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Comparison of the locations where young adults smoke, vape, and eat/drink cannabis: Implications for harm reduction

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ABSTRACT

Background: Cannabis vaping and edible use are increasingly popular methods of cannabis use. These discreet methods could increase risk of cannabis-related problems by facilitating cannabis use in a wider range of settings.

Methods: A sample of 1018 college students were recruited to complete a survey about their health and behavior. Participants who used cannabis in the past year (35.1%, n = 357) answered questions about their cannabis use, including where they were the last time they smoked, vaped, or ate/drank cannabis, and their experience of cannabis-related problems.

Results: Compared with cannabis smoking, participants were more likely to have vaped cannabis (15.8% smoked vs. 24.6% vaped; $X^2 = 4.59$, p = .032), and were slightly, but not statistically significantly, more likely to have used cannabis edibles (17.5% smoked vs. 24.2% used edibles; $X^2 = 3.57$, p = .059), in locations other than a private residence. For example, participants were more likely to have vaped cannabis in a car than to have smoked cannabis in a car (8.8% vaped vs. 3.5% smoked; $X^2 = 4.26$, p = .039). More frequent cannabis vaping was associated with driving while high on cannabis, even after accounting for overall frequency of cannabis use and other covariates (OR = 1.22, p = .047). More frequent cannabis vaping and edible use were associated with various cannabis-related problems, but, in general, these associations became statistically non-significant after accounting for overall frequency of cannabis use.

Conclusions: Cannabis vaporizers and edibles facilitate cannabis use in locations that require discretion. Increased availability of cannabis vaporizers and edibles could increase risk of cannabis-related problems by enabling use in more settings.

1. Introduction

Cannabis vaping and edible use are increasingly popular methods of cannabis use that offer alternatives to traditional cannabis smoking (Borodovsky et al., 2017; Jones, Hill, Pardini, & Meier, 2016; Lamy et al., 2016; Morean, Kong, Camenga, Cavallo, & Krishnan-Sarin, 2015). Although these non-combustible methods of cannabis use might reduce the adverse respiratory effects of cannabis smoking (e.g., bronchitis) (Lynskey, Hindocha, & Freeman, 2016; Tashkin et al., 1987; Taylor, Poulton, Moffitt, Ramankutty, & Sears, 2000; Tetrault et al., 2007), they might also present important public health risks (Borodovsky et al., 2017; Budney, Sargent, & Lee, 2015; Lee, Crosier, Borodovsky, Sargent, & Budney, 2016). For example, vaporizers and edibles facilitate cannabis use in prohibited locations by minimizing the distinctive cannabis odor produced by cannabis smoking and by disguising use through resemblance to legal products, like e-cigarettes and baked goods. In fact, both adolescents and adults report that an important reason for choosing vaporizers and edibles is to conceal cannabis use (Etter, 2015; Friese, Slater, Annechino, & Battle, 2016; Friese, Slater, & Battle, 2017; Giombi, Kosa, Rains, & Cates, 2018; Jones et al., 2016; Malouff, Rooke, & Copeland, 2014), which could facilitate cannabis use in risky locations, such as in a car. Our internet search of cannabis websites (e.g., grasscity.com) suggests that at least some cannabis users are choosing vaporizers and edibles specifically so that they can use while driving. For example, in an online forum discussion of cannabis vaping and driving, one person wrote: “But it wouldn't really smell because of the vape… I'm skeptical about lighting up a joint in a car, but I'd imagine that vaping would be fine, right?” (FreeYourSoul, 2013). Although driving while high on cannabis is illegal, such prohibitions may be ignored and may be quite difficult to enforce if discreet methods of

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cannabis use allow individuals to hide use from authority figures (e.g., police).

Moreover, as cannabis vaporizers and edibles facilitate cannabis use in a wider range of settings, frequency of cannabis use could increase (Budney et al., 2015; Lee et al., 2016), thereby increasing risk for cannabis-related problems, such as physical dependence and impaired control over use. The prevalence of cannabis use disorder is linked with frequent cannabis use (Coffey et al., 2002; Noack, Höfler, & Lüken, 2011), and, in a prospective study of adult cannabis users, more frequent cannabis use at baseline was associated with a greater likelihood of having a cannabis use disorder three years later, even after accounting for demographic characteristics, family history of substance use disorder, and psychiatric disorders (Blanco et al., 2016). Thus, cannabis vaporizers and edibles might allow cannabis users to use cannabis more often, and in high-risk situations (i.e., while driving), which might increase risk for developing symptoms of cannabis use disorder (e.g., tolerance, withdrawal, using more than planned), as well as other cannabis-related problems.

This study had two primary aims. Our first aim was to test the hypothesis that cannabis users are more likely to vape cannabis, or use cannabis edibles, than to smoke cannabis in locations where discretion is important, including in a car. To test this hypothesis, we conducted within-person comparisons of the locations a person last smoked, vaped, and used a cannabis edible. Our second aim was to test the hypothesis that more frequent cannabis vaping and edible use are associated with increased risk of driving while high and more cannabis-related problems, even after accounting for sociodemographic factors (age, sex, race, SES), more substantive factors (sensation seeking, age of cannabis use initiation, frequency of binge drinking and drug use), and overall frequency of cannabis use.

