Exploring cannabis concentrates on the legal market: User profiles, product strength, and health-related outcomes

L. Cinnamon Bidwell, Sophie L. YorkWilliams, Raeghan L. Mueller, Angela D. Bryan, Kent E. Hutchison

A Institute of Cognitive Science, University of Colorado Boulder, UCB 344, Boulder, CO 80309-0345, USA
B Department of Psychology & Neuroscience, University of Colorado Boulder, UCB 345, Boulder, CO 80309-0345, USA

ABSTRACT

Background: Concentrated cannabis products are increasingly available and used, particularly in states with legal cannabis, but little is known about the profiles and characteristics of concentrate users. We aimed to characterize user profiles of cannabis users living in states with legal medical or recreational cannabis who reported using concentrates to those who do not use concentrates.

Methods: An anonymous online survey was advertised in California, Colorado, Nevada, Oregon, and Washington. We compared respondents who endorsed frequent concentrate use (FC; N = 67) (i.e. 4 days/week) with cannabis users who never use concentrates (NC; N = 64), and with those who smoke/vaporize cannabis flower frequently but never or very rarely use concentrates (FF; N = 60), on measures related to cannabis use patterns and cannabinoid product strength, other substance use, and occupational functioning and health.

Results: FC endorsed more symptoms of cannabis use disorder as compared to non-concentrate users (p < 0.05), but were similar to FF and NC on other health and occupational outcomes. FC also differed from FF and NC in that they tended to use cannabis that was higher in THC (p < 0.0005), even when using non-concentrated forms of cannabis (p < 0.005). Over half of FC users reported typically using concentrates of at least 80% THC, and 21% endorsed use of (non-concentrated) dry cannabis flower containing at least 30% THC.

Conclusions: Concentrate users endorsed higher symptoms of cannabis use disorder and use higher strength cannabis even when using non-concentrated forms. Frequent use of concentrates may be associated with additional risks over and above frequent use of flower forms.

1. Introduction

The Cannabis sativa L. plant contains hundreds of phytocannabinoids, but putatively of highest importance to public health risk is the psychoactive cannabinoid delta-9-tetrahydrocannabinol (THC). Recently, there has been an increase in the use and availability of concentrated forms of cannabis that have higher THC strengths than typical cannabis flower or bud (Daniulaityte et al., 2017; Stogner & Miller, 2015). Concentrated cannabis products (or “concentrates”) are made by extracting cannabinoids from the plant into a form with a much higher THC concentration than flower (Raber, Elzina, & Kaplan, 2015). In states with legalized use of cannabis, it is common for retail and medical dispensaries to sell concentrates with THC concentrations that are at least four times that of typical smoked flower strains. In 2015, the Colorado Department of Revenue reported the average THC strength of dispensary-sold flower strains was 17.1%, whereas the average concentrate strength was 62.1% THC (Koski, Kammerzell, Burack, Grotenhermen, & Franson, 2015). Whereas THC concentration is of paramount concern in relation to concentrate use, the extraction process can result in high levels of other cannabinoids, such as cannabidiol (CBD) which may interact with THC altering its effects (Ranganathan & D’Souza, 2006). Striking numbers from point of sale data provided by Colorado recreational and medical dispensaries suggest that sales of concentrates have more than doubled between 2015 and 2016 (Bingham, 2015). The increased popularity of these higher strength concentrated products may increase the harms associated with cannabis use and contribute to greater cannabis dependence and withdrawal symptoms (Loflin & Earleywine, 2014; Volkow, Compton, Weiss, 2014). However, the risks associated with use of concentrated products are still unknown (Stogner & Miller, 2015).

