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Correlates of cannabis vape-pen use and knowledge among U.S. college students

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ABSTRACT

Introduction: The proliferation of electronic devices, such as vape-pens, has provided alternative means for cannabis use. Research has found cannabis-vaping (i.e., vape-pen use) is associated with lower perceived risks and higher cannabis use. Knowledge of these products may increase likelihood of subsequent use. As policies for cannabis shift, beliefs that peers and family approve of this substance use (injunctive norms) increase and there has been an increase in vape-pen use among young adults (18–35 year olds); however, correlates thereof remain unknown. Young adults often engage in cross-substance use with cannabis and alcohol, making alcohol a potential correlate of cannabis vape-pen use and knowledge. Therefore, we examined alcohol use and other potential correlates of vape-pen use and knowledge among a sample of university students.

Methods: This secondary data analysis utilized surveys at multiple colleges in the U.S. (N = 270). Alcohol use, social anxiety, cannabis expectancies, injunctive and descriptive norms and facets of impulsivity were examined as correlates of vape-pen use and knowledge using bivariate correlations and logistic regressions.

Results: Alcohol use was correlated with cannabis vape-pen use and knowledge. Frequency of cannabis use, peer injunctive norms, and positive expectancies were associated with increased likelihood of vape-pen use. Lack of premeditation, a facet of impulsivity, was associated with cannabis vape-pen knowledge.

Conclusions: Given the unknown nature and consequences of cannabis vape-pens, the present findings offer valuable information on correlates of this behavior. Further, correlates of knowledge of vape-pens may point to areas for education and clinical intervention to prevent heavy cannabis vape-pen use.

1. Introduction

Cannabis is the most commonly used illicit substance in the United States (U.S.) (SAMHSA, 2014) and is increasing among young adults (18–25 year olds; Gaher & Simons, 2007; Phillips, Phillips, Lalonde, & Tormohlen, 2015; SAMHSA, 2014). As use increases, perceptions of cannabis use may become more favorable (Buckner, 2013) with lower perceived risks (Budney, Sargent, & Lee, 2015). Perceived risk influences behavior change, and may be fostered by knowledge and personal beliefs (Ryan, 2009).

The Integrated Behavioral Model (IBM; Montaño & Kasprzyk, 2015) is an extension of the Theory of Reasoned Action and the Theory of Planned Behavior (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1977; Janz & Becker, 1984; Rosenstock, 1974). These theories emphasize the importance of attitudes, subjective norms, and perceived control as having direct influence over one's intentions to perform a behavior. The IBM utilizes these constructs but adds knowledge and personal beliefs as key constructs in predicting if someone will carry out a behavior or not. Specifically *knowledge* is theorized to affect an individual's behavior directly (i.e. salience of behavior, environment, habit, and knowledge; Jaccard, Dodge, & Dittus, 2002). The IBM posits that even if one has a strong intention, they still need the requisite knowledge in order to carry out a behavior (Montaño & Kasprzyk, 2015).

As new cannabis routes of administration emerge, it is important to

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examine how knowledge of these methods may foster use (Farrell, 2001; Ryan, 2009). Knowledge of cannabis products has not been consistently shown to increase overall use, however it has been linked to increasing positive attitudes towards the substance, which can then lead to increased substance use (Farrell, 2001). Prior research, although concerning electronic cigarettes (e-cigarettes) for nicotine rather than cannabis, explains that many young adults will likely try new technologies to administer substances. Specifically, as e-cigarette technology improves for nicotine, these same devices provide alternative means for cannabis use, such as through a cannabis vape-pen (Brown & Cheng, 2014; Giroud et al., 2015). Given that simply knowing about a device or a new way to use a substance (i.e. cannabis vape-pens) may affect an individual's behavior, as theorized by the IBM, examining knowledge of cannabis vape-pen use may offer valuable insight to possible risk factors for subsequent use, and means of potential behavior change.

Several common portable electronic devices are used for vaping cannabis (i.e., “vape-pens”). These devices are commercially available and the most popular design resembles e-cigarettes (Brown & Cheng, 2014; Lee, Crosier, Borodovsky, Sargent, & Budney, 2016). Given lack of regulation, varying devices, and tetrahydrocannabinol (THC) potencies of products, components within the vapor produced by cannabis vape-pens are not well understood and gauging how much THC is administered can be difficult (Cranford, Bohnert, Perron, Bourque, & Ilgen, 2016; Douglas et al., 2015; Giroud et al., 2015). However, vape-pens are potentially appealing to cannabis users because of their less detectable odor and perception of reduced negative health effects compared to smoking cannabis (Budney et al., 2015; Etter, 2015; Johnson et al., 2016; Malouff, Rooke, & Copeland, 2014). U.S. national surveys have found between 9.9%–39% of adults report ever using cannabis vape-pens (Lee et al., 2016; Schauer, King, Bunnell, Promoff, & McAfee, 2016). Cannabis vape-pen use among college students appears higher than the national U.S. average (29% use; Jones, Hill, Pardini, & Meier, 2016), and men have been found to report higher vape-pen use than women (Jones et al., 2016; Lee et al., 2016). Further, individuals younger than 44 years-old, with higher education, and current cannabis users were more likely to report trying vape-pens with cannabis (Cranford et al., 2016). Given these findings, as new means of administration for cannabis continue to emerge, it is important not only to examine the devices themselves, but also how people's knowledge of these cannabis vape-pens may foster initial and sustained use of them.