2. Methods

2.1. Participants

Participants were bachelor's and master's-level students from a large southwestern university in the United States. The university is located in a state where medicinal cannabis use is legal but recreational use is not. Students had the opportunity to complete an anonymous online questionnaire about college student health and behavior for course credit or extra credit in the fall of 2016 and spring of 2017. There were a total of 1018 respondents, of which 98% (n = 998) completed the survey. Participants' mean age was 22.15 (SD = 5.94) and 62% (n = 634) were women. Fifty-five percent of the sample was White/Caucasian, 26% Hispanic or Latino, 12% Asian, 6% Black/African American, and 1% American Indian or Alaska Native. The majority of participants (75%) were from middle class to upper class families. These demographics closely resemble the demographics of the student population at this particular university with one exception: women were overrepresented in this study (62% vs. 49% in the undergraduate population). Analyses report on the 357 participants (35.1%) who had used cannabis in the past year. The past-year prevalence of cannabis use in this sample is similar to that reported among college students in the Monitoring the Future study (37.9%) (Johnston, O'Malley, Bachman, Schulenberg, & Miech, 2016). Among past-year cannabis users, participants' mean age was 20.62 (SD = 4.14) and 61.9% (n = 221) were women. Sixty percent of past-year cannabis users were White/Caucasian, 23% were Hispanic or Latino, 8% were Asian, 8% were Black/African American, and 2% were American Indian or Alaska Native. Sixty-nine percent of past-year cannabis users were from middle to upper class families. Missing data were limited because participants were automatically notified if they skipped a question and were given another opportunity to answer the question. Across all analyses, only 2–7% of participants were missing data, as noted in the tables. This study was approved by the University Institutional Review Board.

2.2. Measures

2.2.1. Past-year frequency of cannabis use, cannabis vaping, and edible use

Past-year cannabis users were asked how often they used cannabis in the past year, how often they used a cannabis vaporizer in the past year, and how often they used a cannabis edible (ate or drank) in the past year. Response options were: no use in the past year (scored '0'), < 5 times (scored '1'), > 5 times but less than once a month (scored '2'), about once a month (scored '3'), once a week (scored '4'), a couple times a week (scored '5'), nearly every day (scored '6'), and more than once a day (scored '7'). The percentage of participants who endorsed each response option is as follows: 0.0%, 47.5%, and 37.3% did not use, vape, and eat/drink cannabis, respectively; 31.1%, 26.7%, and 46.6% used, vaped, and ate/drank cannabis < 5 times; 11.5%, 9.0%, and 8.8% used, vaped, and ate/drank cannabis > 5 times but less than once a month; 8.4%, 6.7%, and 5.7% used, vaped, and ate/drank cannabis about once a month; 16.3%, 5.3%, and 1.1% used, vaped, and ate/drank cannabis once a week; 17.7%, 3.7%, and 0.3% used, vaped, and ate/drank cannabis a couple times a week; 10.1%, 0.8%, and 0% used, vaped, and ate/drank cannabis nearly every day; and 5%, 0.3%, and 0.3% used, vaped, and ate/drank cannabis more than once a day.

2.2.2. Locations where cannabis was used

Past-year cannabis users reported where they were the last time they smoked cannabis; where they were the last time they vaped cannabis; and where they were the last time they used a cannabis edible (i.e., ate or drank cannabis). Location was coded as private residence (i.e., at an apartment/house, in a dormitory) vs. all other locations (e.g., in a car, at a bar or club, at a restaurant, concert, park/woods/hiking trail, etc.). The majority of participants used cannabis in a private residence the last time they used regardless of cannabis use method. For example, of the 341 participants who smoked cannabis in the past year, 80.3% (n = 274) last smoked cannabis in a private residence; of the 187 participants who vaped cannabis in the past year, 74.3% (n = 139) last vaped cannabis in a private residence; and of the 222 participants who used a cannabis edible in the past year, 74.4% (n = 165) last used an edible in a private residence.

2.2.3. Driving while high on cannabis

Past-year cannabis users reported whether they had ever driven a car while high on cannabis. Forty-seven percent (n = 168) of past-year cannabis users reported driving while high on cannabis in their lifetime.

