Published in final edited form as:

Am J Drug Alcohol Abuse. 2018 ; 44(6): 628–641. doi:10.1080/00952990.2018.1436179.

Leveraging user perspectives for insight into cannabis concentrates

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Abstract

Background—The US has seen an increase in the popularity of highly concentrated forms of cannabis (hereafter concentrates) and too little is known about the potential risks associated with their use.

Objectives—The present study aims to better understand the patterns and outcomes of concentrates use through the perspectives of young adult users.

Methods—Participants ($N = 234$, 27.9% female) aged 18–35 years were recruited using SurveyMonkey Audience® and had ingested concentrates at least once in the past 6 months. They were queried on concentrates use patterns (e.g., frequency, medical/recreational) and the effects experienced after using concentrates (e.g., physiological/psychological, strength/duration).

Results—A total of 27.8% of participants reported frequent use of concentrates (10 days in past month). Those who used for medical purposes or lived in states where use is legal were more likely to use concentrates frequently. While most (64.2%) did not report experiencing potentially serious side effects, some reported a sense of altered reality/confusion (23.3%), rapid heartbeat (11.2%), lung pain (9.9%) and severe paranoia (6.9%). Among those who used concentrates in the past month ($N = 168$), 72.6% used concentrates with other cannabis forms, 57.7% used along with alcohol, and 22.6% used with other drugs.

Conclusion—Continued research on concentrates use in the US is needed. Research-informed policies that foster safe and responsible use of concentrates are necessary to protect users, especially those who use concentrates frequently, from potential negative side effects.

Keywords

Cannabis; cannabis concentrates; young adult; online survey

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Declaration of interest

The authors report no conflicts of interest.

Introduction

Cannabis concentrates (hereafter concentrates) are an extracted form of cannabis that contain especially potent concentrations of tetrahydrocannabinol (THC), the primary psychoactive constituent of cannabis (1). Extract production using butane is illegal in the US without a proper license (2–5). Still, concentrates labs exist nationwide, especially in Western states and in states with relaxed marijuana laws (6). Possession and purchase of concentrates are allowed in states that have legalized medicinal or recreational cannabis, where concentrates can be legally purchased at a dispensary (5,7). Concentrates can contain as high as 80% THC, which is roughly four times stronger than what is found in a “high grade” cannabis plant (8). Notably, there are many different types of concentrates, each made from different processes and containing a different average THC potency (9,10). Dry processing methods, which are some of the oldest methods of producing concentrates, result in Kief, which averages 25–30% THC concentrations (9,10). Water-based processing methods create hash, or “bubble,” which typically yields an average of 40–45% THC (9,10). Solvent-based processes result in butane hash oil, or “wax,” which also has many other names (10). While these types typically vary widely in potency, the average is 65–70% THC (9). Finally, carbon dioxide-based methods yield CO₂ oil, which averages 50–55% THC (9,10). Each of these extract forms have higher average THC concentrations than do traditional forms of cannabis. Additionally, there are increased risks with the novice production of concentrates (e.g., contaminated concentrates due to residual solvents), which is more likely in states where marijuana remains illegal and not accessible by a legitimate retailer (10,11).

There is also concern that the inhalation of such high levels of THC may increase health risks among some users (12). Specifically, Loflin & Earleywine (12) surveyed US adults recruited via Craigslist postings and found that concentrates use was associated with perceived tolerance and withdrawal symptoms versus regular cannabis use. A related study of college students revealed an association between concentrates use and cannabis use problems (i.e., physiological dependence) that could not be explained by various potential confounders (13). Similarly, Chan et al. (14) surveyed cannabis users across 20 countries and found that participants who reported a lifetime diagnosis of mental health problems (depression and anxiety) and a greater number of other substances used were more likely to report marijuana concentrates use.

