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Characterizing marijuana concentrate users: A web-based survey

Raminta Daniulaityte[1,2], **Francois R. Lamy**[1,2], **Monica Barratt**[7,8,9], **Ramzi W. Nahhas**[3,6], **Silvia S. Martins**[4], **Edward W. Boyer**[5], **Amit Sheth**[2], and **Robert G. Carlson**[1,2]

[1]Center for Interventions, Treatment, and Addictions Research (CITAR); Department of Population and Public Health Sciences, Wright State University Boonshoft School of Medicine

[2]Ohio Center of Excellence in Knowledge-enabled Computing (Kno.e.sis); Department of Computer Science and Engineering, Wright State University

[3]Division of Epidemiology and Biostatistics; Department of Population and Public Health Sciences, Wright State University Boonshoft School of Medicine

[4]Department of Epidemiology; Columbia University Mailman School of Public Health

[5]Department of Emergency Medicine; University of Massachusetts Medical School

[6]Department of Psychiatry; Wright State University Boonshoft School of Medicine

[7]Drug Policy Modelling Program, National Drug and Alcohol Research Centre, UNSW Australia

[8]National Drug Research Institute, Faculty of Public Health, Curtin University, Australia

[9]Centre for Population Health; Burnet Institute, Australia

Abstract

Aims—The study seeks to characterize marijuana concentrate users, describe reasons and patterns of use, perceived risk, and identify predictors of daily/near daily use.

Methods—An anonymous web-based survey was conducted (April-June 2016) with 673 US-based cannabis users recruited via the Bluelight.org web-forum and included questions about marijuana concentrate use, other drugs, and socio-demographics. Multivariable logistic regression

Correspondence: Raminta Daniulaityte, PhD, Center for Interventions, Treatment, and Addictions Research, Department of Community Health, Wright State University Boonshoft School of Medicine, 3171 Research Blvd., Suite 124; Dayton, OH 45420-4006, Phone: 937-775-1411, raminta.daniulaityte@wright.edu.

Author Disclosures

Contributors

R. Daniulaityte, A. Sheth, R. Carlson, R. Nahhas, S. Martins and E. Boyer designed the study. F. Lamy contributed to design, testing and implementation of the web survey. M. Barratt helped with survey implementation and recruitment of study participants. R. Daniulaityte reviewed the literature, conducted statistical analyses and wrote the first draft of the paper. All authors reviewed, commented, and edited the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of Interest

All authors declare that there are no conflicts of interest.

analyses were conducted to identify characteristics associated with greater odds of lifetime and daily use of marijuana concentrates.

Results—About 66% of respondents reported marijuana concentrate use. The sample was 76% male, and 87% white. Marijuana concentrate use was viewed as riskier than flower cannabis. Greater odds of marijuana concentrate use was associated with living in states with "recreational" (AOR=4.91; p=0.001) or "medical, less restrictive" marijuana policies (AOR=1.87; p=0.014), being male (AOR=2.21, p=0.002), younger (AOR=0.95, p<0.001), number of other drugs used (AOR=1.23, p<0.001), daily herbal cannabis use (AOR=4.28, p<0.001), and lower perceived risk of cannabis use (AOR=0.96, p=0.043). About 13% of marijuana concentrate users reported daily/near daily use. Greater odds of daily concentrate use was associated with being male (AOR=9.29, p=0.033), using concentrates for therapeutic purposes (AOR=7.61, p=0.001), using vape pens for marijuana concentrate administration (AOR=4.58, p=0.007), and lower perceived risk of marijuana concentrate use (AOR=0.92, p=0.017).

Conclusions—Marijuana concentrate use was more common among male, younger and more experienced users, and those living in states with more liberal marijuana policies. Characteristics of daily users, in particular patterns of therapeutic use and utilization of different vaporization devices, warrant further research with community-recruited samples.

Keywords

marijuana concentrates; cannabis; web survey

1. Introduction

Marijuana concentrates, also known as "dabs," "hash oil," "shatter," or "wax," are highly potent tetrahydrocannabinol (THC) preparations derived from cannabis plant material, frequently using solvent-based methods (Drug Enforcement Administration, 2014; Drug Policy Alliance, 2015). Such products contain very high THC levels that can range from 40% to 80% (Drug Enforcement Administration, 2014). In comparison, according to 2014 data, THC content in illicit cannabis plant material was found to be around 12% (ElSohly et al., 2016). Marijuana concentrates are typically vaporized using various types of vaporization devices ranging from discreet e-cigarette-like devices (dabs or wax pens) adapted for concentrate use to large dabs "rigs" (water pipes) that require use of a torch to heat a titanium or glass "nail" to vaporize the concentrate (Budney et al., 2015; Drug Policy Alliance, 2015). They can also be placed on top of dried marijuana plant material and smoked (Drug Enforcement Administration, 2014).

There are numerous slang names that are being used to refer to marijuana concentrates, such as "dabs," "shatter," "wax," and "oil," including names that suggest how the concentrates were produced (e.g., "butane hash oil" or BHO) (Bailey, 2017). The terminology is still evolving as new types of production (e.g., rosin) or use methods (e.g., gravity bong dabs) emerge. "Dabs" is one of the more commonly appearing slang terms that is used to refer to concentrates regardless of how they have been produced (e.g., "BHO dabs" or "rosin dabs") or how they are consumed (e.g., "dabs rig" or "vape pen for dabs" or "vaping dabs") (Chambers, 2017).