2.2.4. Cannabis-related problems

Cannabis-related problems were assessed with the Marijuana Consequences Questionnaire (MACQ) (Simons, Dvorak, Merrill, & Read, 2012), a 50-item self-report measure that assesses cannabis use consequences in eight domains: physical dependence (sum of four 'yes/no' items, coefficient alpha = 0.73, M = 0.66, SD = 1.08; example item: "I have found that I needed larger amounts of cannabis to feel any effect, or that I could no longer get high on the same amount that used to get me high"), impaired control (sum of six 'yes/no' items, coefficient alpha = 0.73, M = 1.30, SD = 1.53; example item: "I often have found it difficult to limit how much cannabis I use"), academic/occupational consequences (sum of five 'yes/no' items, coefficient alpha = 0.68, M = 0.47, SD = 0.95; example item: "The quality of my work or schoolwork has suffered because of my cannabis use"), social-interpersonal consequences (sum of six 'yes/no' items, coefficient alpha = 0.66, M = 0.91, SD = 1.09; example item: "My boyfriend/girlfriend/spouse/parents have complained to me about my cannabis use"), self-care (sum of nine 'yes/no' items, coefficient alpha = 0.80, M = 1.33, SD = 1.86; example item: "I have not had as much time to pursue activities or recreation because of my cannabis use"), self-perception (sum of five 'yes/no' items, coefficient alpha = 0.68, M = 1.20, SD = 1.30; example item: "I have felt guilty about my cannabis use"), risk behaviors (sum of eight 'yes/no' items, coefficient alpha = 0.62,

M = 0.87, SD = 1.07, example item: "When using cannabis I have done impulsive things that I regretted later"), and blackout use (sum of seven 'yes/no' items, coefficient alpha = 0.57, M = 1.30, SD = 1.29; example item: "I have had a blackout after using cannabis heavily [i.e., could not remember hours at a time]"). The MACQ has been shown to have good convergent and discriminant validity (Simons et al., 2012).

2.3. Covariates

Covariates were sociodemographic factors (age, sex, race, SES), more substantive factors (sensation seeking, age of cannabis use initiation, frequency of binge drinking and drug use), and overall frequency of cannabis use. These covariates were selected based on theory and prior research demonstrating that they are associated with cannabis vaporizer and edible use and cannabis-related problems (Friese et al., 2017; Harder, Stuart, & Anthony, 2010; Jones et al., 2016; Jones, Swift, Donnelly, & Weatherburn, 2007; Schauer, King, Bunnell, Promoff, & McAfee, 2016).

2.3.1. Race

Participants reported their race. Responses were dummy coded as follows: White/Caucasian (reference group), Hispanic or Latino, Black/African American, and Other race/ethnicity.

2.3.2. Socioeconomic status

Participants were asked: "In terms of income, how would you describe your family's socioeconomic status?" Response options were "upper class," "upper-middle class," "middle class," "lower middle class," and "working class." Responses were scored from 1 to 5, with '1' indicating working class and '5' indicating upper class (M = 3.15, SD = 0.95).

2.3.3. Sensation seeking

Participants completed the Brief Sensation Seeking Scale – an 8-item scale that has been shown to be a reliable and valid measure of sensation seeking personality traits (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002). Participants rated each of the 8 items on a five-point scale ranging from '1' = strongly disagree to '5' = strongly agree. Responses to each of the 8 items were summed (M = 28.14, SD = 5.04).

2.3.4. Age of onset of cannabis use

Participants reported on the age that they first used cannabis (M = 16.41, SD = 3.26).

2.3.5. Other substance use

Participants reported on their past-year frequency of binge drinking (defined as 4+ drinks on one occasion for women and 5+ drinks for men) and past-year use of illicit drugs other than cannabis. Response options were: no use in the past year (scored '0'), < 5 times (scored '1'), > 5 times but less than once a month (scored '2'), about once a month (scored '3'), once a week (scored '4'), a couple times a week (scored '5'), nearly every day (scored '6'), and more than once a day (scored '7'). The percentage of participants who endorsed each response option for past-year frequency of binge drinking was 12.6% (did not binge drink), 19.2% (< 5 times), 16.9% (> 5 times but less than once a month), 20.3% (about once a month), 18.1% (once a week), 12.0% (a couple times a week), 0.9% (nearly every day), and 0.0% (more than once a day). The percentage of participants who endorsed each response option for past-year frequency of illicit drug use was 70.5% (did not use illicit drugs), 16.3% (< 5 times), 6.6% (> 5 times but less than once a month), 2.9% (about once a month), 2.0% (once a week), 1.2% (a couple times a week), 0.3% (nearly every day), and 0.3% (more than once a day).

2.4. Statistical analyses

To test whether cannabis users were more likely to use cannabis in locations other than a private residence the last time they vaped cannabis or used a cannabis edible compared with the last time they smoked cannabis, we limited the sample to cannabis users who had both vaped and smoked cannabis in the past year in analyses of vaping, and we limited the sample to cannabis users who had both used cannabis edibles and smoked cannabis in the past year in analyses of edible use. Then, we used McNemar's test, which accounts for the paired nature of the data, to compare the location of a person's last cannabis vaping episode (or last edible use) to the location of that same person's last cannabis smoking episode, with location coded as private residence vs. all other locations. Parallel analyses were conducted to test whether cannabis users were more likely to use cannabis in a car the last time they vaped cannabis or used cannabis edibles compared with the last time they smoked cannabis, with location coded as in a car vs. all other locations.