2. Examined constructs

A consideration of the relevant theoretical and empirical literature explained in Section 1 points to several constructs with potential importance to vape-pen use and knowledge: impulsivity, descriptive and injunctive cannabis norms, cannabis expectancies, social anxiety, and alcohol use.

2.1. Impulsivity

Impulsivity, defined as acting with diminished thought or regard for possible consequences (Brewer & Potenza, 2008; Moeller et al., 2001), is a complex, heterogeneous construct that has been related to cannabis use and other risky behaviors among college students (Bidwell et al., 2013; Whiteside, Lynam, Miller, & Reynolds, 2005), but has not been related to vape-pen use or knowledge. Impulsivity relates to overall cannabis use among young adults (Bidwell et al., 2013). Those who endorse greater impulsivity typically are more likely to try or be willing to try cannabis (Bidwell et al., 2013; Cranford et al., 2016; Etter, 2015; Lee et al., 2016). Thus, there is a strong likelihood of relationships between impulsivity and cannabis vape-pen use or knowledge.

2.2. Normative beliefs

Evidence shows that perceptions regarding an individual's overall use may be impacted by peers' and parents' approval (Buckner, 2013). These perceptions are known as *normative beliefs* (Fishbein & Ajzen, 1977), and they have been shown to influence both perceived prevalence (i.e., descriptive norms) and perceived approval of cannabis by others (injunctive norms; Buckner, 2013). Perceptions that others use or approve of cannabis relate to more frequent cannabis problems and use (Buckner, 2013; Neighbors, Geisner, & Lee, 2008). Specifically, when perceptions of peer approval are high, positive expectancies may mediate an increase in cannabis use (Neighbors et al., 2008), however normative beliefs have not been examined among cannabis vape-pen users. It is likely that when cannabis use is perceived as positive by parents or peers, one may be more likely to engage in varying forms of cannabis use, including vape-pens.

2.3. Positive/negative expectancies

Cannabis Expectancies are anticipated effects individuals believe they will experience from the substance, which may affect decisions regarding substance use (Jones, Corbin, & Fromme, 2001). Expectancies connect memory with behavior to reflect knowledge of a relationship between events and objects (Goldman, Brown, & Christiansen, 1987). Young people are more likely to be influenced by positive than negative expectancies due to an over-emphasis on pleasurable effects, especially among more impulsive individuals (Smith & Anderson, 2001). Specifically, cannabis expectancies have been related significantly to future substance use (Barnwell & Earleywine, 2006). Thus, it will be important to determine whether cannabis expectancies also relate to cannabis vape-pen use and knowledge given lower perceived risk and potential for increased use among young adults.

2.4. Social anxiety

In addition to overall cannabis use and general psychological correlates such as impulsivity, norms and expectancies, we examined a variable with direct clinical relevance that has demonstrated relationships to cannabis use. *Social Anxiety* and social anxiety disorder (SAD) diagnosis remains high in undergraduate samples compared to the general population (Buckner, Bonn-Miller, Zvolensky, & Schmidt, 2007). Those with SAD are more vulnerable to cannabis use disorders (MUD; Buckner, Silgado, & Schmidt, 2011), and SAD is the only internalizing disorder found to be directly related to cannabis problems (Buckner et al., 2008; Buckner, Mallott, Schmidt, & Taylor, 2006). Similarly, having a negative social encounter due to anxiety has been related to cannabis-related problems (Phillips et al., 2015), and young women who smoke daily have reported a higher state of anxiety, even after adjusting for other substance use (Patton et al., 2002).

2.5. Other substance use

Individuals who report co-use of substances remain at an increased risk for related negative consequences. *Alcohol* is frequently co-used with cannabis by young adults (Gaher & Simons, 2007) and reciprocal relationships between alcohol and cannabis have been found. Specifically, genetic and environmental influences on subjective effects of one drug can alter subjective effects of the other (Haberstick et al., 2010). Further, studies have found parallel correlates of alcohol and cannabis use such as impulsivity, expectancies, and anxiety (Barnwell & Earleywine, 2006; Bidwell et al., 2013; Phillips et al., 2015). College students who use alcohol frequently were two times more likely to use vape-pens in a recent study (Jones et al., 2016). Further, alcohol use increases the chance of co-use with other substances, such as cannabis and tobacco (Yu & Williford, 1992).