Marijuana concentrate use is a growing trend across the United States (Bell et al., 2015; Carson, 2013; Drug Enforcement Administration, 2014; Relyea, 2016; Woods, 2016; Zhang et al., 2016). In states that allow retail of marijuana products for recreational use, they can be obtained legally from licensed retailers and producers. Qualified patients can also have legal access to such products at some medical marijuana dispensaries (Drug Enforcement Administration, 2014).

Because of the increased THC concentration and novel means of administration, use of marijuana concentrates may contribute to more severe problems in terms of the risks associated with cannabis use, such as addiction, psychotic disorders, and potential cognitive impairment (Degenhardt et al., 2013; Hall and Degenhardt, 2009; Keller et al., 2016; Miller et al., 2016; Moore et al., 2007; Stogner and Miller, 2015). Furthermore, with increasing use of more potent marijuana products, findings from older studies on the effects of marijuana use should be reassessed for relevance to current patterns and trends of use (Volkow et al., 2014).

Although media reports about marijuana concentrate use in the U.S. have been increasing (Associated-Press, 2014, 2015; Denson, 2014; Healy, 2015; Wyatt and Johnson, 2015), research remains limited. One prior web-based survey used Craigslist to recruit 357 individuals in the U.S. who reported “dabs” use. The study found that users viewed marijuana concentrates to be more dangerous than herbal/flower cannabis and reported an increase in tolerance and withdrawal symptoms (Loflin and Earleywine, 2014). A study that focused on e-cigarette use to vaporize cannabis among high school students in Connecticut, found that 4.5% of the total sample (N=3,847) had used e-cigarettes to vaporize hash oil (Morean et al., 2015). Several case reports have been presented on adverse medical consequences associated with marijuana concentrate production in patients presenting for treatment in states with more liberal cannabis legalization policies (Bell et al., 2015; Keller et al., 2016).

Analysis of Twitter data demonstrated a greater level of marijuana concentrate-related tweeting activity in states that allow recreational and/or medical use of cannabis (Daniulaityte et al., 2015). Similarly, analysis of Google search data found that dabbing searches were significantly more frequent in states with recreational marijuana legalization, and indicated an increasing trend in the U.S. (Zhang et al., 2016). Another Twitter-based study analyzed a sample of 3,540 tweets related to dabbing marijuana concentrates and found relatively few tweets mentioning extreme effects related to dabbing; “passing out” and respiratory issues were among the more commonly mentioned physiologic effects (Cavazos-Rehg, Krauss, Sowles, Connolly, et al., 2016). Prior research has also concluded that dabbing-related information is readily available on YouTube (Krauss et al., 2015) and Instagram (Cavazos-Rehg et al., 2016).

There is a lack of data on the characteristics of marijuana concentrate users as well as user knowledge, attitudes, and behaviors related to marijuana concentrate use. This study is based on an anonymous web-based survey conducted via the Bluelight.org web forum. Data obtained from the U.S.-based subsample were analyzed to: 1) identify regional (state-level cannabis policy-related), socio-demographic, cannabis, and other drug use characteristics

associated with marijuana concentrate use; 2) characterize marijuana concentrate users' perceptions of risk and sources, patterns and reasons of use, and 3) identify regional, sociodemographic, and marijuana concentrate use characteristics associated with daily/near daily concentrate use.

2. Methods

2.1. Bluelight Web Forum

Bluelight.org is a publicly available web forum that is focused on sharing information and experiences related to drug use practices, including cannabis-related discussions. Bluelight is the largest and one of the most popular drug discussion websites (Anderson et al., 2017). Furthermore, the Bluelight community supports research and has been used as data source for web-based research on illicit drug use by numerous prior studies (Anderson et al., 2017; Soussan and Kjellgren, 2014, 2015), including research that used Bluelight as a platform to recruit participants for web-based surveys (Chiauzzi et al., 2013; Soussan and Kjellgren, 2016). The third author (M.B.), who has served as a volunteer research administrator for Bluelight's research portal for the last 10 years, has helped facilitate engagement with the Bluelight community and provided guidance in implementation of participant recruitment procedures.

Recruitment through a web-based forum is likely to produce a sample of respondents who have more extensive drug use histories (Davey et al., 2012; Soussan and Kjellgren, 2016) than a random sample of cannabis users. However, these individuals can be characterized as innovative drug users or trend-setters (Boyer et al., 2005) and thus are a valuable source of information on emerging drug use practices.

2.2. Participants And Recruitment

Data were collected between April and June 2016. The web-based survey was completely anonymous (no IP addresses were collected), and developed using Qualtrics (Qualtrics, 2016). The aforementioned administrator (M.B.) posted an invitation to participate in the study in the "Drug Studies" section of Bluelight.org, which is devoted to promoting research opportunities to the community. A banner advertisement was visible to all site members or visitors for the duration of the recruitment period. Bluelight moderators were asked to promote the survey in their respective site pages, including the Cannabis forum. These posts inviting participation in the survey were pinned to forums so that they did not move out of view as the web forum activities progressed. During the recruitment period, the Bluelight research administrator (M.B.) posted several participation reminders to encourage individuals to take part in the study.

Participation was completely voluntary, anonymous, and there was no monetary incentive to participate in the study. The Institutional Review Boards at the participating institutions approved the survey under Exemption 2 (online survey, no personally identifiable information obtained).