Given the increasing popularity of concentrates among both recreational and medical cannabis users, Daniulaityte et al. (15) encourage continued research on the health consequences of concentrates use, as well as its concomitant use with other drugs. That study, which focused on similar research questions to those of this study, concluded that marijuana concentrate use was more common among male, younger, and more experienced users, as well as those living in states with more liberal marijuana policies (15). Race/ethnicity did not show significant association with marijuana concentrate use, nor with more frequent patterns of use (15). Obtaining marijuana concentrates free from friends or family members was the most commonly reported source of marijuana concentrates, and nearly two-thirds (63%) rated the perceived availability as easy or very easy (15). Most marijuana concentrate users (54%) reported using concentrates a few days per month or less frequently

in the last year, and approximately 13% reported daily or near daily use (15). The most common reason for marijuana concentrate use was to “get high” (86%) (15).

Consequently, the aim of the present study is to expand our understanding of concentrates use among young adults given the relatively scant literature in this area. Using an existing online panel, we surveyed young adult concentrates users aged 18–35 years across the US to better understand their patterns and outcomes of use as well as the concomitant use of concentrates with other substances. We targeted 18–35 year olds because these age groups have the highest rates of cannabis use. Specifically, 20% of 18–25 year olds in the US used cannabis in the past month, followed by 12.7% of 26–34 year olds and 5.3% of those 35 years old in the US (16). Results obtained through this investigation can inform public health surveillance of individuals who are using this novel and highly potent form of cannabis.

Methods

Participants and recruitment

In September 2015, an online survey was administered to members of SurveyMonkey® Audience, a proprietary panel of respondents who are recruited from a diverse population of more than 30 million people who complete SurveyMonkey surveys. SurveyMonkey sent email invitations to SurveyMonkey® Audience members who were US residents between the ages of 18–35 years asking them to take our survey. Survey responses were collected until at least 250 participants met our eligibility criteria (US resident, 18–35 years old, used concentrates in the past 6 months). When inquiring about recent concentrates use in order to confirm eligibility, we described concentrates and provided pictures for reference as shown in Figure 1. Details on SurveyMonkey® Audience recruitment methodology can be found in Appendix A.

After reviewing the responses for data consistency, logical response patterns, and responses that were harmonious with concentrates use, our final sample included 234 participants. The 234 participants came from across the country, including individuals from 43 states (AL, DE, KY, NM, RI, SC, WV and DC were not represented). All study procedures were reviewed and approved by the University’s Institutional Review Board.

Survey content

Before inviting SurveyMonkey® Audience members to take our survey, we pilot tested a draft survey among concentrates users from our prior cannabis study for feedback on terminology, item clarity, adequacy of response options, and other topics of interest (17). Thirty respondents took the draft survey online and provided feedback via open-ended text boxes for each item, and nine of these respondents provided additional feedback over the phone. The survey was subsequently refined. Note that in the survey we used the term “concentrates” as recommended by those in the pilot study. Below we discuss sections of content in the survey. Exact question wording and responses can be found in Appendix B.

Concentrates use patterns

Participants were queried on their frequency of use of concentrates in the past 30 days, and multiple choice responses ranged from intermittent to all 30 days. For purposes of our analysis, we dichotomized those who used 10 days in the past month versus those who did not in order to examine characteristics associated with approximately the top 25th percentile in frequency of concentrates use in our sample (this also corresponded to using at least 2–3 times per week). Participants were also asked the age at which they first used concentrates, and whether they used concentrates for medical and/or recreational reasons. In addition, we assessed participants' difficulty in obtaining concentrates and how they had obtained concentrates (i.e., the source) in the past 6 months and how they ingested concentrates in the last 6 months.

Concomitant use of concentrates with other substances

Participants were queried about their use of concentrates with other substances to experience overlapping effects in the past 30 days. Substances queried separately included “another form of marijuana (i.e., buds/flower, joints/blunts, edibles),” “alcohol,” and “any other drugs besides alcohol.” Along with their response to the last item, participants were asked to list the specific drugs or medications they had used along with concentrates to experience overlapping effects.

Concentrates effects/dislikes

Participants were queried about the strength and length of the effects experienced after using concentrates, as well as how well they felt they were able to perform everyday activities after use. Participants were also asked whether they felt that concentrates increased their tolerance to cannabis, specific dislikes they had about using concentrates, and whether they ever experienced specific physiological and/or psychological effects after using concentrates.

