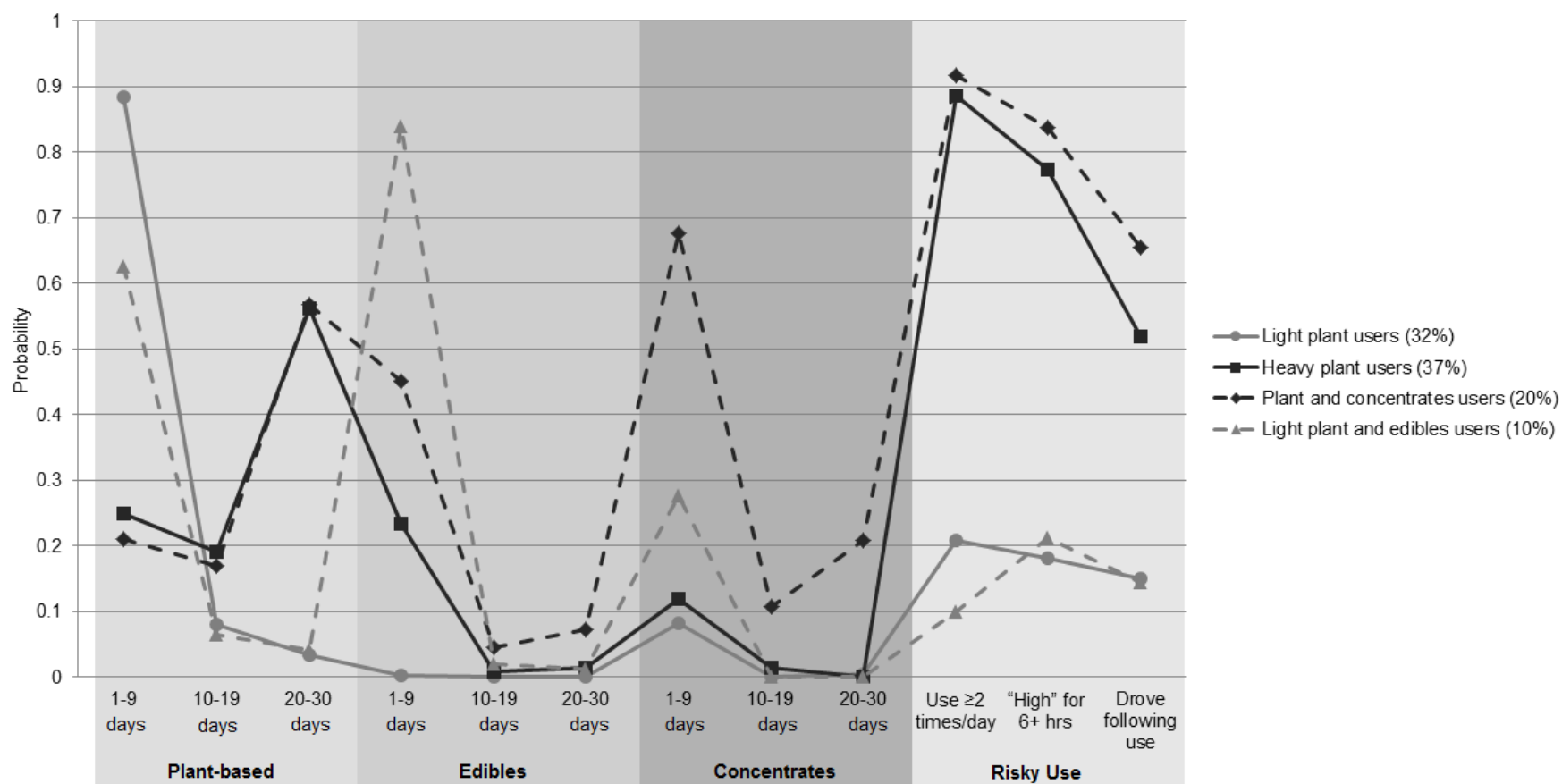


Figure 1. Item response probabilities for four-class latent class model of marijuana use

Table 4 includes both unadjusted and adjusted odds ratios from the multinomial logistic regression analysis to identify characteristics associated with membership in classes, with the “Light plant” group treated as the reference group. In the model adjusting for all covariates, medical patients were more likely to be in the “Heavy plant” and “Plant and concentrates” user classes compared to the “Light plant” user class. Those living in a state with legal recreational use were more likely to belong to the “Plant and concentrates” and “Light plant and edibles” user classes. Those living in a state with legal medical use were more likely to belong to the “Light plant and edibles” user class. Males and those of nonwhite race were more likely to belong to the “Heavy plant” or “Plant and concentrates” user classes. Older participants were more likely to belong to the “Heavy plant” user class. Participants that were not employed were less likely to belong to the “Plant and concentrates” user class. Finally, when compared to the “Light plant” class, those with a Bachelor’s degree were more likely to belong to the “Light plant and edibles” user class but less likely to be in the “Heavy plant” or “Plant and concentrates” user classes.