To be eligible for participation, individuals had to: 1) be 18 years of age or older; and 2) report use of any form of cannabis at least once in their lifetime. Individuals who chose to

click on the survey link were first provided with an online informed consent form and had to click “yes” to indicate their consent to participate in the study. If they indicated agreement to participate, they were linked to eligibility questions. Only those who were eligible were linked to the survey questions.

A total of 1,437 respondents clicked “yes” to indicate agreement to participate and were linked to eligibility questions, of whom 18 were not eligible. Of the 1,409 eligible respondents,1,082 completed the survey (77%). Thirteen were identified as inconsistent respondents (e.g., indicating age of first cannabis use greater than current age) and excluded, resulting in an international sample of 1,069 respondents. The present analysis was limited to the U.S.-based subsample of 673 respondents.

2.3. Survey Questions

The survey took about 10–15 minutes to complete and included questions about use of different types of cannabis products and other drugs; knowledge, attitudes and behaviors related to marijuana concentrate use; and socio-demographic characteristics. Demographic variables included age, gender, ethnic/racial background, education, employment status, country of residence, and state (Table 1). When possible, survey questions were adopted and/or modified from prior studies (Loflin and Earleywine, 2014; Palamar et al., 2015) and established assessments (e.g., National Survey on Drug Use and Health). Design of the questionnaire was also informed by our team’s prior analyses of social media data on cannabis product use (Daniulaityte et al., 2016; Daniulaityte et al., 2015; Lamy et al., 2016). The survey items were reviewed by the Bluelight web forum administrator and moderators for additional editorial and technical suggestions.

Use of marijuana concentrates (dabs/wax/shatter) and other types of cannabis products was assessed using the following question: “Have you ever, even once, used the following types of cannabis products?” A list of cannabis products included in the survey is displayed in Table 1. Frequency of use was assessed: “In the past year, how frequently, on average, have you used [cannabis product]?” Response options included: “Did not use in the past year”; “Less than 1 day per month”; “About 1–2 days per month”; “About 1 day per week”; “About 2–3 days per week”; and “Almost every day or every day.” Reasons for use: “Why do/did you use marijuana concentrates (dabs/wax/shatter)?” Methods of use: “How have you used marijuana concentrates (dabs/wax/shatter)?” Sources of marijuana concentrates: “How have you ever obtained marijuana concentrates (dabs/wax/shatter)?” Method of production (if made own): “What method did you use to make marijuana concentrates (dabs/wax/shatter)?” Perceived health-related risks were assessed with the following questions: “In general, do you think that daily (near daily) smoking of [flower/herbal cannabis; marijuana concentrates] could lead to the following health risks?” Nine health risks were selected based on prior research on cannabis use (National Academies of Sciences, 2017), and web-based discussions of potential health-related issues. They included: harm to the lungs, anxiety/panic attacks, addiction, poor concentration, lack of motivation, poor memory, depression, psychosis/schizophrenia and cannabinoid hyperemesis syndrome. Likert scale response options included: 1-Not at all; 2-A little; 3-Quite a bit; 4-Very much so. Perceived

risk variables (for flower/herbal marijuana and marijuana concentrates) were calculated by adding Likert scale ratings for each of the nine health-related risks.

2.4. Statistical Analyses

Statistical analyses were conducted using SPSS (IBM-Corporation, 2016). Frequencies and descriptive statistics were used to characterize the sample and marijuana concentrate use practices. Paired sample t-tests were used to compare marijuana concentrates and flower/herbal cannabis in terms of user perceptions of health-related risks.

First, multivariable logistic regression analysis was conducted to identify regional (state-level cannabis policy-related), socio-demographic, and drug use characteristics associated with marijuana concentrate use. Drug use characteristics included the following variables: perceived risk of cannabis use, age of first cannabis use, daily herbal/flower cannabis use, and number of other drugs ever used. The number of other cannabis products ever used was not included in the multivariable logistic regression analysis because this variable was associated with the state-level cannabis policy variable.

Second, multivariable logistic regression analysis was conducted to identify regional, socio-demographic, and marijuana concentrate use characteristics associated with “daily or almost daily” marijuana concentrate use in the past year. Marijuana concentrate use characteristics included the following variables: perceived risk of marijuana concentrate use, reasons of use (therapeutic vs. to get high/experiment only), method of administration (vape pens), and involvement in production (ever made own concentrates). Selection of drug use- related variables for the two multivariable logistic regression analyses was based on prior research on marijuana concentrate and other emerging practices of cannabis use (Lankenau et al., 2017; Lee et al., 2016; Loflin and Earleywine, 2014).

Socio-demographic characteristics included race/ethnicity (“non-Hispanic white” vs. all others), age, sex (male vs. “female or transgender"), education (“some college education or more” vs. “high school or less”), and employment (“full or part time employed” vs. all others). To assess regional influences, states were classified into 4 groups based on cannabis legalization policies. The “Recreational” group included AK, CO, OR, WA, and DC, all of which have passed recreational marijuana laws and implemented them, or started their implementation, as of March 2016. States with medical marijuana programs were grouped into two categories based on their restrictiveness in term of such criteria as the degree to which the state’s law imposes barriers to becoming a registered medical marijuana user, whether cultivation and/or dispensaries are allowed, and the total amount of cannabis that the state’s law allows a user to possess (Chapman et al., 2016; Williams et al., 2016). The “Medical, less restrictive” group includes 11 states (AZ, CA, HI, IL, MA, MI, ME, MT, NM, NV, RI) classified as having less regulated programs. “Medical, more restrictive” includes 8 states (CT, DE, MD, MN, NH, NJ, NY, VT) that have been classified as having more restricted and “medicalized” programs. The “Illegal” group included 27 states (AL, AR, FL, GA, IA, ID, IN, KS, KY, LA, MO, MS, NC, NE, ND, OH, OK, PA, SC, SD, TN, TX, UT, VA, WV, WI, WY) that had no comprehensive medical cannabis laws implemented as of March 2016.