Demographic characteristics

Participants were asked to report their age, race, state of residence, highest level of school completed, and employment status. State of residence was used to code legal status of cannabis in the participant's state enacted by the time of survey administration (use not legal, medical use legal, medical and recreational use legal) (18,19). For a list of states for each legal status, see footnote to Table 1. Gender and household income were included in their SurveyMonkey® Audience profile and provided with their survey data.

Analyses

Descriptive statistics were used to describe the study sample and concentrates use patterns of participants. Pearson chi-square tests were used to examine associations between legal status of cannabis in the participant's state and source of concentrates (specifically buying from a drug dealer/stranger). Logistic regression was used to examine associations between demographic and cannabis use characteristics with four main outcomes (a) frequent concentrates use (10 days in the last 30 days), (b) use of concentrates with other forms of cannabis (among past month users), (c) concomitant use of concentrates with alcohol and/or

drugs (among past month users), and (d) reporting potentially serious side effects. Variables with significant bivariable associations were entered into multivariable logistic regression models predicting the outcome of interest. Legal status of cannabis was assessed in regards to associations with use patterns instead of region of the country or ease of access because these variables are related and legal cannabis status is more relevant than these variables. Regarding reported effects and perceptions of concentrates use, Pearson chi-square tests were also used to examine associations between frequency of concentrates use and reported strength of concentrates effects, changes in tolerance due to concentrates use, ability to perform tasks under the influence of concentrates, and reported dislikes about concentrates. For all analyses, a P value <0.05 was considered significant, and odds ratios and 95% confidence intervals are reported for the logistic regression analyses. We did not adjust the alpha level for multiple testing because our four binary outcomes represent a small number of planned outcomes of qualitatively different domains of interest (20–22). Accordingly, the outcome of experiencing serious effects following concentrates use was not significantly associated with any of the other three outcomes (frequent concentrates use, use of concentrates with other forms of cannabis, or concomitant use of concentrates with alcohol and/or drugs). We do note, however, that concomitant use of concentrates with alcohol/drugs was significantly associated with use of concentrates with other forms of cannabis (65.6% of participants who had used concentrates with other forms of cannabis used with alcohol/drugs, while 45.7% of those who had not used concentrates with other forms of cannabis used with alcohol/drugs; $\chi^2 (1, N = 168) = 5.5, p = 0.019$). Nonetheless, we keep these behaviors as distinct outcomes because they are meaningfully different from one another in consideration that many cannabis users regard its use to be low risk of cannabis use, in general, and especially in comparison to the use of alcohol and other drugs (23,24). Frequent concentrates use was associated with using with other forms of cannabis (81.5% of participants who had used concentrates frequently had used with other forms of cannabis, while 67.0% of those who had not used concentrates frequently engaged in this behavior; $\chi^2 (1, N = 168) = 4.2, p = 0.039$), but we adjusted for frequent use in the multivariable model predicting use with other forms of cannabis. There were no other significant associations among the four outcomes. All statistical analyses were conducted using SAS for Windows version 9.4 (SAS Institute, Cary, NC).

Results

Demographic characteristics and concentrates use patterns (Table 1)

The participant sample was mostly male (72.1%) and White (67.7%) with an average age of 25 years. Most of the participants were employed (69.7%), and 24.8% had earned at least a Bachelor's degree. Nearly half (44.2%) lived in the Western region of the US, and 64.6% lived in a state where either recreational and/or medical use is legal.

More than half of participants (55.1%) reported using cannabis for recreational purposes only. Among the 105 participants who used for medical reasons (including those who also used recreationally), the most common conditions reportedly being treated by cannabis were pain/inflammation ($n = 27, 25.7\%$), anxiety ($n = 12, 11.4\%$), and insomnia ($n = 10, 9.5\%$). Only 32.5% reported that obtaining concentrates was difficult, and this was more common in

states where cannabis is illegal (50.0% in illegal states, 26.9% in states where only medical use is legal, and 5.3% in states where both recreational and medical use are legal; $\chi^2 (2, N=226) = 25.9, p < 0.001$). The most common sources of concentrates were from a friend/relative for free (63.2%) followed by buying from a friend/relative (39.8%).