Table 4. Multinomial latent class logistic regression models, unadjusted and adjusted results

	Heavy plant-based users vs Light plant-based users		Plant-based and concentrates users vs Light plant-based users		Light plant-based and edibles users vs Light plant-based users	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Medical patient						
No medical card/prescription	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Medical card/prescription	2.98 (1.63, 5.45)	2.73 (1.84, 4.06)	13.02 (6.23, 27.18)	8.82 (5.49, 14.16)	2.11 (0.90, 4.91)	1.64 (0.95, 2.84)
Legal status of marijuana						
Use is not legal	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Only medical use is legal	0.80 (0.59, 1.07)	0.86 (0.64, 1.14)	1.02 (0.72, 1.44)	0.81 (0.57, 1.16)	1.66 (1.07, 2.56)	1.53 (1.03, 2.29)
Recreational use is legal	0.69 (0.42, 1.12)	0.88 (0.58, 1.32)	1.94 (1.14, 3.31)	1.85 (1.19, 2.86)	3.29 (1.88, 5.77)	3.19 (1.97, 5.15)
Gender						
Female	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Male	2.07 (1.55, 2.75)	1.75 (1.35, 2.28)	2.88 (2.10, 3.94)	2.29 (1.69, 3.09)	0.92 (0.63, 1.36)	1.00 (0.70, 1.42)
Age						
18 to 20 years	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
21 to 25 years	1.51 (0.98, 2.31)	1.87 (1.26, 2.79)	1.15 (0.76, 1.74)	1.42 (0.92, 2.20)	1.16 (0.64, 2.12)	0.84 (0.49, 1.44)
26 to 34 years	1.69 (1.10, 2.59)	2.42 (1.63, 3.60)	1.04 (0.70, 1.55)	1.48 (0.97, 2.26)	1.74 (0.97, 3.12)	1.12 (0.66, 1.90)
Race/ethnicity						
White	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Not White	1.72 (1.27, 2.34)	1.48 (1.12, 1.96)	1.75 (1.25, 2.45)	1.60 (1.14, 2.24)	0.94 (0.58, 1.51)	1.01 (0.67, 1.54)
Employment						
Employed	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Unemployed/Other	0.90 (0.65, 1.25)	0.86 (0.65, 1.15)	0.62 (0.38, 0.996)	0.57 (0.40, 0.82)	0.79 (0.51, 1.24)	0.97 (0.67, 1.40)
Education						
< Bachelor's degree	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
≥ Bachelor's degree	0.42 (0.31, 0.56)	0.36 (0.27, 0.48)	0.45 (0.32, 0.63)	0.41 (0.29, 0.58)	2.18 (1.41, 3.37)	1.90 (1.32, 2.72)

4. Discussion

Although marijuana user profiles have been previously studied using latent class analysis (Chung, Flaherty, & Schafer, 2006; Grant et al., 2006; Pearson et al., 2016; Taylor et al., 2017), our study is the first to consider novel forms of marijuana that are increasingly becoming more popular. We found four distinguishable classes among our sample of young adult marijuana users. While the largest groups included light and heavy plant-based users, two classes with high likelihood of poly-marijuana use emerged highlighting a group that uses plant-based products rather frequently and to also use concentrates, and another group characterized by less frequent use of plant-based products and edibles. The plant and concentrates group was similar to the heavy plant user group as use was heavy and they were likely to drive after use. Conversely, the light plant and edibles users were more like light plant users where use was not heavy and they were unlikely to drive after use.

Participants characterized by poly-marijuana use were more likely to live in states where use was legal, which lends support to our hypothesis that increased use of novel marijuana products will occur more frequently among residents in legal marijuana states. The availability proneness theory associates increased substance use with greater accessibility, and our findings likewise indicate greater use of novel marijuana forms in areas of greater availability (e.g., via dispensaries in legal states). Our findings corroborate those of Borodovsky et al. (2016) who similarly found that marijuana users in medical marijuana states were more likely to try novel marijuana forms via vaping or eating. Furthermore, the class of participants that used both plant products and concentrates used heavily, specifically using marijuana frequently, multiple times per day, and spending more time high. The behaviors of this group were similar to the group characterized by heavy plant-based marijuana use. These findings point toward an association

between poly-marijuana use and heavier marijuana use, which has also been reported among marijuana users in Oregon (Oregon Public Health Division, 2016). Medical patients were also much more likely to be in this group, and research shows that medical users tend to use more frequently (Roy-Byrne et al., 2015; Woodruff & Shillington, 2016). As one uses marijuana regularly, their tolerance may increase and/or they might become curious causing them to seek other modes of ingestion, especially in states where use is legal and access is easier due to the array of products available at dispensaries. Chronic or heavy marijuana use in its traditional form can lead to addiction, cognitive impairment, and poor educational or social achievements (Volkow et al., 2014). Yet, there is no scientific evidence that delineates how high potency marijuana products impact these consequences. It has been suggested that high potency product use could result in greater likelihood of psychosis or addiction (Loflin and Earleywine, 2014; Pierre et al., 2016). To elucidate whether different forms and ingestion modes of marijuana have varying health or social consequences for users, it will be important for surveillance systems and longitudinal studies to measure marijuana use in this level of detail.