To test whether more frequent cannabis vaping and edible use were each associated with increased risk of ever driving while high on cannabis, we used logistic regression. Frequency of cannabis vaping and frequency of edible use were the independent variables (considered separately), and ever driving while high on cannabis was the dependent variable. To evaluate whether any association between cannabis vaping or edible use and driving while high on cannabis could be explained by factors associated with selection into cannabis vaping and edible use, as opposed to vaping and edible use per se, we entered covariates into the model. Covariates were entered sequentially because it can be informative to know which covariates accounted for an association. Sociodemographic factors were entered first (age, sex, race, and SES); more substantive factors were added second (sensation seeking, age of cannabis use initiation, frequency of binge drinking and drug use); and frequency of cannabis use was entered last, to ascertain if greater overall frequency of cannabis use could explain any association between cannabis vaping or edible use and driving while high on cannabis.

To test whether more frequent cannabis vaping and edible use were each associated with more cannabis-related problems, we used negative binomial modeling. Frequency of cannabis vaping and frequency of edible use were the independent variables (considered separately) and each of the eight MACQ cannabis consequences scales were the dependent variables. Negative binomial models are appropriate because of the count nature of the dependent variables (i.e., a count of cannabis-related problems). As with the analyses of driving while high on cannabis, the same covariates were used and were added in a sequential fashion. Analyses were conducted using SAS version 9.4 (SAS Institute: Cary, NC).

3. Results

3.1. Prevalence and correlates of cannabis vaping and edible use

Of the 357 past-year cannabis users in the present study, 95.5% (n = 341) had smoked cannabis in the past year, 52.4% (n = 187) had vaped cannabis in the past year, 62.2% (n = 222) had used cannabis edibles in the past year. Moreover, 51.5% (n = 184) had vaped and smoked cannabis in the past year, 59.1% (n = 211) had used edibles and smoked cannabis in the past year, and 38.9% (n = 139) used all three methods.

Table 1 shows correlates of past-year frequency of cannabis vaping and edible use. This table shows Spearman correlations, a nonparametric version of the Pearson correlation selected because some variables were skewed. Correlates of vaping and edible use were similar and included male sex, greater overall frequency of cannabis use, earlier age of onset of cannabis use, greater frequency of alcohol and illicit drug use, and sensation seeking. For example, young adults who used

Table 1
Correlates of past-year frequency of cannabis vaping and edible use among past-year cannabis users (N = 357).[a]

Correlates	Cannabis vaping		Cannabis edible use	
	r_s[b]	p	r_s[b]	p
Age	−0.01	0.85	−0.01	0.92
Male sex	**0.13**	**0.011**	**0.11**	**0.035**
White/Caucasian race	0.03	0.54	0.07	0.20
SES	**0.14**	**0.006**	0.07	0.18
Overall frequency of cannabis use	**0.52**	**< 0.001**	**0.47**	**< 0.001**
Age of first cannabis use	**−0.21**	**< 0.001**	**−0.18**	**< 0.001**
Frequency of binge drinking	**0.23**	**< 0.001**	**0.19**	**< 0.001**
Frequency of illicit drug use	**0.33**	**< 0.001**	**0.27**	**< 0.001**
Sensation seeking	**0.18**	**< 0.001**	**0.15**	**0.005**

Bold indicates statistically significant analyses at $p < 0.05$.
[a] Ns ranged from 349 to 357 for past-year cannabis users, because 8 people were missing data on one or more of the variables in this table.
[b] Spearman correlations are presented because of skewed distributions.

cannabis more frequently in general tended to vape cannabis ($r_s = 0.52$, $p < .001$) and use cannabis edibles ($r_s = 0.47$, $p < .001$) more frequently (Table 1). Higher SES was statistically significantly associated with more frequent past-year cannabis vaping ($r_s = 0.14$, $p = .006$) but not with more frequent past-year cannabis edible use ($r_s = 0.07$, $p = .18$).

3.2. Location of cannabis use

Participants most often used cannabis in a private residence the last time they used cannabis, regardless of whether they had smoked, vaped, or used a cannabis edible (Table 2). Among cannabis users who smoked and vaped cannabis in the past year (n = 184), cannabis users were more likely to have vaped cannabis in locations other than a private residence the last time they vaped (24.6%) than to have smoked cannabis in locations other than a private residence (15.8%; $X^2 = 4.59$, $p = .032$) the last time they smoked. In addition, cannabis users were more likely to have vaped cannabis in a car the last time they vaped (8.8%) than to have smoked cannabis in a car (3.5%; $X^2 = 4.26$, $p = .039$) the last time they smoked (Table 2, Panel A).

Among cannabis users who had smoked cannabis and used cannabis edibles in the past year (n = 211), cannabis users were slightly, but non-significantly, more likely to have used edibles in locations other than a private residence (24.8%) the last time they used an edible than to have smoked cannabis in locations other than a private residence the last time they smoked (17.5%) ($X^2 = 3.57$, $p = .059$). In addition, cannabis users were not more likely to use an edible in car than to smoke in a car ($X^2 = 0.18$, $p = .67$).

Table 2
Within-person comparisons of the location cannabis users last smoked vs. vaped (Panel A) and the location cannabis users last smoked vs. used a cannabis edible (Panel B).