Frequent concentrates use (10 days in the past 30 days)

About 27.8% of participants used concentrates at least 10 days in the past month. As shown in Table 2, in a multivariable model including those variables that were significant in bivariable analysis, using concentrates for medical purposes and the legal status of cannabis were significantly associated with frequent concentrates use with adjusted odds ratios slightly above 2 (rightmost column of Table 2; medical use aOR 2.2, $p = 0.037$; both recreational and medical use are legal aOR 2.5, $p = 0.039$).

Use of concentrates with other forms of cannabis

Among those who reported using concentrates in the past month ($n = 168$), nearly 3/4 (72.6%) had used concentrates with other forms of cannabis (20.2% one time, 24.4% two to five times, 14.3% 6–10 times, 13.7% more than 10 times). Significant associations with this behavior assessed by logistic regression are shown in Table 3 (top model results). In a multivariable model including variables that were significant in bivariable analysis, residing in a legal cannabis state (medical use legal aOR 2.5, $p = 0.023$; medical and recreational use legal aOR 4.1, $p = 0.026$) and using an oil rig to ingest concentrates (aOR 2.8, $p = 0.009$) were significantly associated with increased odds of using concentrates with other forms of cannabis.

Use of concentrates with alcohol and other drugs

57.7% of participants who had used concentrates in the past month ($n = 168$) reported using concentrates with alcohol to experience overlapping effects at least once (16.7% once, 26.8% 2–5 times, 7.7% 6–10 times, 6.6% more than 10 times). 22.6% had used concentrates with other drugs in the past 30 days to experience overlapping effects (7.2% once, 7.2% 2–5 times, 3.6% 6–10 times, 4.8% more than 10 times). Among past-month extract users who provided details about the types of drugs used with concentrates ($n = 16$), the drugs specified included cocaine/crack ($n = 5$, 31.3%), pain medications (e.g., Vicodin, morphine) ($n = 4$, 25.0%), Adderall ($n = 3$, 18.8%), MDMA (ecstasy, $n = 3$, 18.8%), anxiety/depression medications (e.g., Xanax) ($n = 3$, 18.8%), LSD ($n = 2$, 12.5%), and mushrooms ($n = 1$, 6.3%) (note: some participants listed more than one type of drug). Because the use of concentrates with alcohol and other drugs were significantly associated with each other (35.4% of participants who had used concentrates with alcohol also used with drugs, while 5.6% of those who had not used concentrates with alcohol used with drugs; $\chi^2 (1, N=167) = 20.6, p < 0.001$) and they represent one risky behavior construct (using cannabis with other substances), these were combined into one dependent variable for purposes of statistical modeling. Approximately 60.1% of those who used concentrates in the past month had used the concentrates along with alcohol and/or drugs. Significant associations with concomitant use of concentrates and alcohol/drugs are also shown in Table 3 (middle model). In the multivariable model, residing in a state where medical use is legal was significantly associated with increased odds of concomitant concentrates and alcohol/drug use (aOR 3.6,

$p = 0.001$), whereas using for both medical and recreational purposes was associated with decreased odds of this behavior when compared to recreational users (aOR 0.3, $p = 0.003$) (rightmost column of Table 4).

Effects/perceptions of concentrates use

Participants' responses detailing the effects of concentrates use and reported dislikes about concentrates are shown in Table 4. Among those who used concentrates in the past 6 months ($n = 234$), the strength of the effects of concentrates was described by nearly half of participants (44.0%) as moderately strong and by over a quarter (25.6%) of participants as very strong. Nearly half (49.2%) reported that the effects lasted about 1–2 hours following ingestion and 29.9% said the effects lasted for more than two hours. Reported strength of effects was significantly associated with frequency of concentrates use [$\chi^2 (3, N = 234) = 13.2, p = 0.004$]; the proportion who believed concentrates were very strong was 40.9% among intermittent users (used in past six months but not in past 30 days), 25.8% among those who used 1–2 days in the past month, 17.1% among those who used 3–9 days in the past month, and 15.4% among those who used 10 days in the past month.