3. Results

3.1. Demographic And Drug Use Characteristics

The majority of the U.S.-based respondents (N=673) were male (76%), with at least some college education or more (74%), and employed (60%). The majority self-identified race as white (87%), and about 6% indicated that they were of Hispanic ethnicity (Table 1). The sample characteristics are similar to other studies that used Bluelight and other web forums to recruit participants (Chiauzzi et al., 2013; Vandrey et al., 2012).

The sample included respondents from all states except Nebraska. As expected, the greatest numbers of respondents were from the most populous states; for example, 86 were from California, 43 from Florida, 42 from New York, and 40 from Texas.

The participants had extensive drug use experience. Reported lifetime use of selected substances is presented in Table 1. Almost all had used alcohol, about 92% had used tobacco, 74% e-cigarettes, and about 75% illicit pharmaceutical opioids. Use of LSD, psilocybin, and cocaine HCl were each reported by over 66% of the respondents. About 53% had used methamphetamine, and almost 30% heroin.

The participants had extensive exposure to different types of cannabis products (Table 1). Almost all (99%) reported lifetime use of the most common form of cannabis—herbal/flower (weed/bud). Over 40% indicated that they used herbal/flower marijuana on a daily or near daily basis in the past year. Marijuana resin and marijuana edible use were each reported by over 80% of respondents. Lifetime use of cannabis tinctures, ingestible oil (such as Rick Simpson oil), and CBD oil were each reported by over 25% of respondents. Over 66% reported use of marijuana concentrates.

Demographic and drug use history characteristics of the subgroup of marijuana concentrate users (n=447) are presented in Table 1. About 84% were male, about 70% had some college education or more, and almost 60% were employed. Lifetime history of use of hashish, kief (dry sift/pollen), and marijuana edibles were each reported by about 90% of marijuana concentrate users, and more than half reported using flower/herbal cannabis (weed/bud) daily or near daily in the past year.

3.2. Predictors of Marijuana Concentrate Use

Multivariable logistic regression analysis results (Table 2) indicate that living in “Recreational” (vs. “Illegal”) states was the strongest predictor of lifetime marijuana concentrate use (AOR (Adjusted Odds Ratio)=4.91; p=0.001). Living in a “Medical, less restrictive” state and being male were also associated with greater odds of marijuana concentrate use (AOR=1.87, p=0.014, and AOR=2.21, p=0.002, respectively), while older age was associated with lower odds of marijuana concentrate use (AOR=0.95, p<0.001). Education and employment status had no significant association with marijuana concentrate use. Among drug-related variables, a greater number of other drugs ever used (AOR=1.23, p<0.001) and daily marijuana (flower/bud) use (AOR=4.28, p<0.001) were related to significantly greater odds of using marijuana concentrates. Greater perceived risk of

cannabis use was also significantly associated with lower odds of marijuana concentrate use (AOR=0.96, p=0.043).

3.3. Characterizing Marijuana Concentrate Use

3.3.1. Frequency and Reasons Of Use—Most marijuana concentrate users (54%) reported using concentrates a few days per month or less frequently in the last year. About 13% reported daily or near daily use of marijuana concentrates (Table 3).

To "get high" was the most commonly reported reason for marijuana concentrate use (86%). However, many also reported therapeutic reasons, such as to help sleep (45%), control pain (32%), or increase appetite (31%) (Table 3). Overall, about 61% reported ever using marijuana concentrates for self-treatment purposes (including help with sleep, pain, appetite, control nausea, quit using other drugs, and get away from problems). Many individuals reported multiple reasons for use--about 90% of those who reported using marijuana concentrates for therapeutic purposes also reported using them to get high or experiment.

3.3.2. Methods of Use—Using a "dabs rig" was the most common method to consume marijuana concentrates (77%) (Table 3). A dabs rig is a special type of water pipe, usually a large tabletop unit that is used primarily for marijuana concentrates. The process involves using a torch to heat a titanium or glass "nail" to vaporize marijuana concentrates. Vape pens were the second most commonly used method (66%). Vape pens are small, e-cigarette-like vaporization devices adapted for marijuana concentrate use (Lee et al., 2016). About 13% reported using a gravity bong—a self-made smoking device that reportedly makes smoking significantly more efficient and can be made using simple household items such as water bucket and 2-liter plastic bottle. Over 15% reported using a "nectar collector," which is a vertical vaporizer that is a smaller and more portable version of a dabs rig. Besides vaporization devices, many individuals also reported smoking concentrates along with herbal/flower cannabis in a marijuana joint (44%) or blunt (33%).

3.3.3. Sources and Involvement In Production—The most commonly reported method of obtaining marijuana concentrates was "free from friends/family" (69%), followed by purchase from friends/family (42%) and purchase from dealers (around 41%) (Table 3). Over 24% reported buying from medical dispensaries and about 10% from a recreational cannabis store. Almost 8% reported use of Cryptomarkets (DarkNet markets) that allow anonymous transactions via their location on the hidden (or "Dark") web and use of cryptocurrencies for payment (Barratt and Aldridge, 2016).