Panel A. Within-person comparisons of the location cannabis users last smoked and vaped cannabis among those who smoked and vaped cannabis in the past year (n = 184).[a]

Location	Smoked cannabis	Vaped cannabis	McNemar's test	
	% (n)	% (n)	χ^2	p-Value
Private residence	84.2 (144)	75.4 (129)	**4.59**	**0.032**
Location other than a private residence	15.8 (27)	24.6 (42)		
In a car	3.5 (6)	8.8 (15)	**4.26**	**0.039**
Location other than a car	96.5 (165)	91.2 (156)		

Panel B. Within-person comparisons of location cannabis users last smoked cannabis and used edibles among those who smoked cannabis and used edibles in the past year (n = 211).[b]

Location	Smoked cannabis	Used edible (s)	McNemar's test	
	% (n)	% (n)	χ^2	p-Value
Private residence	82.5 (170)	75.8 (155)	3.57	0.059
Location other than a private residence	17.5 (36)	24.2 (51)		
In a car	6.3 (13)	5.3 (11)	0.18	0.67
Location other than a car	93.7 (193)	94.7 (195)		

[a] N = 171, because 13 participants were missing location data.
[b] N = 206 because 5 participants were missing location data.

Table 3
Associations between past-year frequency of cannabis vaping (Panel A) and edible use (Panel B) and driving while high on cannabis (N = 357).

Panel A: Associations between frequency of cannabis vaping and odds of driving while high on cannabis. ORs refer to frequency of cannabis vaping before (Model 1) and after (Models 2–4) sequentially controlling for covariates.

Independent variables	OR	95% CI	p
Model 1: Frequency of Cannabis Vaping	**1.67**	**1.40, 1.99**	**< 0.001**
Model 2: Model 1 + Age, Sex, Race, and SES	**1.67**	**1.40, 2.00**	**< 0.001**
Model 3: Model 2 + Sensation Seeking, Age of First Cannabis Use			
Frequency of Binge Drinking, and Frequency of Drug Use	**1.48**	**1.24, 1.77**	**< 0.001**
Model 4: Model 3 + Frequency of Overall Cannabis Use	**1.22**	**1.01, 1.49**	**0.047**

Panel B: Associations between frequency of edible use and odds of driving while high on cannabis. ORs refer to frequency of edible use before (Model 1) and after (Models 2–4) sequentially controlling for covariates.

Independent variables	OR	95% CI	p
Model 1: Frequency of Edible Use	**1.96**	**1.50, 2.58**	**< 0.001**
Model 2: Model 1 + Age, Sex, Race, and SES	**1.94**	**1.48, 2.56**	**< 0.001**
Model 3: Model 2 + Sensation Seeking, Age of First Cannabis Use			
Frequency of Binge Drinking, and Frequency of Drug Use	**1.60**	**1.20, 2.13**	**0.001**
Model 4: Model 3 + Frequency of Overall Cannabis Use	1.19	0.88, 1.61	0.26

Note. N = 349 because 8 participants were missing data on one or more covariates. Statistically significant associations are shown in bold. Race was dummy coded into one of four groups: Response options for frequency of cannabis use, cannabis vaping, edible use, binge drinking, and drug use were: no use in the past year (scored '0'), < 5 times (scored '1'), > 5 times but less than once a month (scored '2'), about once a month (scored '3'), once a week (scored '4'), a couple times a week (scored '5'), nearly every day (scored '6'), and more than once a day (scored '7').

3.3. Cannabis vaping and edible use and risk of driving while high on cannabis

Table 3 shows associations between past-year frequency of cannabis vaping and ever driving while high on cannabis (Panel A), as well as associations between past-year frequency of cannabis edible use and ever driving while high on cannabis (Panel B). More frequent vaping

Table 4
Associations between past-year frequency of cannabis vaping and cannabis-related problems among past-year cannabis users. RRs refer to frequency of cannabis vaping before (Model 1) and after (Models 2–4) sequentially controlling for covariates.

Independent variables	MACQ cannabis use consequences scales											
	Physical dependence			Impaired control			Academic/occupational			Social-interpersonal		
	RR	SE	p	RR	SE	p	RR	SE	p	RR	SE	p
Model 1: Frequency of Cannabis Vaping	**1.39**	**0.06**	**< 0.001**	**1.19**	**0.04**	**< 0.001**	**1.23**	**0.08**	**0.007**	1.04	0.04	0.32
Model 2: Model 1 + Age, Sex, Race, and SES	**1.41**	**0.06**	**< 0.001**	**1.19**	**0.04**	**< 0.001**	**1.18**	**0.08**	**0.029**	1.06	0.04	0.14
Model 3: Model 2 + Sensation Seeking, Age of First Cannabis Use, Frequency of Binge Drinking, and Frequency of Drug Use	**1.29**	**0.06**	**< 0.001**	**1.13**	**0.04**	**0.004**	1.08	0.07	0.31	1.04	0.04	0.40
Model 4: Model 3 + Frequency of Overall Cannabis Use	1.06	0.04	0.18	1.01	0.04	0.87	0.96	0.08	0.59	0.99	0.05	0.88