Over half of participants (52.1%) believed that they could perform their everyday activities (i.e., work, school, errands, etc.) very well when using concentrates and only 5.6% reported not being able to perform tasks well at all. The ability to perform tasks well when using concentrates was associated with frequency of use [$\chi^2 (3, N = 234) = 17.1, p = 0.001$]; 34.9% of intermittent users, 50.0% of those who used 1–2 days in the past month, 53.7% of those who used 3–9 days in the past month, and 70.8% of those who used 10 days in the past month believed they could perform tasks very well when using concentrates. Over 1/3 (37.3%) of concentrates users believed that concentrates did increase their tolerance to cannabis somewhat or definitely. The belief that concentrates somewhat/definitely increased cannabis tolerance did not differ significantly by frequency of concentrates use.

The most commonly reported dislikes about concentrates were the cost (41.0%), followed by its illegal status in some states (30.3%), concerns about concentrates being chemically processed (not natural) (26.9%), difficulty accessing concentrates (23.5%), and the subsequent increase in their cannabis tolerance (22.2%). Notably, only 11.5% reported that they disliked the other side effects from concentrates use. These reported dislikes did not differ significantly by frequency of concentrates use.

Only 35.8% of participants reported experiencing any of the potentially serious specific side effects listed on the survey. The most common side effects endorsed were a sense of altered reality/confusion (23.3%), followed by rapid heartbeat (11.2%), lung pain (9.9%), and severe paranoia (6.9%). Table 5 includes significant associations with reporting these side effects. In the multivariable model, the legal status of cannabis (both recreational and medical use are legal aOR 2.6, $p = 0.026$) was associated with increased odds of reporting side effects, whereas using concentrates solely for medical purposes (compared to only recreational use, aOR 0.4, $p = 0.017$) was associated with decreased odds of reporting side effects. Notably, in bivariable analysis, those who reported concomitant use of concentrates along with alcohol or drugs to experience overlapping effects in the last month had almost twice the odds of reporting side effects (OR 1.8, $p = 0.046$) compared to those who did not

engage in concomitant use with alcohol or drugs, but this effect was not significant in the multivariable model.

Discussion

There is limited research examining concentrates use, with only three studies that are based on the perspectives of the users themselves. Despite differences in recruitment methods, participants in our study, Loflin & Earleywine's (12) study, and Daniulaityte et al. (15) were relatively similar in terms of their demographics and cannabis use patterns (e.g., majority Caucasian male participants, equally dispersed frequency of concentrates use, and even breakdown of medical versus recreational cannabis users). Likewise, Meier (13) targeted undergraduate cannabis users from a university in a state where medical cannabis use is legal but recreational use is not and similarly found concentrates users to be disproportionately male and Caucasian. In terms of specific concentrates use characteristics, while most of our participants used concentrates infrequently, nearly 1/3 of our participants had ingested concentrates 10 or more days in the past month. Related research also found that nearly 1/3 of concentrates users similarly ingested this form of marijuana at least once per week. Likewise, in multivariable models, both our study and Daniulaityte et al. (15) found that frequent users of concentrates were more likely to attribute their concentrates use to medical reasons. Loflin & Earleywine (12) similarly found that nearly half of the concentrates users in their sample ingested this potent form of cannabis for medical reasons. Taken together, the consistent results across ours and related studies signal that medical marijuana users may turn to concentrates more regularly than recreational users and in order to alleviate symptoms of their medical conditions. Furthermore, medical concentrates users were less likely to report adverse side effects following concentrates use that could be due to perceptions of its medicinal benefits above and beyond perceived disadvantages of its use. Thus, while evidentiary support for the use of cannabis to treat medical conditions is still lacking (25), building a scientific evidence to support the medical use for concentrates is significant and timely.