Evidence suggests *tobacco* is also frequently used with cannabis by

young adults (McDonald, Popova, & Ling, 2016; Morean, Lipshie, Josephson, & Foster, 2017), and smoking tobacco in early adolescence is associated with developing high-risk cannabis use patterns (Nelson, Van Ryzin, & Dishion, 2015). Tobacco users are more likely than nonusers to try cannabis initially (Wagner & Anthony, 2002), and those who experiment with these products are more likely to become regular cannabis smokers (DiFranza & Wellman, 2005; Henningfield, Rose, & Giovino, 2002). In addition, smoking tobacco and related social factors can positively influence perceptions of cannabis use among young adults (Berg et al., 2015). Given that cigarettes continue to be the main source of tobacco use (Berg et al., 2015), we considered cigarette use in relation to cannabis vape-pen use.

3. Specific aims

Due to the changing landscape among both cannabis legislation and the increasing use and availability of vape-pens for cannabis use, this topic remains timely. In order to explore this further, we assessed factors potentially related to cannabis vape-pen use and knowledge of these devices based on relevant theory and evidence. We examined demographics, alcohol and tobacco use, cannabis expectancies, cannabis use, social anxiety, norms, and impulsivity as potential correlates of vape-pen use and knowledge. Given the high correlation among alcohol and cannabis, we hypothesized that those who had higher alcohol use would be more likely to both use and have heard of vape-pens (i.e., vape-pen knowledge). Further, based on prior research with strong correlations to cannabis use and our remaining constructs; we posited that there would be a higher likelihood of vape-pen use/knowledge among those who were more impulsive, socially anxious, with more positive expectancies of cannabis, and higher cannabis descriptive and injunctive norms. Given the novelty of vape-pens, we used a bottom-up approach to these analyses in order to ensure inclusion of as many potentially relevant correlates as possible.

4. Material and methods

4.1. Data collection

This study was a secondary analysis of data from a web-based survey of U.S. college students' cannabis use behaviors and correlates thereof (see Sartor et al., 2017). Participants were current undergraduates from four U.S. colleges or universities, and there were substantially more female participants enrolled in part because one recruiting university enrolls only women. Students were required to be 18 or older and proficient in English. Participants provided informed consent electronically before proceeding to the survey. IRB approval was obtained from the principal investigator's home institution and all institutions where data collection occurred.

4.2. Items and measures

Descriptions of all measures utilized in this study can be found below. Internal consistency reliability was tested for all multiple item measures using data from the present study.

4.2.1. Demographics

Participants reported their sex, age, year in school, living arrangements, race/ethnicity, and work status.

4.2.2. Vape-pen use and knowledge

Participants reported whether they had ever ingested cannabis using a portable electronic vaporizer (i.e., “electronic joint”, “JuJu Joint”, or “vape-pen”) and how often they had used them (6 options: “No, I have never even heard of those”, “No, I have heard of them, but never smoked one”, “yes, one time”, “yes, 2 or 3 times”, “yes, between 4 and 10 times”, “yes, > 10 times”). Given that a small minority of students endorsed lifetime vape-pen use, those selecting options between “yes, one time” to “yes, > 10 times” were classed as *having used vape-pens*. We utilized a similar coding strategy for vape-pen knowledge by identifying students who used vape-pens combined with those who have not used one but endorsed the second statement “I have heard of them…” to create the second outcome variable of having *vape-pen knowledge*.

4.2.3. Cannabis use

Respondents indicated their average cannabis use (smoked or eaten). Responses ranged from 0 (“*Less than four times in my life*” [*including never*]) to 7 (*once or more every day*).

4.2.4. Tobacco use

Respondents were asked about cigarette use only. Lifetime cigarette use was assessed with the question, “How old were you when you first smoked a cigarette.” Response options ranged from “less than 12 years of age” to “ > 25” with an option of “I have never smoked a cigarette in my life.” For the purposes of this study, this measure was recoded as a binary item of *ever smoked* (yes/no). Regular cigarette smoking was assessed with the question “How old were you when you started regularly (daily) cigarette smoking.” Response options were the same as *Lifetime* use, and this item was also recoded as a binary measure.

4.2.5. Cannabis expectancies

On the *Marijuana Effect Expectancy Questionnaire* (MEEQ; Schafer & Brown, 1991) participants rated 48 items on a 5-point scale ranging from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*). The MEEQ assesses three positive (Relaxation/Tension Reduction; Social/Sexual Facilitation; Perceptual/Cognitive Enhancement) and three negative (Cognitive/Behavioral Impairment; Craving/Physical; Global Negative) effects, which are summed to create two higher-order subscales (Aarons, Brown, Stice, & Coe, 2001). Following prior studies (Hayaki et al., 2011; Vangsness, Bry, & LaBouvie, 2005), we considered only positive versus negative expectancies, both of which showed high internal consistency (α = 0.95 and 0.95, respectively).