Although a few recent studies have provided the first glimpse into concentrate user characteristics, prior work has either primarily
examined concentrate use in samples of users without legal cannabis access (Chan et al., 2017; Daniulaityte et al., 2017), or have only compared proportional differences in cannabis use between states with different legal status, but did not elucidated differences in the health status of users (Sagar, Lambros, Dahlgren, Smith, & Gruber, 2018). We sought to extend this burgeoning literature by examining the profiles of adult cannabis concentrate users with legal market cannabis access in the U.S.focusing on states such as Colorado and Oregon who were among the first to legalize. As legal cannabis access is increasingly common in the U.S., these states provide a unique vantage point on the legal use of concentrated cannabis. In this exploratory study, we aimed to characterize concentrate use by comparing user profiles and patterns of use in individuals who reported using concentrates frequently to 1) a primary comparison group of those who reported never using concentrates, but did endorse use of some form of cannabis, and 2) a more conservative secondary comparison group of those who reported frequent use of more typical flower or “bud” forms of cannabis, but rare or no use of concentrates. Our primary correlates included measures of cannabis use frequency, typical product strength, cannabis dependence, other substance use, and occupational functioning and health.

2. Materials and methods

2.1. Procedures & measures

An anonymous unpaid online “Cannabis and Health” survey including measures related to cannabis use, other substance use, occupational functioning, and health was advertised targeted to individuals aged 21–70 who lived in California, Colorado, Nevada, Oregon, and Washington on social media and through cannabis dispensaries, upon study approval from the University of Colorado Institutional Review Board. In order to assess broad correlates of concentrate use, respondents were queried on demographics, cannabis use, and outcomes such as health, well-being, and other substance use. See details below.

The survey was hosted on Qualtrics software, licensed to our university (https://oit.colorado.edu/qualtrics) and required online informed consent. The survey took approximately 20 min to complete. Surveys were collected from January–July 2017. Respondents used in the final analyses reported residing in Colorado (43.8%), California (24.6%), Oregon (12.5%), Washington (11.9%), and Nevada (5.0%). Besides California, each of these states had legal access to both medical and recreational cannabis at the time of data collection. While California’s full recreational cannabis legalization came into effect shortly after the present study data were collected, recreational use had been decriminalized for several years via its 2010 Senate bill 1449 (which rendered cannabis possession an infraction not unlike a traffic violation). Respondents were asked typical demographics questions, including their age, gender, employment status and how old they were when they started using cannabis regularly (e.g. once a month, twice per week, daily, etc.).

Substance use behaviors were queried with emphasis on measures of cannabis use. Specifically, respondents were asked how often they engaged in different types of cannabis use (e.g., smoking/vaporizing dry cannabis flower, using higher strength concentrates, edibles, etc.). Those who reported daily use for a particular mode of cannabis administration were asked how many times per day s/he consumed cannabis using that method. The following questions were used to query frequency of cannabis use: “On average, how often do you smoke cannabis flower?”, “On average, how often do you use cannabis concentrates (e.g. hash oil, shatter, wax, cartridges)?” “On average, how often do you consume edibles? This question refers to anything that you consume orally like capsules, food, or drink (e.g. baked goods etc.)”. A full range of response choices were provided from, “Never”, to “Daily”. These categorical responses were then translated into a quantity representing number of days per week. For instance, a response of “one day a month” was computed as 0.25 days per week on average. For each route of consumption that respondents endorsed at least one day per month, they were asked to estimate the strength of THC and CBD, a second primary cannabinoid present across different forms of cannabis, for the product s/he used most often. The following questions were used to query cannabis product strength: “How much THC and/or CBD is in the cannabis flower that you use most often?”, “How much THC and/or CBD is in the concentrates that you use most often?”. “On average, how many milligrams (mg) of THC and/or CBD do you consume at one time when using an edible?” The range of response choices differed based on product type. For cannabis flower, the range was between “0%” and “greater than 30%.” For concentrates, the range was “0%” to “Isolate 100%.” For edibles, the range was “0 mg” to “greater than 200 mg”. Although still only a self-report metric, this level of detail is possible in our sample because state regulations (in all represented states) require that the cannabinoid content (as determined through state licensed testing laboratories) be displayed on all legal market products.