Regarding potential effects of concentrates use, Meier's findings revealed an association between concentrates use and cannabis use problems (i.e., physiological dependences) that could not be explained by a variety of potential confounders. Similarly, over 1/3 of participants noted a possible increase in their tolerance to cannabis that was due to their use of concentrates, which further corroborates the emerging research (12,26). Our findings also lend support to a number of negative side effects following concentrates use (e.g., lung pain, heart palpitations, loss of consciousness) that, while endorsed by only a minority of participants in our sample as well as individuals on social media (27), could be worth monitoring. It is worth noting that over half of our participants indicated that they can still perform everyday activities very well when using concentrates; additionally, the Daniulaityte et al. (15) participants were similar to ours in that the majority did not view concentrates as very risky regarding potential health effects. Still, given the increased likelihood of addiction, impaired respiratory function, and residual cognitive impairment that are associated with chronic cannabis use in its traditional form, it will be important for future studies to work towards delineating what, if any, heterogeneity in negative outcomes follows chronic ingestion of cannabis in its more potent and concentrated form (28). Furthermore,

concentrates users may be important to track into their middle and later stages of adulthood for negative outcomes that are linked to long-term use of cannabis in its highly potent form.

To extend the early research examining concentrates use, we innovatively queried our participants about the concomitant use of concentrates with other substances, and we found this behavior to be relatively common among the participants in our sample, thus corroborating our related social media research on this topic (27). Building upon a past study in which we found heavy cannabis use to be associated with poly-cannabis use (29), most of our participants co-used concentrates with other forms of cannabis, and this behavior was disproportionately more prevalent among those who used concentrates frequently (i.e., 10 days in the past month) and those who used a rig for ingesting concentrates, possibly because a rig is more amenable to mixing products than a vape pen. In addition, over half of participants co-used concentrates with alcohol, which is consistent with emerging literature that cannabis and alcohol are the most common drugs used simultaneously (30). Previous research on the topic has noted the “heightened effect” of mixing alcohol and cannabis, including a higher blood THC concentration when mixing them (31,32). Nearly one out of five participants engaged in co-use of concentrates with other illicit drugs in the past month to heighten their effects. There are unique and concerning consequences associated with using multiple mood-altering substances simultaneously including increased psychomotor impairment, higher levels of toxicity, and greater risk for overdose (14,15,33). Additionally, some research suggests that using cannabis and other drugs together may be associated with schizotypy (34). There is the possibility for complications and consequences that are compounded when intermingling concentrates use with other substances because the risks of concentrates use in isolation remain unknown. Therefore, longitudinal studies are critical for determining if the risks for such negative health consequences are similarly compounded among individuals who concomitantly use concentrates with other substances.

Although few in number, several studies including a social media surveillance analysis have documented that the use of concentrates and novel cannabis products are more prevalent in states with lenient marijuana policies (15,35,36). Our study expands this finding by signaling that more liberal marijuana policies are also significantly associated with frequent concentrates use, concomitant use of concentrates with other cannabis forms, alcohol, and/or drugs, and greater likelihood for reporting negative side effects following concentrates use. Our findings indicate the need for increased surveillance and research into these risk behaviors while cannabis policy across the country shifts toward leniency.

Limitations

Limitations should be considered when interpreting the results presented. This is a cross-sectional survey; thus, causal associations cannot be determined. This survey sampled a relatively small number of concentrates users from an existing voluntary online panel, and nearly half of participants lived in the Western US. Approximately 1/3 of participants lived in a state where cannabis is not legal in any form. It is possible that these participants were not completely honest in their responses due to fear of incrimination. However, because participants were initially informed about the nature of the survey, and had to admit to using concentrates within the past six months to be eligible, we believe that the likelihood of

falsifying information is minimal. Additionally, participants may have felt reluctant to share when they engaged in risky activities such as concomitant use of concentrates with other, traditional forms of cannabis, alcohol, and/or other drugs. We did not query patterns or consequences of use of other forms of cannabis. At the beginning of the survey, we stressed that the type of concentrates of interest included those that “*generally contain a higher % of THC than other marijuana products*”; however, we did not describe a minimum measure of THC-potency, which could have led to those who used concentrates with relatively low THC concentrations being included in this study. We also described concentrates as being produced using solvent-based methods. Although this is true of many concentrates, some concentrates are produced using solventless methods. Finally, while opt-in panels have the advantages of being convenient and cost-efficient, and reduce the time for data collection, there is potential bias that may be present due to under coverage, high nonresponse, and self-selection (37,38). Due to our eligibility criteria (i.e., current concentrates users) and request that Survey Monkey invite potential participants who are balanced on demographic attributes to match that of the nation, it is possible that our findings could be signaling true differences in concentrates use behaviors across certain demographic groups; still, our use of an existing online panel limits the generalizability of our findings.