Independent variables	MACQ cannabis use consequences scales											
	Self-care			Self-perception			Risk behavior			Blackout		
	RR	SE	p	RR	SE	p	RR	SE	p	RR	SE	p
Model 1: Frequency of Cannabis Vaping	**1.19**	**0.05**	**< 0.001**	1.02	0.04	0.59	**1.14**	**0.04**	**< 0.001**	1.00	0.04	0.90
Model 2: Model 1 + Age, Sex, Race, and SES	**1.18**	**0.05**	**0.002**	1.03	0.04	0.40	**1.14**	**0.04**	**< 0.001**	1.00	0.04	0.99
Model 3: Model 2 + Sensation Seeking, Age of First Cannabis Use, Frequency of Binge Drinking, and Frequency of Drug Use	1.09	0.05	0.10	1.03	0.04	0.52	1.08	0.04	0.050	0.97	0.04	0.36
Model 4: Model 3 + Frequency of Overall Cannabis Use	0.97	0.06	0.62	1.01	0.05	0.80	1.03	0.05	0.46	0.96	0.04	0.38

Note. N = 349 because 8 participants were missing data on one or more covariates. RR = risk ratio. SE = standard error. MACQ = Marijuana Consequences Questionnaire. Statistically significant associations are shown in bold. Response options for frequency of cannabis use, cannabis vaping, edible use, binge drinking, and drug use were: no use in the past year (scored '0'), < 5 times (scored '1'), > 5 times but less than once a month (scored '2'), about once a month (scored '3'), once a week (scored '4'), a couple times a week (scored '5'), nearly every day (scored '6'), and more than once a day (scored '7').

was associated with driving while high on cannabis (OR = 1.67, p < .001; Model 1), even after accounting for age, sex, race, SES, sensation seeking, age of first cannabis use, frequency of binge drinking, frequency of drug use, and overall frequency of cannabis use (OR = 1.22, p = .047; Model 4). Thus, after controlling for all covariates, the odds of driving while high on cannabis were 1.22 times greater for every one-unit increase in past-year frequency of cannabis vaping. Likewise, more frequent edible use was associated with driving while high on cannabis (OR = 1.96, p < .001; Model 1), even after controlling for age, sex, race, SES, sensation seeking, age of first cannabis use, frequency of binge drinking, and frequency of drug use (OR = 1.60, p = .001; Model 3). However, the association between cannabis edible use and driving while high on cannabis was no longer statistically significant after additionally controlling for overall frequency of cannabis use (OR = 1.19, p = .26; Model 4).

3.4. Cannabis vaping and edible use and cannabis-related problems

Table 4 shows associations between past-year frequency of cannabis vaping and cannabis-related problems. In univariate analyses (Model 1), more frequent cannabis vaping was associated with higher levels of physical dependence, impaired control, academic/occupational problems, self-care problems, and cannabis-related risk behavior. These associations remained statistically significant after controlling for sociodemographic covariates (Model 2). After additionally controlling for sensation seeking, age of first cannabis use, frequency of binge drinking, and frequency of drug use (Model 3), associations with physical dependence (RR = 1.29, p < .001) and impaired control (RR = 1.13, p = .004) remained statistically significant but associations with academic/occupational problems (RR = 1.08, p = .31), self-care problems (RR = 1.09, p = .10), and risk behavior (RR = 1.08, p = .05) did not. Finally, after controlling for overall frequency of cannabis use (Model 4), more frequent cannabis vaping was no longer statistically significantly associated with any cannabis-related problems.

Table 5 shows associations between frequency of edible use and cannabis-related problems. In univariate analyses (Model 1), more frequent edible use was associated with physical dependence, impaired control, academic/occupational problems, self-care problems, risk behavior, and black outs. With the exception of blackouts (RR = 1.10, p = .08), these associations remained statistically significant after adding demographic covariates of age, sex, race, and SES (Model 2). Moreover, more frequent edible use became statistically significantly associated with self-perception problems (RR = 1.13, p = .036) after adding demographic covariates. After additionally controlling for sensation seeking, age of first cannabis use, frequency of binge drinking, and frequency of drug use (Model 3), associations with physical dependence (RR = 1.49, p < .001), self-care problems (RR = 1.23, p = .014), and cannabis-related risk behavior (RR = 1.21, p = .001) remained significant. Finally, after controlling for overall frequency of cannabis use, more frequent edible use was associated only with cannabis-related risk behavior (RR = 1.15, p = .020; Model 4). Thus, after controlling for all covariates, for every one-unit increase in past-year edible use, participants were 1.15 times more likely to have engaged in a cannabis-related risk behavior.

4. Discussion

The present study had two primary aims: (1) to test whether cannabis users were more likely to use cannabis in locations other than a private residence, and specifically in a car, the last time they vaped cannabis or used cannabis edibles compared with the last time they smoked cannabis; and (2) to examine whether more frequent cannabis vaping and edible use were associated with more cannabis-related problems (e.g., driving while high on cannabis, physical dependence, impaired control over use, risky behavior). This paper adds to knowledge in several ways.