Over 25% reported that they had made their own marijuana concentrates, most commonly via butane extraction (70%). Respondents also reported using solvent-less methods such ice water extraction and the rosin technique (Table 3). The rosin technique is based on the use of pressure and heat to produce concentrates, and can involve utilization of simple household items such as hair straighteners and parchment paper.

3.4. Perceptions of Health-Related Risks

Average ratings of potential health-related risks associated with daily use of herbal/flower cannabis and marijuana concentrates are presented in Table 4. Overall, respondents did not view daily marijuana concentrate use as very risky in terms of potential health effects. Most health-related risks received an average score close to 2 or between 1 and 2, where 1 means “not at all,” 2 means “a little,” 3 means “quite a bit,” and 4 ”very much so.” Among marijuana concentrate users, the three most highly rated health-related risks associated with daily dabs use were poor memory (average of 2.30), lack of motivation (2.28), and harm to the lungs (2.27), while psychosis (1.48), cannabinoid hyperemesis syndrome (1.50), and depression (1.59) were rated as the least likely. The risk of becoming addicted to cannabis as a result of daily marijuana concentrate use received an average rating of 2.12.

Individuals who did not use marijuana concentrates viewed herbal/flower cannabis use as more harmful to the lungs than marijuana concentrate use, and this difference was statistically significant (p=0.003) (Table 4). Among concentrate users, however, the difference was smaller and not statistically significant (p=0.085). All other health-related risks were rated higher for marijuana concentrate use than for flower cannabis use, all significantly so among concentrate users (p<0.001). Individuals who did not report marijuana concentrate use, however, did not report significantly different average perceived risk for “poor concentration” or “lack of motivation”. Among marijuana concentrate users, the difference in average perceived risks between daily flower cannabis and daily concentrate use was greatest for anxiety/panic attacks.

3.5. Predictors of Daily/Near Daily Marijuana Concentrate Use

Multivariable logistic regression analysis shows that males had over 9 times the odds of others (AOR=9.29, p=0.033) to use marijuana concentrates almost every day or every day in the past year (Table 5). No other socio-demographic variable was significantly associated with daily/near daily use. Living in a state that allows recreational and/or medical marijuana use showed greater odds of daily/near daily marijuana concentrate use compared to "illegal" states, but these differences were not statistically significant (Table 5).

Use of marijuana concentrates for therapeutic purposes increased the odds of daily/near daily concentrate use almost 8 times (AOR=7.61, p=0.001). Use of vape pens for marijuana concentrate administration (AOR=4.58, p=0.007) was also a robust predictor of daily/near daily marijuana concentrate use. Perception of greater health risks of marijuana concentrate use was associated with lower odds of daily/near daily concentrate use (AOR=0.92, p=0.017). Those who reported ever producing marijuana concentrates showed greater odds of daily/near daily use, but this association was not statistically significant (AOR=1.74, p=0.116) (Table 5).

4. Discussion

This study is one of the first to describe the characteristics of marijuana concentrate users based on web-based survey data collected through a drug web-forum. Over 66% of the U.S.-based respondents (N=673) reported use of marijuana concentrates, and about 13% of

concentrate users reported using concentrates almost every day or every day. This relatively high prevalence is likely linked to the fact that the study recruited from the population of users who are engaged in web-based sharing of drug use knowledge and experiences. (Loflin and Earleywine, 2014).

Our findings show that the odds of marijuana concentrate use were almost 5 times greater for those living in the states that allow recreational marijuana use compared to states where marijuana is illegal. Likelihood of use was also significantly greater in states with less restrictive medical marijuana policies. These findings are consistent with prior research showing that states with more liberal marijuana policies, especially those with growing recreational cannabis markets and/or medical dispensary systems, are more likely to exhibit engagement in novel practices of cannabis use (Borodovsky et al., 2016; Daniulaityte et al., 2015). For example, data from Washington show that marijuana concentrates for inhalation are becoming increasingly more popular, accounting for 21% of recreational cannabis sales in 2016, compared to 12% in 2015 (National Academies of Sciences, 2017).

The multivariable logistic regression analysis to identify predictors of marijuana concentrate use did not include “other cannabis products ever used” because this variable is redundant with the variable indicating state legal status in terms of marijuana policies. It is not clear whether living in a state that has less restrictive marijuana policies leads to more cannabis products being used, including concentrates, or if using a greater number of other types of marijuana products, regardless of state legal status, leads to using marijuana concentrates (or both). When number of other cannabis products was added to the model, there was no longer a statistically significant difference between states with different legal statuses. We found a meaningfully large but non-significant interaction between number of products and legal status. The effect of legal status declined as the number of other products used increased; those who used many other cannabis products were highly likely to also use concentrates regardless of their state’s marijuana legal status. However, legal status was more related to concentrate use among those who only use one or two other cannabis products. This potential interaction, which was not statistically significant, warrants further investigation in a larger sample.

Multivariable logistic regression analyses results indicate that males were not only significantly more likely to use marijuana concentrates, but among users they were also about 9 time more likely use concentrates daily or almost daily. These findings are consistent with prior research showing that males are more likely to engage in problematic patterns of cannabis use (Grant et al., 2006). Those who are younger or report a greater number of other drugs used in their lifetime were also significantly more likely to use marijuana concentrates. These characteristics are consistent with a profile of “innovators” who are typically younger, male, and more experienced in other drug use practices (Boyer et al., 2005). In general, males and younger individuals are more likely to exhibit sensation-seeking behaviors (Donohew et al., 1999) and engage in novel drug use practices (Etter, 2015; Lee et al., 2016; Morean et al., 2015; Palamar et al., 2015).