Both the “heavy plant” user group and “plant and concentrates” user group had a higher likelihood of driving after use than the “light plant” or “light plant and edibles” user groups. Marijuana use, in general, impairs one’s ability to drive safely by affecting specific psychomotor abilities and cognitive functions in a dose-dependent manner (Bondallaz et al., 2016). Our findings that driving after using marijuana clustered among heavy users, including those using concentrates, emphasize the need to extend science towards differentiating the potentially varying effects that use of various marijuana forms has on driving abilities. This is especially concerning in light of preliminary research suggesting a heightened intoxication level that can follow concentrated marijuana use (Pierre, 2017). Importantly, our findings support our

hypothesis that a subgroup of participants are more prone to driving after use plus spend more time high, use more frequently and/or across multiple forms. The clustering of these behaviors could be due to one's proneness to engage in risk-taking behaviors more generally as is suggested by the availability proneness theory. Irrespective of the cause, it is worth noting that several studies have found that impaired psychomotor function may be less problematic among heavier, regular users of marijuana who drive while intoxicated versus those who use marijuana less frequently (Ramaekers, Kauert, Theunissen, Toennes, & Moeller, 2008; Desrosiers, Ramaekers, Chauchard, Gorelick, & Huestis, 2015; Ramaekers et al., 2016).

Males and those of a minority race were more likely to be among the heavy user groups (either plant-based products or also used concentrates), were high for long periods of time, and tended to drive after use. Recent epidemiologic studies on racial differences in marijuana use have documented pronounced increases in rates of marijuana use and marijuana use disorders among the Black population (Hasin et al., 2015; Johnson et al., 2015; Lanza et al., 2015). Disparities in rates of marijuana use, including heavy or poly-marijuana use, are concerning given the documented negative social consequences experienced among Black adolescent heavy marijuana users that persist into adulthood (Brook et al., 2011; Green et al., 2016a; Green et al., 2016b; Green and Ensminger, 2006; White et al., 2015).

Our study should be interpreted in light of some limitations. Causal associations cannot be inferred from our cross-sectional survey. It is possible that respondents were not truthful in self reporting their substance use behaviors. Participants were not representative of marijuana users across the country; however, we minimized this bias by using post-stratification weights. Our participants were young adults and results cannot be generalized to different age groups. However, the targeted age group is known to have the highest rates of marijuana use (Center for

Behavioral Health Statistics and Quality, 2016). Finally, we queried about driving after “smoking” marijuana in the past two weeks, rather than after “using” marijuana, which could have resulted in underestimation of this behavior.

4.1. Conclusions

Our study contributes novel information about marijuana user profiles, including poly-marijuana use, among young adults during a time in history when different forms of marijuana are becoming more accessible. Although subgroups that solely used marijuana in its traditional, plant-based form were most prevalent among our participants, using other more potent forms of marijuana in addition to traditional plant-based marijuana was common. Groups who used plant-based products frequently or who also used concentrates tended to engage in heavier use and to drive after use. As more states legalize marijuana use and more dispensaries open, poly-marijuana use could become more prevalent among marijuana users. Due to differing THC levels and modes of administration, monitoring and surveillance of the use of multiple types of marijuana will be important for determining potential varying impacts on physiological and social consequences.

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Contributors

Mrs. Krauss led the acquisition of the data, analyses, interpretation of results and manuscript writing. Ms. Rajbhandari and Ms. Sowles participated in data analysis, interpretation of results, and drafting of the manuscript. Dr. Spitznagel oversaw the data analysis and contributed to the interpretation of results. Dr. Cavazos-Rehg contributed to interpretation of results and critical revisions to the manuscript and provided mentoring on all aspects of the project. All authors have reviewed and approved the final manuscript.

Conflict of Interest

The authors report no conflicts of interest.

Highlights

- Alternative marijuana products (concentrates, edibles) have seen a surge in use.
- Latent class analysis of past month marijuana users based on use patterns and driving after use.
- Four distinguishable classes of marijuana users were found.
- Class that used plant-based marijuana plus concentrates tended to use heavily and drive after use.
- Poly-marijuana user groups were associated with residence in legalized states