First, the present study, to our knowledge, is the first to examine associations between method of cannabis use and location of cannabis use. We found that compared with cannabis smoking, cannabis users were more likely to have vaped cannabis, and were slightly, but not statistically significantly, more likely to have used cannabis edibles, in locations other than a private residence the last time they used either method. Whereas previous research suggests that an important reason

Table 5
Associations between past-year frequency of consuming edibles and cannabis-related problems among past-year cannabis users. RRs refer to frequency of edible use before (Model 1) and after (Models 2–4) sequentially controlling for covariates.

Independent variables	MACQ cannabis use consequences scales											
	Physical dependence			Impaired control			Academic/occupational			Social-interpersonal		
	RR	SE	p	RR	SE	p	RR	SE	p	RR	SE	p
Model 1: Frequency of Cannabis Edible Use	**1.74**	**0.09**	**< 0.001**	**1.27**	**0.07**	**< 0.001**	**1.48**	**0.11**	**< 0.001**	1.10	0.06	0.11
Model 2: Model 1 + Age, Sex, Race, and SES	**1.74**	**0.09**	**< 0.001**	**1.24**	**0.07**	**0.001**	**1.36**	**0.11**	**0.005**	1.12	0.06	0.07
Model 3: Model 2 + Sensation Seeking, Age of First Cannabis Use, Frequency of Binge Drinking and Drug Use	**1.49**	**0.09**	**< 0.001**	1.13	0.07	0.07	1.14	0.11	0.24	1.06	0.06	0.34
Model 4: Model 3 + Frequency of Overall Cannabis Use	1.09	0.06	0.17	0.96	0.07	0.57	0.98	0.11	0.84	1.01	0.07	0.88

Independent variables	MACQ cannabis use consequences scales											
	Self-care			Self-perception			Risk behavior			Blackout		
	RR	SE	p	RR	SE	p	RR	SE	p	RR	SE	p
Model 1: Frequency of Cannabis Edible Use	**1.43**	**0.08**	**< 0.001**	1.11	0.06	0.07	**1.30**	**0.06**	**< 0.001**	**1.11**	**0.05**	**0.048**
Model 2: Model 1 + Age, Sex, Race, and SES	**1.39**	**0.08**	**< 0.001**	**1.13**	**0.06**	**0.032**	**1.30**	**0.06**	**< 0.001**	1.10	0.05	0.08
Model 3: Model 2 + Sensation Seeking, Age of First Cannabis Use, Frequency of Binge Drinking and Drug Use	**1.23**	**0.08**	**0.014**	1.13	0.06	0.05	**1.21**	**0.06**	**0.001**	1.04	0.06	0.52
Model 4: Model 3 + Frequency of Overall Cannabis Use	1.06	0.08	0.51	1.12	0.07	0.09	**1.15**	**0.06**	**0.020**	1.05	0.06	0.42

Note. N = 349 because 8 participants were missing data on one or more covariates. RR = risk ratio. SE = standard error. MACQ = Marijuana Consequences Questionnaire. Statistically significant associations are shown in bold. Response options for frequency of cannabis use, cannabis vaping, edible use, binge drinking, and drug use were: no use in the past year (scored '0'), < 5 times (scored '1'), > 5 times but less than once a month (scored '2'), about once a month (scored '3'), once a week (scored '4'), a couple times a week (scored '5'), nearly every day (scored '6'), and more than once a day (scored '7').

cannabis users choose to vape cannabis and use cannabis edibles is to conceal use (Etter, 2015; Friese et al., 2016; Jones et al., 2016; Malouff et al., 2014), this study provides the first evidence that cannabis users actually use discreet methods in more public locations than when these same cannabis users smoke cannabis. Taken together, these findings support and extend previous research by suggesting that the perceived discretion of cannabis vaping and edible use may influence where people choose to use vaporizers and edibles.

Second, this is the first study to suggest that cannabis vaporizers may facilitate cannabis use in a car and driving while intoxicated. We found that cannabis users who vaped and smoked cannabis in the past year were more likely to have vaped cannabis in a car than to have smoked cannabis in a car the last time they used either method. Although it is not clear if participants drove during or after these episodes of use, it is possible that by facilitating cannabis use in a car, cannabis vaping could increase risk for driving while high on cannabis. In line with this possibility, we found that more frequent cannabis vaping was associated with higher risk of ever driving while high on cannabis, even after accounting for demographic factors (age, sex, race, and SES), more substantive factors (sensation seeking, age of cannabis use initiation, frequency of binge drinking and drug use), and overall frequency of cannabis use. This suggests that vaporizers facilitate driving while high on cannabis, which is concerning given the increasing prevalence of cannabis vaping. Moreover, our finding that 47% of the past-year cannabis users had driven while high on cannabis in their lifetime, suggests that driving while high on cannabis is common. This is in keeping with another study of college students, which found that past-month cannabis users reported similarly high rates of driving while high (McCarthy, Lynch, & Pederson, 2007).