Daily/near daily use of herbal/flower cannabis was also a strong predictor of marijuana concentrate use. Although the interpretation is limited due to the cross-sectional nature of

the collected data, one potential explanation could be that more frequent use of herbal/flower marijuana results in increased tolerance, which would lead some users to seek more potent marijuana products.

Obtaining marijuana concentrates free from friends/family was the most commonly reported source of marijuana concentrates. About 8% reported obtaining marijuana concentrates from cryptomarkets, which are web-based marketplaces that are located on the hidden web ("DarkNet") and require use of cryptocurrencies such as bitcoin for payment to ensure anonymity (Barratt and Aldridge, 2016). Research indicates that cannabis products are among the most commonly sold drugs on cryptomarkets, in particular by U.S.-based sellers (Van Buskirk et al., 2016).

About 26% of marijuana concentrate users reported ever producing concentrates on their own, and butane extraction was the most commonly reported method. Butane-based method has attracted more media attention (Associated-Press, 2014, 2015) due to reports of fires and injuries resulting from using this solvent-based method in home-based operations (Bell et al., 2015). Our study participants also reported using solvent-less methods such as the "rosin" technique, which is a relatively new method that uses pressure and heat to extract THC. Home-based production of rosin can involve utilization of hair straighteners and parchment paper, but recently more specialized tools such as commercial grade "rosin presses" have been appearing on the market (Coffey, 2016). Solvent-less methods might be gaining in attraction as more desirable methods of concentrate production because of the risk of injuries resulting from butane use (Romanowski et al., 2017) and potential product contamination with solvents (Raber et al., 2015).

Over 60% of respondents reported ever using marijuana concentrates for therapeutic purposes (including help with sleep, pain, appetite, control nausea, quit other drugs, and help deal with problems). This is an important finding that dovetails with the growing societal interest in therapeutic potential and health benefits of cannabis for a wide range of medical conditions (National Academies of Sciences, 2017).

Multivariable regression analysis indicates that use of marijuana concentrates for therapeutic purposes increased the odds of daily/near daily marijuana concentrate use over 7 times compared to those who only used concentrates to get high and/or experiment. Vape pen use was also a robust predictor of daily/near daily concentrate use after controlling for other socio-demographic and drug use characteristics. Prior research has also shown that vaporizer use for cannabis administration is generally perceived as healthier than smoking (Budney et al., 2015; Etter, 2015; Lee et al., 2016; Malouff et al., 2014) and can be also viewed as a "therapeutic" way to consume cannabis (Varlet et al., 2016). Therapeutic reasons and methods of consuming marijuana concentrates are indicative of a pattern of medicinal use that is more regular and frequent. Prior research also suggests that medical users tend to use marijuana more frequently than non-medical users (Lankenau et al., 2017). Besides perceived therapeutic benefits, vape pens also are easier to use and offer greater discretion than other methods, which allows use in more places and contributes to greater likelihood of more frequent use (Jones et al., 2016).

Marijuana concentrates were generally viewed as more risky than herbal/flower cannabis in terms of most health-related harms. However, individuals who have never used concentrates thought that concentrates were less harmful for the lungs than herbal/flower marijuana. In contrast, marijuana concentrate users rated concentrates and herbal cannabis as having a more similar level of risk in terms of harm to the lungs. Overall, respondents did not view marijuana concentrates as very risky in terms of potential health effects, with memory, motivation-related effects, and harm to lungs receiving the greatest average scores among individuals who reported marijuana concentrate use. Such risk-minimization attitudes among survey respondents are consistent with the general trend in the U.S. of declining perception of risk of harm from marijuana use (Hughes et al., 2015). Multivariable logistic regression analysis results show that greater perception of risk of herbal cannabis use was associated with lower odds of ever using marijuana concentrates. Similarly, greater perception of risk of marijuana concentrate use was associated with lower likelihood of being a daily/near daily user of marijuana concentrates.

Race/ethnicity did not show significant association with marijuana concentrate use, nor with more frequent patterns of use. Most likely, the sample was not sufficiently diverse to identify ethic/race-based associations. Web-based surveys conducted through web-forums have displayed similar limitations in terms of the inability to recruit racial minorities (Chiauzzi et al., 2013; Vandrey et al., 2012).

We acknowledge that the sample was self-selected among people recruited through a web forum and, among those who started the survey, there were some non-completers, both of which increase the potential for non-generalizable results. Because the survey was completely anonymous and no IP addresses were collected, it was not possible to identify repeat respondents, if any. However, we did not offer any compensation for completing the survey, a method known to discourage deception and repeat responses in web-based research (Bowen et al., 2008). Furthermore, the data were self-reported; however, there is substantial support for the validity and reliability of self-reported data on substance use behaviors (Adair et al., 1995) and data obtained via web-based self-administration (E. T. Miller et al., 2002). Another limitation is the cross-sectional nature of the data. Longitudinal studies are required to understand causal relationships between patterns and reasons of marijuana concentrate and other drug use. The sample underrepresented females and ethnic minorities, and may not generalize to cannabis users across a broader demographic range, or to those who are less willing, or able, to share information online. On the other hand, individuals who use drug related web-forums have been characterized as highly experienced users (Davey et al., 2012; Soussan and Kjellgren, 2016) who may play a pivotal role in disseminating knowledge of emerging drug use practices to their peers, and thus are important prevention targets (Boyer et al., 2005).