Measures also included alcohol use frequency, drinks per typical drinking day, use of cigarettes, illicit drug use (recreational use of illicit or prescription drugs), and use of prescription opiates. Besides cigarettes, no other forms of tobacco use were queried. We investigated DSM-5 Cannabis Use Disorder (CUD) symptomatology using the MINI cannabis screening test, derived from the Mini Neuropsychiatry International Interview (Sheehan et al., 1998), an 11-item measure that corresponds to each of the 11 possible CUD symptoms according to the DSM-5 criteria. Similarly, respondents were queried on past-week experience of several anxiety and depression symptoms as described by DSM-5. With a 0–4 scale (from “not at all” to “very much”), they were asked how often they were bothered by 1. feeling nervous, anxious, or on edge; 2. feeling down, depressed, or hopeless. Other health issues that are associated with cannabis use were measured dichotomously, including self-reported diagnosis of post-traumatic stress disorder (PTSD), past-week experience of pain beyond “everyday kinds of pain”, and sleep disturbance or sleep disorder diagnosis. More global measures of mental health, physical health, overall quality of life, life satisfaction and quality of diet were also queried on a 0–4 scale (from “poor” to “excellent”).

2.2. Analyses

In our primary comparison, we compared cannabis users who endorsed frequent concentrate use (FC) to cannabis users who reported that they never use concentrates (NC). FC was defined as endorsement of concentrate use at least 4 days per week. NC was defined as any endorsement of non-concentrate cannabis use, but no current or past use of concentrates. NC therefore represents a broad comparison group, which encompasses a wide range of cannabis use frequency. We also pursued a secondary, more conservative, level of comparison, to examine differences among users who are similar on cannabis use frequency to our frequent concentrate users, but who never (or at most rarely) use concentrates. This group was defined as endorsement of dry flower use (smoked or vaporized) at least 4 days per week, and use of concentrates < 1 day per month (frequent flower users, but infrequent concentrate users; FF).

Chi-squared and t-tests were used to determine differences between FC and the comparison groups on categorical and continuous measures, respectively. When t-tests yielded significant or trending results, Cohen’s d was used to calculate effect size. Given the relatively large number of outcomes tested in this exploratory investigation, we adopted a significance threshold p < 0.01 for all analyses; p values of < 0.05 were considered significant at trend level. Data were collected via Qualtrics and analyzed in RStudio.

3. Results

Among the 287 completed surveys, 247 reported living in a state where medical and/or recreational cannabis was legal at time of survey.
Table 1
Comparison of survey respondents who frequently use concentrates (FC) to those who never use concentrates (NC), and those who frequently use cannabis flower but rarely use concentrates (FF).