4.2.6. Alcohol use

The *Daily Drinking Questionnaire* (DDQ; Collins, Parks, & Marlatt, 1985) asks number of drinks consumed each day of a typical week, which yielded estimates of average drinks per drinking day over the past month. This measure has been used in many previous studies with good test-retest reliability (Marlatt et al., 1998).

4.2.7. Impulsive behavior

The 20-item, short version of the UPPS-P Impulsive Behavior Scale (Cyders, Littlefield, Coffey, & Karyadi, 2014) was used to measure 5 facets of impulsive behavior (4 items each), which had good internal consistency: negative urgency (α = 0.85), lack of perseverance (α = 0.78), lack of premeditation (α = 0.84), sensation seeking (α = 0.76), and positive urgency (α = 0.86) (Cyders et al., 2007; Whiteside & Lynam, 2003). Participants indicated agreement on a 4-point Likert-type scale ranging from 1 = *Strongly Disagree* to 4 = *Strongly Agree*. This measure has been used in many other studies with good test-retest reliability.

4.2.8. Social anxiety

On the 20-item Social Interaction Anxiety Scale (Mattick & Clarke, 1998), respondents indicate agreement on a 5-point scale ranging from 0 (*Not at all*) to 4 (*Extremely*). Example items include “I have difficulty making eye-contact with others” and “I feel I'll say something embarrassing when talking” (α = 0.92).

4.2.9. Perceived norms

Perceptions of parent and peer approval of cannabis use (not vape-pen use specifically) were assessed via a measure of alcohol norms

modified for cannabis (Baer, 1994). This measure replaces the word 'alcohol' with 'marijuana' and has been utilized in prior studies (Arbour-Nicitopoulos, Kwan, Lowe, Taman, & Faulkner, 2010; Ecker & Buckner, 2014; Neighbors et al., 2008). *Descriptive norms* were assessed via two items regarding peers, which asked how often their peers or average college students use cannabis (0 = never to 7 = every day), and two items regarding parents, which asked "did your mother/father ever use marijuana" (0 = no, 1 = maybe, 2 = yes). Both subscales had good internal consistency (peer: $\alpha = 0.86$, parent: $\alpha = 0.89$). *Injunctive norms* were assessed via three items each (nine-items total), which asked participants how disapproving or approving their mother, father and peers would be if they knew that the respondent smoked cannabis every weekend, daily, or drove a car after smoking cannabis (1 = strong disapproval to 7 = strong approval). These measures had good internal consistency (peer: $\alpha = 0.91$, mother: $\alpha = 0.85$, father: $\alpha = 0.92$).

4.3. Analyses

Given the relative novelty of this topic, we chose to take an exploratory approach; considering multiple factors potentially related to vape-pen use and knowledge. Data were analyzed with the Statistical Package for Social Sciences (SPSS, version 23.0; George & Mallery, 2016). First, distributions were evaluated for all predictor variables treated as continuous to evaluate skewness and kurtosis. Any skewed items were transformed using either log, inverse or squared. Next, bivariate correlations were examined to evaluate relationships among variables and to identify possible multicollinearity.

We then tested logistic regression models holding age, gender, and race constant in a multi-tiered strategy. We tested separate models for vape-pen use and knowledge. We anticipated strong correlations between cannabis use and vape-pen use/knowledge and thus tested regression models including and omitting cannabis use frequency. The former would determine which variables predicted unique variance in vape-pen use/knowledge above and beyond cannabis use. The latter models would capture variables that relate to vape-pen use/knowledge, allowing for possible overlap with current cannabis use.

First, we tested models that included all remaining variables after eliminating one variable from any highly correlated pairs. When confronted with highly correlated pairs of variables, we selected for inclusion the variable having stronger correlations with cannabis vape-pen knowledge and use. Second, we conducted a subsequent set of regression models including only near significant ($p \leq 0.1$) and significant predictors ($p < 0.05$) in order to limit ourselves to the strongest statistical predictors. This standard was used because some variables that are weakly associated with the outcome in a univariate model can be a significant predictor when taken together with other variables (Hosmer, Lemeshow, & Sturdivant, 2013). For parsimony, we report below results only from this subsequent set of models including near significant and significant statistical predictors of vape-pen knowledge or use. Full regression results are available upon request.

5. Results

Following screening of eligible participants, our final sample consisted of 270 college students. The majority of students were in their early 20s (20–23 year olds; 65.2%). Most participants were working part-time, Caucasian, and female (Table 1). Out of the entire sample 61% reported never smoking a cigarette in their lifetime, 88% had never smoked regularly, and 93.8% reported no cigarette smoking in the past week.