Therapeutic use-related practices and use of different types of concentrate vaporization devices warrant further research with large community recruited samples. Answers to important public health questions including understanding the health consequences of marijuana concentrate use over time, concomitant use of other drugs, psychiatric comorbidity and substance use disorder trajectories are needed. The use of marijuana concentrates to self-treat pain and dependence on other drugs are extremely important

research questions (Compton et al., 2017) in the context of pharmaceutical opioid and heroin epidemics (Carlson et al., 2016; Jones et al., 2015; Kanouse and Compton, 2015) and expanding medical marijuana policies in the United States and some other countries (Pacula et al., 2015; Room, 2013).

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Highlights

- 66% of the sample reported lifetime use of marijuana concentrate.
- 13% of marijuana concentrate users reported daily use of concentrates.
- Concentrate users were more likely to be from liberal marijuana policy states.
- Daily concentrate use was associated with therapeutic use and use of vape-pens.
- Marijuana concentrates were viewed as more risky than herbal/flower cannabis.

TABLE 1

Demographic and drug use characteristics (U.S.-based respondents)

Characteristic	Total Sample N=673	Marijuana Concentrate Users N=447
Gender		
Male	513 (76.2)	375 (83.9)
Female	145 (21.5)	59 (13.2)
Transgender	5 (0.7)	4 (0.9)
No response	10 (1.5)	9 (2.0)
Age		
Mean (Std. deviation)	29.6(12.2)	27.0(10.4)
Ethnicity		
Hispanic	41 (6.1)	26 (5.8)
Non-Hispanic	592 (88.1)	390 (87.2)
No response	39 (5.8)	30 (6.7)
Race		
White/Caucasian	583 (86.8)	385 (86.1)
African American	9 (1.3)	8 (1.8)
Asian American	9 (1.3)	4 (0.9)
Native American	10 (1.5)	6 (1.3)
Other	33 (4.9)	24 (5.4)
No response	28 (4.2)	19 (4.3)
Education		
High School or less	169 (25.1)	131 (29.3)
Some college or more	498 (74.0)	312 (69.8)
No Response	6 (0.9)	4 (0.9)
Employment		
Full time	285 (42.3)	173 (38.7)
Part time	119 (17.7)	90 (20.1)
Not employed-disability/retirement	54 (8.0)	27 (6.0)
Not employed-student	98 (14.6)	70 (15.7)
Not employed-caring duties	20 (3.0)	13 (2.9)
Unemployed	42 (6.2)	33 (7.4)
No response	18 (2.7)	14 (3.1)
Lifetime use of other drugs		
Alcohol	669 (99.4)	444 (99.3)
Tobacco	617 (91.7)	417 (93.3)
e-Cigarettes	500 (74.3)	367 (82.1)
Illicit pharmaceutical opioids	506 (75.2)	361 (80.8)
LSD	450 (66.9)	332 (74.3)

Characteristic	Total Sample N=673	Marijuana Concentrate Users N=447
Psilocybin	445 (66.1)	334 (74.7)
MDMA/Ecstasy	386 (57.4)	295 (66.0)
Cocaine HCl	446 (66.3)	321 (71.8)
Methamphetamine	360 (53.5)	252 (56.4)
Salvia divinorum	244 (36.3)	194 (43.4)
Synthetic cannabinoids	237 (35.2)	192 (43.0)
Ketamine	178 (26.4)	141 (31.5)
Heroin	199 (29.6)	155 (34.7)
NBOMe compounds	188 (27.9)	157 (35.1)
Crack cocaine	174 (25.9)	123 (27.5)
Synthetic cathinones	117 (17.4)	96 (21.5)
Lifetime use of cannabis products		
MJ concentrates/ dabs	447 (66.4)	447 (100)
Herbal/flower MJ/weed	666 (99.0)	445 (99.6)
Resin/Hashish	553 (82.2)	400 (89.5)
Kief/keef	504 (74.9)	410 (91.7)
MJ edibles	582 (86.5)	415 (92.8)
Cannabis tinctures	198 (29.4)	170 (38.0)
Ingestible oil (Simpson)	192 (28.5)	174 (38.9)
Cannabis topicals	115 (17.1)	98 (21.9)
CBD oil	179 (26.6)	151 (33.8)
Frequency of Herbal/flower MJ/weed		
Daily or near daily use	273 (40.6)	236 (52.8)

Table 2

Multivariable Logistic Regression Analysis: Adjusted Odds Ratios (AOR) for Predictors of marijuana concentrate use

Variables	AOR	95% CI	p
State Cannabis Laws			
Recreational (vs. Illegal)	**4.91**	**2.00 – 12.0**	**0.001**
Medical, less restrictive (vs. Illegal)	**1.87**	**1.13 – 3.07**	**0.014**
Medical, more restrictive (vs. Illegal)	1.58	0.88 – 2.84	0.130
Socio-demographic characteristics			
Gender (Males vs. Female/Transgender)	**2.21**	**1.35 – 3.60**	**0.002**
Race/Ethnicity (White, Non-Hisp. vs. Other)	0.87	0.52 – 1.45	0.585
Age	**0.95**	**0.93 – 0.97**	**<0.001**
Education (Some College vs. Less)	0.75	0.44 – 1.28	0.296
Employed (Employed vs. Not)	0.78	0.51 – 1.20	0.253
Cannabis and Other Drug Use Characteristics			
Perceived risk of marijuana (weed/bud) use	**0.96**	**0.92 – 0.99**	**0.043**
Age of initiation of marijuana use	0.96	0.89 – 1.04	0.344
Daily use of marijuana (weed/bud)	**4.28**	**2.69 – 6.80**	**<0.001**
Number of other drugs ever used	**1.23**	**1.15 – 1.30**	**<0.001**

Hosmer and Lemeshow Test: Chi-square=9.91, df (8), p=0.270; out of total sample of 673 cases, 618 were included; 55 cases were excluded due to missing values for some of the variables; out of all included cases,409 had used marijuana concentrates.