|                                | FC          | NC          | p-Val | Ef.sz. | FF          | p-Val | Ef.sz. |
|--------------------------------|-------------|-------------|-------|-------|-------------|-------|-------|
| N                              | 67          | 64          | –     | –     | 60          | –     | –     |
| Demographics                   |             |             |       |       |             |       |       |
| Gender (% male)                | 59.7%       | 42.2%       | 0.07  | < 0.005 | 48.3%       | 0.27  | –     |
| Age                            | 37.5 (15.8) | 47.1 (17.5) | < 0.005 | –     | 46.9 (17.2) | < 0.005 | –     |
| Age at onset of regular cannabis use | 21.6 (12.5) | 25.2 (16.4) | 0.15  | –     | 21.4 (11.4) | 0.94  | –     |
| Race/ethnicity                 |             |             |       |       |             |       |       |
| White non-Hispanic             | 78.8%       | 79.7%       | –     | 0.74  | 76.7%       | –     | 0.23  |
| White Hispanic                 | 11.5%       | 7.8%        | –     | –     | 3.3%        | –     | –     |
| Asian                          | 1.5%        | 1.6%        | –     | –     | 3.3%        | –     | –     |
| African American               | 1.5%        | 6.3%        | –     | –     | 8.3%        | –     | –     |
| Native American                | 3.0%        | 4.7%        | –     | –     | 8.3%        | –     | –     |
| Native Hawaiian/Pacific Islander | 1.5%      | 0%          | –     | –     | 0.0%        | –     | –     |
| Employment status              |             |             |       |       |             |       | 0.15  |
| Full-time employed/student     | 58.2%       | 48.4%       | –     | –     | 45%         | –     | –     |
| Part-time employed/student     | 11.9%       | 12.5%       | –     | –     | 8.3%        | –     | –     |
| Unemployed/retired/homemaker   | 29.9%       | 39.1%       | –     | –     | 46.7%       | –     | –     |
| Cannabis use                   |             |             |       |       |             |       |       |
| Days vaping/smoking flower per week | 6.0 (2.1) | 4.2 (3.1) | < 0.0001 | 0.71 | 6.7 (0.9) | 0.04 | – 0.38 |
| Percent daily users            | 79.1%       | 47.6%       | 0.08  | –     | 81.7%       | < 0.01 | 0.55 |
| Per-day vaping/smoking use sessions (among daily users) | 4.6 (1.5) | 3.9 (1.7) | –     | –     | 3.7 (1.6) | –     | –     |
| Days of concentrate use per week | 6.7 (0.8) | –           | –     | 0.04 (0.1) | < 0.0000 | 11.6 | –     |
| Percent daily users            | 79.1%       | 0%          | –     | –     | 0%          | –     | –     |
| Per-day concentrate use sessions (among daily users) | 4.1 (1.7) | –           | –     | –     | –           | –     | –     |
| Days of edible use per week    | 1.4 (2.1)   | 1.5 (2.3)   | 0.70  | –     | 1.1 (2.1)   | 0.56  | –     |
| Other substance use            |             |             |       |       |             |       |       |
| Alcohol users                  | 59.7%       | 56.3%       | 0.64  | –     | 50.0%       | 1.0   | –     |
| Alcohol drinking days per week among drinkers | 2.1 (1.9) | 2.8 (1.8) | 0.16  | –     | 2.2 (2.0)   | 0.88  | –     |
| Drinks per drinking day among drinkers | 2.4 (0.8) | 2.4 (1.5) | 0.99  | –     | 2.5 (1.3)   | 0.83  | –     |
| Cigarette users                | 19.4%       | 17.2%       | 0.92  | –     | 25%         | 0.59  | –     |
| Prescription opiate use        | 14.9%       | 6.3%        | 0.19  | –     | 10.0%       | 0.57  | –     |
| Illicit drug use               | 16.4%       | 9.4%        | 0.35  | –     | 13.3%       | 0.81  | –     |
| Health & well being            |             |             |       |       |             |       |       |
| Registered medical cannabis cardholder | 49.3% | 31.8%       | 0.06  | –     | 40.7%       | 0.43  | –     |
| Sleep disorder                 | 46.3%       | 42.9%       | 0.83  | –     | 44.1%       | 0.95  | –     |
| PTSD symptoms                  | 32.8%       | 19.0%       | 0.11  | –     | 25.4%       | 0.47  | –     |
| Pain symptoms                  | 58.2%       | 48.4%       | 0.34  | –     | 55.0%       | 0.85  | –     |
| Depression                     | 0.72 (1.0)  | 0.62 (0.9)  | 0.57  | –     | 0.76 (1.1)  | 0.81  | –     |
| Anxiety                        | 1.1 (1.3)   | 0.7 (0.9)   | 0.05  | 0.34  | 0.66 (1.0)  | 0.04  | 0.37 |
| Overall health                 | 2.4 (1.1)   | 2.7 (1.0)   | 0.10  | –     | 2.5 (1.0)   | 0.59  | –     |
| Mental health                  | 2.7 (1.1)   | 2.8 (1.2)   | 0.48  | –     | 2.6 (1.2)   | 0.67  | –     |
| Physical health                | 2.4 (1.2)   | 2.6 (1.0)   | 0.40  | –     | 2.4 (1.0)   | 0.79  | –     |
| Quality of life                | 2.7 (1.1)   | 2.9 (0.9)   | 0.36  | –     | 2.7 (1.0)   | 0.70  | –     |
| Diet                           | 2.2 (1.0)   | 2.4 (0.90)  | 0.17  | –     | 2.1 (0.9)   | 0.58  | –     |