5.1. Cannabis use

The majority of students (54.1%) had tried cannabis in their lifetime and 10.7% reported having ever tried a vape-pen. For those who endorsed lifetime use, cannabis use tended towards lower frequency with 14.8% reporting having smoked "less than four times in my life"; 15.2% reporting having smoked 1–8 times per year; and 10% smoked 1 to 2 times per month. The 14.1% of more frequent users reported smoking once a week (3.3%), 2–4 times per week (5.2%), almost every day (3.0%) or 'once or more every day' (2.6%). There were no statistically significant gender differences for ever having tried a cannabis vape-pen, X^2 (2) = 0.952, $p = 0.621$, or for having knowledge of cannabis vape-pens, X^2 (2) = 0.466, $p = 0.792$.

Table 1
Descriptive statistics for key study variables (N = 270).

Frequencies and percentages for categorical variables	N (%)
Female	218 (80.7)
Age	
19 and under	63 (23.3)
20–23 years	176 (65.2)
25–26	16 (5.9)
27 and over	15 (5.5)
Ethnicity/Race	
Caucasian	158 (60.1)
African American	26 (9.9)
Asian	34 (12.9)
Multi-race	22 (8.4)
Other	23 (8.7)
Work status	
No outside employment	82 (30.9)
Part-time	166 (62.6)
Full-time	17 (6.4)
Class status	
Freshman	46 (17.2)
Sophomore	49 (19.3)
Junior	92 (34.9)
Senior	77 (28.6)
Have used a vape-pen (*Vape-pen use*)	29 (10.7)
Have heard of vape-pens (*Vape-pen knowledge*)	120 (44.4)
Lifetime cigarette smoking (*Ever smoked*)-*Binary* (*y/n*)	101 (38.8)
Past week cigarette smoking	16 (6.2)

Means (Standard Deviations) for continuous variables[a]	Mean (SD)	Sample range
Cannabis use frequency	1.6 (1.9)	0–7
Alcohol use-drinks per drinking day	4.4 (3.12)	1–21
Cannabis expectancies		
Negative	43.4 (22.1)	3–95
Positive	44.8 (22.3)	1–91
Social anxiety	25.7 (15.7)	0–71
Impulsivity		
Negative urgency	9.0 (3.4)	4–16
Sensation seeking	10.6 (3.1)	4–16
Lack of premeditation	6.8 (2.4)	4–16
Cannabis injunctive norms		
Peers	8.1 (4.4)	3–21
Father	4.8 (3.0)	3–18
Cannabis descriptive norms		
Parent	1.5 (1.5)	0–4
Peers	6.9 (3.6)	0–14

[a] Mean marijuana use ranged from (0) ' < 4 times in my life' and (7) 'once or more every day.' Positive/negative expectancies ranged from (1) 'Strongly Disagree' to (5) 'Strongly Agree.' Social anxiety ranged from (1) 'Not at all true of me' to (5) 'Extremely characteristic or true of me.' Impulsivity ranged from (1) 'Agree Strongly' to (4) 'Disagree Strongly.' Injunctive norm ranged from (1) 'Strong Disapproval' to (7) 'Strong Approval.' Descriptive norm peer ranged from (0) 'Never' to (7) 'Every Day.' Descriptive norm parent was (0) no (1) maybe (2) yes.

Table 2
Bivariate correlations.

	1	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Vape-pen Ever use	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2.Vape-pen Knowledge	0.38**	–	–	–	–	–	–	–	–	–	–	–	–	–
3. Gender	0.05	− 0.02	–	–	–	–		–	–	–	–	–	–	–
4. Race	− 0.06	0.01	0.02	–	–	–	–	–	–	–	–	–	–	–
5. Positive Ex.	0.22**	0.16*	− 0.03	− 0.18**	–	–	–	–	–	–	–	–	–	–
6. Drinks/drinking day	0.21**	0.19*	0.25**	− 0.11	0.03	–	–	–	–	–	–	–	–	–
7 Lack of premed	0.12	0.22**	0.10	− 0.05	0.08	0.11	–	–	–	–	–	–	–	–
8. Negative urgency	0.02	0.15*	0.01	0.06	− 0.13*	0.14*	0.08	–	–	–	–	–	–	–
9. Sensation seeking	0.06	0.06	0.15*	0.20**	− 0.09	0.23**	− 0.28**	0.26**	–	–	–	–	–	–
10. Social anxiety	− 0.04	0.05	− 0.02	− 0.10	0.29**	− 0.14*	0.12	0.09	− 0.24**	–	–	–	–	–
11. Inj. norm-peer	0.35**	0.24**	0.11	− 0.07	0.20**	0.29**	0.10	− 0.03	0.15*	0.01	–	–	–	–
12. Inj. norm-father	0.26**	0.22**	− 0.01	− 0.19**	0.19**	0.17**	0.17*	− 0.04	0.06	0.02	0.42**	–	–	–
13. MJ use	0.44**	0.29**	0.09	− 0.17**	0.29**	0.47**	0.19**	0.06	0.14*	− 0.01	0.54**	− 0.34**	–	–
14. Past week Cigarette Smoking	0.06	− 0.08	0.08	0.07	0.04	0.05	− 0.04	0.05	0.13*	− 0.10	0.03	− 0.07	0.15*	–
15. Lifetime cigarette Smoking	0.12	0.04	0.17**	0.02	0.07	0.23**	− 0.07	− 0.09	0.12	− 0.11	0.23**	− 0.15*	0.35**	0.32**