Table 3

Characteristics of Marijuana Concentrate Users (N=447)

Characteristics	Number (%)
Frequency of marijuana concentrate use in the past year	
Did not use in the past year	82 (18.3)
A few days per month or less	239 (53.5)
About 1–3 days per week	68 (15.2)
Almost every day or every day	58 (13.0)
Reasons of marijuana concentrate use	
To get high	383 (85.7)
To experiment	271 (60.6)
To help sleep	200 (44.7)
To control pain	144 (32.2)
To increase appetite	140 (31.3)
To get off other drugs	86 (19.2)
To control nausea	80 (17.9)
To get away from problems	69 (15.4)
Methods of use	
Dabs/oil rig	343 (76.7)
Vape pen	293 (65.5)
Pipe	210 (47.0)
In a marijuana joint	195 (43.6)
In a marijuana blunt	147 (32.9)
Gravity bong	57 (12.8)
“Nectar collector”	69 (15.4)
Hookah	27 (6.0)
Perceived availability	
Easy or very easy	280 (62.6)
Sources of marijuana concentrates	
Free from friends/family	308 (68.9)
Bought from a dealer	183 (40.9)
Bought from friends/family	188 (42.1)
Made own	115 (25.7)
Bought at a medical dispensary	108 (24.2)
Bought at a recreational store	45 (10.1)
Bought from the DarkNet	35 (7.8)
Bought from a web store	6 (1.3)
If made own, what methods ever used:	N=115
Butane extraction	78 (67.8)
Isopropyl glycol extraction	43 (37.4)

Characteristics	Number (%)
Ice water extraction	38 (33.0)
Rosin extraction	18 (15.7)
Glycerin extraction	12 (10.4)

TABLE 4

Comparing differences in perceived risks (rated from 1=not at all to 4=very much so) associated with daily herbal/flower marijuana and marijuana concentrates (dabs) use

Type of Risk	Among non-users of marijuana concentrates				Among users of marijuana concentrates			
	Herbal/ Flower Use	Concentrate Use	t (df)	p	Herbal/ Flower Use	Concentrate Use	t (df)	p
Harm to Lungs	2.54	2.38	3.06 (188)	**0.003**	2.33	2.27	1.73 (439)	0.085
Anxiety/Panic Attacks	2.02	2.24	−4.07 (187)	**<0.001**	1.84	2.15	−9.60 (440)	**<0.001**
Addiction to cannabis	1.96	2.12	−3.46 (187)	**<0.001**	1.97	2.12	−5.06 (440)	**<0.001**
Poor concentration	2.28	2.35	−1.33 (187)	0.186	2.04	2.23	−6.21 (438)	**<0.001**
Lack of motivation	2.29	2.31	−0.48 (187)	0.629	2.15	2.28	−4.11 (439)	**<0.001**
Poor memory	2.19	2.32	−2.80 (187)	**0.006**	2.17	2.30	−4.20 (438)	**<0.001**
Depression	1.61	1.77	−3.55 (187)	**<0.001**	1.50	1.59	−4.03 (437)	**<0.001**
Psychosis	1.41	1.66	−5.38 (187)	**<0.001**	1.28	1.48	−7.20 (439)	**<0.001**
Cannabis Hyperemesis Syndrome	1.39	1.70	−5.48 (186)	**<0.001**	1.32	1.50	−5.87 (438)	**<0.001**

Table 5

Multivariable Logistic Regression Analysis: Adjusted Odds Ratios (AOR) for Predictors of daily marijuana concentrate use

Variables	AOR	95% CI	p
State Cannabis Laws			
Recreational (vs. Illegal)	2.15	0.64 – 7.23	0.217
Medical, less restrictive (vs. Illegal)	1.87	0.87 – 4.02	0.112
Medical, more restrictive (vs. Illegal)	1.61	0.53 – 4.86	0.397
Socio-demographic characteristics			
Gender (Males vs. Female/Transgender)	**9.29**	**1.20 – 72.2**	**0.033**
Race/Ethnicity (White, Non-Hisp. vs. Other)	0.67	0.30 – 1.46	0.311
Age	0.96	0.93 – 1.02	0.245
Education (Some College vs. Less)	0.99	0.47 – 2.11	0.984
Employed (Employed vs. Not)	0.88	0.44 – 1.77	0.713
Characteristics of Marijuana Concentrate Use			
Perceived risk of MJ concentrate use	**0.92**	**0.86 – 0.99**	**0.017**
MJ concentrate use for therapeutic purposes	**7.61**	**2.23 – 26.0**	**0.001**
Vape pen use to administer MJ concentrates	**4.58**	**1.53 – 13.7**	**0.007**
Produced MJ concentrates	1.74	0.87 – 3.48	0.116

Hosmer and Lemeshow Test: Chi-square=5.94, df (8), p=0.650; out of total sample of 447 cases, 407 were included; 40 cases were excluded due to missing values for some of the variables; out of all included cases, 49 were daily users.