and reported currently using some form of cannabis. From this 247, 67 respondents were categorized as FC, 64 as NC. In our secondary comparison group focused on only frequent users, 60 were classified as FF (37 of the 60 FF had never used concentrates). The distribution of state residency did not differ across these user groups (p = 0.54). Means or N by cannabis use group for each outcome are reported in Table 1. Mean age was 37.5 for FC and 47.1 for NC (p < 0.005). Ethnicity, onset age of regular cannabis use, gender, and employment status did not differ between groups.

3.1. Cannabis use, product concentration, and dependence

Respondents in the FC group endorsed use of cannabis concentrates an average of 6.7 days per week, and 59.1% endorsed using concentrates containing at least 80% THC (Fig. 1). FC reported smoking or vaporizing cannabis flower 6.04 days per week while NC used cannabis only 4.16 days on average (p < 0.0001; d = 0.7). Among respondents from either group who reported daily flower use, FC and NC did not significantly differ on cannabis use sessions per day. Edible use frequencies were not different between groups.

When asked about use of non-concentrated forms of cannabis, FC estimated the approximate concentration of THC in their typical choice of dry flower to be higher than NC (p < 0.0005). Specifically, > 20% of FC reported typically using flower with a THC concentration of > 30%, compared to just 1.8% of NC respondents (for details, see Fig. 2a). Conversely, FC’s estimated CBD strength of their typical dry flower product was lower than NC (p < 0.01; for more details, see Fig. 2b).

On average, FC endorsed 2.08 (SD = 2.5) of 11 symptoms of DSM-5 Cannabis Use Disorder (CUD), while NC endorsed 1.10 (SD = 2.0; p = 0.02; d = 0.43). Item level analyses revealed that this difference was primarily driven by FC more frequently endorsing a desire to stop, significantly cut down, or control their cannabis use (p < 0.005), and a need to “use a lot more cannabis” to get the feeling that they wanted (p < 0.005). Trend level differences emerged for cannabis use before doing something potentially dangerous (e.g., driving; p = 0.02) and experience of cannabis withdrawal symptoms (p = 0.04) in the past 12 months.

3.2. Other substance use

There were no group differences in alcohol use frequency or quantity (drinks per drinking day), endorsement of cigarette use, prescription opiate use, or non-cannabis recreational drug use.

3.3. Health and well-being

There were no significant group differences in ratings of general health, mental health, physical health, quality of life, and diet. There were also no group differences in endorsement of pain in the past 7 days, PTSD, sleep disorder, depression, or medical card status. FC reported a trend towards greater past-week severity of anxiety
symptoms than NC, specifically feeling nervous, anxious, or on edge ($p = 0.05$).

3.4. Secondary analysis: comparing frequent concentrate (FC) vs. frequent flower (FF) users

Results of the secondary analysis focused on comparing frequent concentrate (FC) users to those who frequently used flower forms of cannabis (FF) were largely consistent with the primary analysis. FC were younger than FF ($p < 0.005$) and endorsed significantly higher per-day smoking/vaporizing frequency than FF (i.e. more use sessions per day, $p < 0.01$; $d = 0.55$). Further, the FC group’s dry flower THC strength was higher than FF ($p < 0.005$; for details, see Fig. 2a). However, in contrast to the above, when accounting for frequency of use, the CUD symptom comparison did not meet our significance threshold. Specifically, FC respondents endorsed only a trend towards higher CUD symptom count compared to those in FF, who endorsed 1.25 symptoms on average ($SD = 2.0$; $p = 0.04$; $d = 0.37$). Further, item level analyses resulted in trends towards FC more frequently reporting a “desire to stop, significantly cut down, or control their cannabis use” ($p = 0.03$) and needing to “use a lot more cannabis” to get the feeling that they wanted ($p = 0.01$) compared to FF.