Interestingly, cannabis users were not more likely to use cannabis edibles in a car than to smoke cannabis in a car, and more frequent edible use was not associated with increased risk of driving while high on cannabis after controlling for all covariates. This suggests that of the two discreet methods of cannabis use (cannabis vaping and edible use), cannabis vaping may pose a greater risk for use in a car and driving while high. One possibility is that cannabis users prefer cannabis vaping to edible use in driving situations due to the delay and variability of intoxication associated with cannabis edibles (Ghosh et al., 2015).

Third, the present study also offers new information that more frequent cannabis vaping and edible use are each associated with higher levels of cannabis-related problems, including physical dependence, impaired control, and cannabis-related risk behavior. Some of these associations, particularly associations with physical dependence, remained after controlling for a variety of covariates, including sensation seeking, age of first cannabis use, and frequency of binge drinking and drug use. However, with one exception (the association between frequency of edible use and cannabis-related risk behavior), associations between more frequent cannabis vaping and edible use became statistically non-significant after controlling for more frequent cannabis use. Our finding that associations between cannabis vaping and edible use and cannabis-related problems became non-significant after controlling for more frequent cannabis use might suggest that more frequent cannabis users tend to select into cannabis vaping and edible use. Thus, more frequent cannabis use, and not vaping and edible use per se, may account for why cannabis users who use vaporizers and edibles show more cannabis-related problems. In essence, more frequent cannabis use might have confounded associations between cannabis vaping and edible use and cannabis-related problems. However, another explanation is that cannabis vaping and edible use might lead to more frequent cannabis use, by allowing cannabis users to use cannabis at times they otherwise would not (Budney et al., 2015). In essence, more frequent cannabis use might be a mediator (and not a confounder) of associations between cannabis vaping and edible use and cannabis-related problems. In this case, our covariate control for overall frequency of cannabis use might represent an over-control. Importantly, it is possible that more frequent cannabis users select into vaping and edible use, and vaping and edible use may also contribute to more frequent use. Longitudinal studies are needed to determine whether cannabis vaping or edible use are prospectively associated with increases in frequency of cannabis use, which may, in turn, explain increases in cannabis-related problems.

A strength of the study is that our analyses of the locations cannabis users smoked, vaped, and used cannabis edibles compared each user to him or herself. This is important because it controls for between-person factors associated with selection into vaping and edible use and with selection factors associated with using cannabis in public. Still, this study has limitations. First, our analyses of associations between frequency of vaping and edible use and cannabis-related problems are between persons and could be explained by selection factors related to cannabis vaping and edible use. For example, individuals who vape cannabis or use cannabis edibles may just be higher in deviance proneness or externalizing problems, which could explain associations with cannabis-related problems. We attempted to account for this by controlling for a sensation seeking and frequency of binge drinking and drug use, but other factors related to deviance proneness could still explain the associations. Another possibility is that individuals who vape cannabis may be more likely own a car, which could explain the association between cannabis vaping and driving under the influence of cannabis. Although we controlled for SES, we did not ask participants if they owned a car. Second, and relatedly, this study is cross-sectional, and thus cannot determine whether cannabis vaping and edible use precede the onset of cannabis-related problems. Prospective studies are needed to determine the temporal associations between methods of cannabis use and cannabis-related problems. Third, although we found that cannabis users were more likely to vape in a car than to smoke in a car, it was not clear that using in car meant that the person was actually driving or drove following use. However, findings suggested that cannabis users who vaped cannabis more frequently were at increased risk of driving while high, even after controlling for overall frequency of cannabis use.

Fourth, the sample comprises a relatively small sample of cannabis users enrolled in courses at a single university located in a medical cannabis state. It is not clear whether findings will generalize to students enrolled in universities in other states and to young adults not enrolled at a university. As to whether findings will generalize to students in other states, research suggests that cannabis vaping and edible use are more prevalent in states with medical marijuana laws (Borodovsky, Crosier, Lee, Sargent, & Budney, 2016). As to whether findings will generalize to young adults not enrolled at a university, the prevalence of cannabis use is similar between college students and their non-college attending peers (Johnston et al., 2016). However, college students may have higher levels of protective factors (e.g., SES) that reduce the risks associated with cannabis vaping and edible use. Therefore, it is possible that the current study may have underestimated the potential risks of cannabis vaping and edible use.

5. Conclusions

This study has implications for research and public policy. Regarding research, studies should regularly assess method of cannabis use. Growing evidence suggests that cannabis vaporizers and edibles may be used for different reasons than joints or other smoking devices (Etter, 2015; Friese et al., 2016; Jones et al., 2016; Malouff et al., 2014), and the present study suggests that these methods may involve unique risks that should be weighed against potential benefits (e.g., reduced smoking-related adverse respiratory effects; Budney et al., 2015; Gartner, 2015; Lynskey et al., 2016). For example, our finding of a link between cannabis edible use and cannabis-related risk behavior is particularly interesting in light of increased emergency visits due to cannabis edibles (Barrus et al., 2016). Regarding public policy, although many states prohibit cannabis use in public locations and in motor vehicles, and all states prohibit driving while high, such prohibitions may be ignored and may be quite difficult to enforce if discreet methods of cannabis use enable individuals to hide use from authority figures (e.g., police). Thus, we need to educate police officers on how to recognize discreet cannabis products.

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