Notes: *$p < 0.05$; **$p < 0.01$; ever use = ever used a vape-pen; knowledge = vape-pen knowledge; Positive Ex. = positive expectancies; social anxiety = social interaction anxiety.
Log transformations: lack of premed = impulsivity-lack of premeditation; MJ use = marijuana use frequency; drinks per drinking day.
Square root transformation: negative urgency = impulsivity-negative urgency; Inj. norm-peer = injunctive norms-peer.
Inverse transformation: Inj. norm-father = injunctive norms-father, the direction of all correlations involving this variable were reversed to be in line with the raw version of the variable.
Cigarette smoking was binary (yes/no).

5.2. Bivariate correlations among study variables

Several bivariate correlations were notable (Table 2). Drinks per drinking day were correlated significantly with vape-pen use ($p < 0.01$) and to a lesser extent with vape-pen knowledge ($p < 0.05$; Table 2). Frequency of cannabis use and positive expectancies also correlated significantly with increased likelihood of vape-pen use. Lack of premeditation, negative urgency, and cannabis use were correlated significantly with knowledge of cannabis vape-pens. Social anxiety, sensation seeking, and cigarette use were not significantly correlated with cannabis vape-pen use or knowledge (Table 2). There were several pairs of strongly significantly correlated coefficients (all p's < 0.001): negative expectancies with positive expectancies, all descriptive norms with injunctive norms, mother's injunctive norms with father's injunctive norms, lack of perseverance with lack of premeditation, and positive urgency with negative urgency. The variable listed second in each pairing was retained in subsequent regression models (e.g., positive expectancies, negative urgency, etc.) due to higher correlations with vape-pen use/knowledge. For parsimony, only variables included in the subsequent regression models are reported in Table 2 but a full set of correlations is available upon request from the first author.

5.3. Logistic regressions with/without cannabis use

5.3.1. Cannabis vape-pen use

Following initial bivariate correlations, we tested logistic regressions including all variables from Table 2. We tested models including both near significant ($p \leq 0.10$) and significant statistical predictors ($p \leq 0.05$)—as mentioned in Section 4.3—because significance of a given variable in a multiple regression is dependent upon other variables in the model. Given the bottom-up approach, it was important to remain inclusive and avoid omitting any potentially significant variables from the logistic regressions. Although these variables were included, frequency of cannabis use was the only significant statistical predictor of vape-pen use (O.R. = 139.92, 95% C.I.: 6.81–2873.50, $p < 0.001$). However, when cannabis use was removed from the model, positive expectancies, alcohol intake, and peer injunctive norms were all significant statistical predictors (Table 3).

5.3.2. Cannabis vape-pen knowledge

When cannabis use frequency was included in the logistic regression model, lack of premeditation, which is a facet of impulsivity, statistically predicted vape-pen knowledge (Table 4). Negative urgency, another facet of impulsivity, trended towards significance (O.R. = 1.63, 95% C.I.: 0.99–2.70, $p = 0.056$). Without cannabis use frequency included, lack of premeditation still predicted cannabis vape-pen knowledge statistically (Table 4). Further, drinks per drinking day and negative urgency trended towards significance (Table 4).

Table 3
Logistic regression model predicting cannabis vape-pen use (including near significant/significant variables, omitting cannabis use frequency).

	Without cannabis use		
	O.R.	95% C. I.	*p*-Value
Positive expectancies	1.04	1.01–1.06	0.012
Drinks per drinking day	12.49	1.48–105.65	0.020
Cannabis peer injunctive norms	3.75	1.79–7.86	< 0.001

Notes: Demographics (race and gender) and other variables (sensation seeking, lack of premeditation, social interaction anxiety, and cannabis injunctive norms-father, past week cigarette smoking) were included in initial regression models but were not near significant or significant predictors and thus were omitted from the final model. Cannabis use frequency was the only significant statistical predictor of vape-pen use when included in model. OR = odds ratio; C.I. = confidence intervals.