Consistent with the primary comparison, there were no significant group differences on any other health or substance use measures. A trend for higher anxiety emerged, also consistent with the above, with FC reporting greater anxiety severity, in feeling nervous, anxious, or on edge in the past week as compared to FF ($p = 0.04$; $d = 0.37$).

4. Discussion

Our goal was to examine patterns of use and individual characteristics among frequent users of cannabis concentrates with legal market access to both concentrate and non-concentrate forms of cannabis.

Our study is the first to report on DSM-5 Cannabis Use Disorder (CUD) symptoms in concentrate users. Symptoms of CUD were higher...
for FC (2.1 symptoms endorsed on average) as compared to NC (1.1 symptoms endorsed on average), with FC more frequently endorsing “a desire to stop, significantly cut down, or control” their cannabis use and a need to “use a lot more cannabis.” Importantly, endorsement of 2 or more symptoms corresponds to the DSM-5 criteria of mild CUD. Consistent with these findings, concentrate users from another US survey reported higher rates of both tolerance and withdrawal as compared to flower users (Bingham, 2015) and those from a survey of college students reported higher physiological dependence (Meier, 2017). Similarly, another US survey comparing current and former concentrate users found that current users more frequently endorsed feeling “worried” about their cannabis use relative to former users (Sagar et al., 2018). This work suggests that desiring to use more cannabis and the development of physiological dependence and tolerance may be a feature of frequent concentrate use. However, FC did not differ significantly from FF on CUD symptoms, although findings were trending in a similar direction. This suggests that follow up studies should address whether it is frequency of use, rather than form of cannabis (concentrate vs. other forms), that is driving some of the primary associations of concentrate use with CUD. Additionally, it is uncertain whether concentrate use increases the risk for CUD or if those with CUD liability prefer to use concentrates.

Given that state regulations in the states examined here require that the cannabinoid content is displayed on all legal market products, participants were able to provide the strength of THC and CBD in the products they used most often, providing much needed and novel data on strength patterns among users of different forms of cannabis. Those who endorsed frequent use of concentrated cannabis tended to use concentrates daily and over half reported typically using concentrated products of at least 80% THC. Concentrate users also endorsed use of higher THC strength flower strains as compared to other users, including those endorsing frequent use of non-concentrated cannabis. Compared to NC, FC also reported use of smoked flower forms containing lower levels of CBD, which is a non-intoxicating cannabinoid that may mitigate the harmful effects of THC (Ranganathan & D’Souza, 2006). Although there have been reports of errors in product cannabinoid labeling for certain types of cannabis (Vandrey et al., 2015), together these findings suggest that THC exposure is consistently higher in frequent users of concentrates regardless of the administration form.

When examining other health and occupational outcomes, concentrate users did not differ from non-concentrate users. Our finding of no significant differences in the gender or the frequency or quantity of alcohol or other drug use among concentrate users as compared to other cannabis users was inconsistent with prior surveys (Chan et al., 2017; Danialuityte et al., 2017) that found concentrate users were more likely to be male and had higher rates of illicit drug use compared to higher strength flower users. These opposing findings may be at least partially explained by the more general sampling nature of prior surveys, which captured a large number of individuals without legal market access to cannabis. Associations with illicit drug use in prior studies may have been driven by the sampling of illicit cannabis users who may also be more likely to use other illicit drugs.

4.1. Methodological considerations and limitations

Notably, our sample focuses exclusively on individuals with legal market access and findings need to be replicated in larger studies comparing across states and countries with various cannabis policies. This focused sample allows a novel comparison to prior surveys and a unique window into a sample of cannabis users who are making decisions about cannabis use and form of administration without legal constraints. Nearly all states represented had legal access to both medical and recreational cannabis at the time of data collection. One exception was California, whose full recreational cannabis legalization did not come into effect until shortly after the present data were collected, which may impact the interpretation of the data from Californian participants. We do note that the ratio of medical to non-medical card holders in our data did not differ significantly for participants from California vs. those from other states.