6. Discussion

This study investigated factors associated with vape-pen use and knowledge. We found evidence, specifically in models omitting cannabis use frequency, supporting our hypothesized link between alcohol and cannabis vape-pen use and knowledge. Relationships between alcohol and vape-pen use were particularly strong. This is likely due to established relationships between alcohol and cannabis use (Gaher & Simons, 2007; Jones et al., 2016).

Similar to prior research (Buckner, 2013; Jones et al., 2001; Neighbors et al., 2008), we found that positive cannabis expectancies and peer injunctive norms related to vape-pen use, specifically in models omitting cannabis use frequency. This suggests that cannabis use frequency relates strongly to cannabis vape-pen use and knowledge, above and beyond other items within our models. Further, the strong relationship between cannabis use frequency and vape-pen use in our first model suggests it is unlikely that cannabis vape-pen use precedes other forms of cannabis use; unlike current trends with nicotine, where young adults are increasingly beginning with e-cigarettes rather than combustible cigarettes (Brown & Cheng, 2014).

The lack of significant relationships found with cigarette smoking is

Table 4
Logistic regression model predicting cannabis vape-pen knowledge (including near significant/significant variables, with and without cannabis use frequency in the model).

	With cannabis use			Without cannabis use		
	OR	95% C.I.	*p*-Value	OR	95% C.I.	*p*-Value
Lack of premeditation	15.25	1.71–136.46	0.015	20.43	2.45–170.64	0.005
Negative urgency	1.63	0.99–2.70	0.056	1.57	0.96–2.58	0.074
Drinks per drinking day[1]	–	–	–	3.27	0.98–10.86	0.053
Cannabis use frequency	6.91	2.64–18.07	< 0.001	–	–	–

Notes: Demographics (race and gender) and other variables (positive cannabis expectancy, alcohol intake, sensation seeking, social interaction anxiety, cannabis injunctive norms-peer, and cannabis injunctive norms-father, lifetime and past week cigarette smoking) that were not near significant predictors in initial models and were omitted from the final models. O.R. = odds ratio; C.I. = confidence interval.

[1] Was not significant with cannabis use frequency included ($p = 0.961$) but was nearly significant without cannabis use included.

somewhat surprising given prior findings in some samples linking cannabis with cigarette use among young adults (McDonald et al., 2016; Morean et al., 2017). The lack of significant relationships is likely due to low rates of cigarette smoking in this sample. Only 39% reported ever smoking a cigarette in their lifetime and only 6% reported smoking in the past week. However, our sample is not unique in lower cigarette smoking rates among college students, as prior studies have reported similar low cigarette smoking (Meier, Tackett, Miller, Grant, & Wagener, 2015; Rigotti, Lee, & Wechsler, 2000). Future studies should further examine nicotine use and its relationship to cannabis vape-pen use and knowledge.

Our sample of college students was less likely to report vape-pen use than in previous studies (Jones et al., 2016); however, this may be due to the lower number of male respondents in our study. Previous research has found that men use cannabis vape-pens more than women (Jones et al., 2016; Lee et al., 2016; Morean et al., 2017), although recent results are beginning to suggest that male-female differences in cannabis use may be decreasing (Johnson et al., 2015). These findings align with the current study, given that we did not find any significant gender differences for cannabis vape-pen use or knowledge. Our study is unique in that no previous studies have examined primarily Caucasian, female students' vape-pen use and knowledge. Given that women make up a majority of undergraduates enrolled at four-year colleges in the U.S. (55%; Lopez & Gonzalez-Barrera, 2014; U.S. Department of Education, 2014), examination of a primarily female sample has merit. Recent research has indicated that males and females react to substances differently, yet these differences remain understudied (Schepis et al., 2011). There has, however, been evidence that women have an earlier onset, or progress faster from initial use of cannabis into treatment (i.e. “telescoping”; Hernandez-Avila, Rounsaville, & Kranzler, 2004). Therefore, the present findings may enhance our knowledge regarding potential correlates of cannabis vape-pen use and knowledge, particularly among young women.

Just under half of our mainly female sample had even heard of vape-pens, which suggests there may be opportunity to further educate young adults, specifically women, regarding cannabis vape-pens. Further, it may be possible to reduce subsequent vape-pen use by informing young adults of risks associated with the cannabis vape-pen use, based on theory and empirical results supporting the influence of health-related knowledge on health behaviors (Ryan, 2009). Utilizing theory such as the IBM may offer structure in educating young adults on cannabis vape-pens and could be highly impactful in guiding education/prevention programs in a population similar to the present sample. Influencing knowledge (e.g., highlighting risks) may impact beliefs and perceptions and reduce misconceived approval towards cannabis vape-pen use. This may potentially buffer against perceptions that cannabis vape-pen use is normative. Our findings suggest impulsivity—specifically lack of premeditation—relates to vape-pen knowledge. Therefore, future studies should focus on young adults who tend to act quickly, without forethought and in response to negative affect. There may be particular need for accurate information about risks of cannabis vape-pen use so that these individuals might avoid subsequent problem use.

In addition to addressing vape-pen knowledge, influencing perceived norms and positive cannabis expectancies may also help young adults to avoid or reduce vape-pen use. Our study adds to the literature that cannabis expectancies and injunctive norms are significantly related to cannabis intake and may hold important implications regarding vape-pen use. Previous evidence found that as cannabis injunctive norms become more favorable, use may increase (Buckner, 2013). We found that peer injunctive norms and positive expectancies were significant statistical predictors of cannabis vape-pen use without cannabis use frequency included in the model, however future research would benefit from further examining these constructs to deconstruct how they relate to cannabis vape-pen use regardless of one's current cannabis use status. This is in line with previous research examining overall cannabis use and strong relationships to peer injunctive norms (Neighbors et al., 2008) and positive expectancies (Smith & Anderson, 2001). This may suggest that people are most likely to use cannabis vape-pens in environments where expectancies of drug use are mostly positive and they are surrounded by peers who share favorable attitudes towards cannabis use.

When examining alcohol use, we found that each additional drink per drinking day was associated with 12 times greater likelihood of cannabis vape-pen use, which is a much stronger relationship than in prior studies (Jones et al., 2016). This is important because previous findings linked alcohol and cannabis with common heritable, genetic influences (Haberstick et al., 2010), as well as other common behavioral factors, such as expectancies and impulsivity (Gaher & Simons, 2007; Whiteside et al., 2005). Given the relationship between alcohol and vape-pen use combined with strong correlations of each to peer injunctive norms, there may be a similar social component to cannabis vape-pen use and knowledge. Alcohol and cannabis are frequently used socially among young adults and evidence also supported a relationship between vape-pen use and social factors. This may suggest young adults' understanding of cannabis vape-pens is mostly positive due to low perceived risk-factors and social approval.

Alcohol had a small but significant negative correlation with social anxiety, however, it was surprising that vape-pen use and knowledge were not related to social anxiety. Previous research has found that social anxiety may increase the desire to use cannabis while in a stressful situation (among those who already use), especially for women and people with SAD (Buckner et al., 2011). However, vape-pen use/knowledge in this mainly female sample may have related more closely to social factors than to negative affect.

6.1. Limitations

This study used cross-sectional data, therefore it is impossible to determine the temporal ordering of associations among these variables. Thus, one cannot be certain if the chosen variables predicted subsequent cannabis vape-pen knowledge and use. Furthermore, the MEEQ

(Schafer & Brown, 1991) does not assess desirability of vape-pen expectancies, so findings may differ if using another scale. There was also only a small subset of participants who endorsed smoking cigarettes regularly (i.e., only 6% reported smoking in the past week). Although this is similar to recent findings regarding cigarette smoking among college students (Meier et al., 2015); the parent survey did not include questions on e-cigarette use. Given that young adults are more likely to try new technologies to administer substances (Brown & Cheng, 2014), some college students may use e-cigarettes rather than combustible cigarettes. Due to the omission of questions regarding e-cigarette use, we were not able to account for all nicotine use among our sample. Lastly, the homogeneity of the sample was a limitation. Data were collected from four separate universities and although it has a more diverse sample than many other college studies, there were still substantially more females. The present study does, however offer unique insight into factors pertaining to female college students' cannabis vape-pen use and knowledge.

6.2. Conclusions and implications

This study is novel in that previous work has not examined college student knowledge of vape-pens and how it may relate to their use, expectancies, or norms associated with cannabis. Future research would benefit from further examining these predictors, yet utilizing longitudinal data may offer more insight. The limited literature would benefit from exploring the IBM and potential moderators and mediators of how vape-pen knowledge may relate and interact with use. Vape-pens may act as a new form of gateway into cannabis use (Giroud et al., 2015), therefore examining mediators and moderators can be valuable to predict both negative consequences and frequency of cannabis use. Given the unknown consequences of vape-pens, the present findings offer valuable information on correlations and potential predictors of their use, particularly among female college students. Such work may have preventive implications for those at risk of negative cannabis-related consequences.

Given the societal approval that is leading to a greater number of states allowing cannabis to be used both medicinally and recreationally, it is important to understand new techniques for ingesting cannabis. Vape-pens for cannabis are particularly relevant due to their growing popularity among young people (Giroud et al., 2015; Gostin & Glasner, 2014; Jones et al., 2016; Morean, Kong, Camenga, Cavallo, & Krishnan-Sarin, 2015). More research is needed to clarify the temporal nature of these relationships. However, the current findings offer insight into potential factors that may contribute to the growing rates of cannabis use through vape-pens, particularly as they pertain to female college students.

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