Given the reliance on self-report, cross-sectional data, and single-item or otherwise brief measures of health, these analyses provide information on broad correlates of concentrate use that should be pursued with more detailed, longitudinal assessments in future work. Incorporation of other potentially relevant factors, such as years of cannabis use, may further enrich our understanding of this topic. In addition, other variables such as smoking topography and cannabis administration techniques likely impact actual THC exposure regardless of the strength of the product used, so it will be important in future work to examine the patterns suggested here in human laboratory studies that include assessment of blood THC levels as well as other relevant cannabinoinds.

4.2. Summary

Although concentrate users were similar to other cannabis users on many demographic, substance use, and health measures, frequent concentrate users in our survey had higher THC exposure across different forms of cannabis administration and were more likely to report a need to use more cannabis to get the feeling they desired, which may be associated with increased tolerance and dependence. Higher strength concentrated products may be associated with long-term consequences in terms of higher drug exposure and greater risk for dependence, pointing to a need to examine enduring effects on neurobiology, mental health, and behavior in concentrate users.

Declarations of interest

There are no conflicts of interest.

References

Bingham, R. (2015). The state of legal marijuana markets. In Research, A.M. (Ed.). Executive Summary(5th ed.).
Chan, G. C. K., Hall, W., Freeman, T. P., Ferris, J., Kelly, A. B., & Winstock, A. (2017). User characteristics and effect profile of Butane Hash Oil: An extremely high-potency cannabis concentrate. Drug and Alcohol Dependence, 179, 32-38.
Danialuityte, R., Lamy, F. R., Barratt, M., Nahhas, R. W., Martins, S. S., Boyer, E. W., ... Carlson, R. G. (2017). Characterizing marijuana concentrate users: A web-based survey. Drug and Alcohol Dependence, 175, 399-407.
Koek, L., Kammerzell, R., Burke, J., Grotenhermen, F., & Franson, K. (2015). In Environment, C.D.o.P.H.A. (Ed.). Marijuana equivalency in portion and dosage an assessment of physical and pharmacokinetic relationships in marijuana production and consumption in Colorado.
Loflin, M., & Earleywine, M. (2014). A new method of cannabis ingestion: The dangers of dab? Addictive Behaviors, 39, 1430-1433.
Meier, M. H. (2017). Associations between butane hash oil use and cannabis-related problems. Drug and Alcohol Dependence, 179, 25-31.
Raber, J. C., Elzenga, S., & Kaplan, C. (2015). Understanding dab: Contamination concerns of cannabis concentrates and cannabinoid transfer during the act of dabbing. The Journal of Toxicological Sciences, 40, 797–803.
Ranganathan, M., & D’Souza, D. C. (2006). The acute effects of cannabinoids on memory in humans: A review. Psychopharmacology, 188, 425–444.
Sagar, K. A., Lamброс, A. M., Dahlgren, M. K., Smith, R. T., & Gruber, S. A. (2018). Made from concentrate? A national web survey assessing dab use in the United States. Drug and Alcohol Dependence, 190, 133–142.
Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., ... Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. The Journal of Clinical Psychiatry, 59(Suppl. 20), 22–33.
Stogner, J. M., & Miller, B. L. (2015). The dabbing dilemma: A call for research on butane hash oil and other alternate forms of cannabis use. Substance Abuse, 36, 393–395.
Vandrey, R., Raber, J. C., Raber, M. E., Douglass, B., Miller, C., & Bonn-Miller, M. O. (2015). Cannabinoid dose and label accuracy in edible medical cannabis products. JAMA, 313(24), 2491.
Volkow, N. D., Compton, W. M., & Weiss, R. S. (2014). Adverse health effects of marijuana use. The New England Journal of Medicine, 371, 879.