Conclusions

The cannabis legalization landscape is changing, which requires the development of research-informed policies that will foster safe and responsible use of cannabis to protect users or those who are contemplating initiation, many of whom are unaware of the health consequences. Future research should examine potential negative effects from consuming concentrates over the long-term, because our findings signal increasing use of concentrates with other forms of cannabis and/or other substances, as well as increasing use among those who ingest concentrates for medical purposes.

Acknowledgments

Funding

This work was supported by the National Institute of Drug Abuse under grants R01 DA039455, R01 DA032843 and K02 DA043657.

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Appendix A

SurveyMonkey recruitment methodology

After taking SurveyMonkey surveys, participants are asked if they would like to join the online panel where they can take surveys in exchange for donations to a charity of their choice. SurveyMonkey collects detailed information to create a profile for each panel member so that they can receive surveys that match their demographic characteristics and/or interests. To maintain high-quality responses, panel members are limited in the number of surveys that can be taken per week, and non-cash incentives are used. Wronski and Liu¹ describe SurveyMonkey to a greater extent.

¹Wronski L, Liu M. *Calibrating cross-national panel surveys*. [PowerPoint presentation]. International Conference on Survey Methods in Multinational, Multiregional and Multicultural Contexts (3MC). [updated 27 July 2016; cited 30 June 2017]. <https://csdiworkshop.org/index.php/past-events/3mc-2016/presentations/304-wednesday-july-27th>.

SurveyMonkey sent email invitations to SurveyMonkey® Audience members who were US residents between the ages of 18–35 years asking them to take our survey. In addition to email invitations, some participants were “routed” to our survey from the SurveyMonkey website. In this “router” method, visitors to the SurveyMonkey website who indicate that they would like to take a survey are routed to an appropriate survey based on their demographic characteristics. Survey responses were collected until at least 250 participants met our eligibility criteria (US resident, 18–35 years old, used concentrates in the past 6 months). Other eligibility criteria were confirmed via online survey questions (e.g., “How old are you?”, “How recently have you used marijuana concentrates?”) before participants provided online consent to enter the survey. Approximately 9,386 email invitations were sent by SurveyMonkey to Audience members and 3,623 participants were “routed” to our survey from the SurveyMonkey website; thus, a total of 13,009 potential participants received an invitation to our survey.

From the 13,009 invitations, 3,709 (29%) participants responded by trying to take our survey and 364 (364/3,709; 10%) were eligible and consented to participate. However, 74 of these started but did not complete the survey, leaving 290 participants with complete survey data (290/3,709; 8%). Two “trap” questions were added to the survey to identify participants who were not reading the survey carefully (i.e., “Please select ‘B’ as your answer choice.”, “What does 2 + 2 equal?”). Item responses to survey items described below were also reviewed for data consistency, logical response patterns and responses that were harmonious with concentrates use. After removing six participants who failed the trap questions, 47 participants with inconsistent or illogical response patterns (i.e., frequency of concentrates use in the past month did not match a separate item asking how recently they used concentrates), and three participants who appeared to refer only to edibles use, our final sample included 234 participants. The 234 participants came from across the country, including individuals from 43 states (AL, DE, KY, NM, RI, SC, WV and DC were not represented).

Duplicate participants were prevented by using the SurveyMonkey platform option that prevents participants from taking a survey more than once from a web browser or email address. The survey was anonymous unless a participant opted to provide their email address to be considered for future studies. For those participants who opted to provide their email address, confidentiality was protected by SurveyMonkey security infrastructure and practices² and by storing downloaded data on a secure server at Washington University that was only accessible by the research team. This study was reviewed and approved by the University’s Institutional Review Board.

²SurveyMonkey Security Statement: Survey Monkey; 2017 [Available from: <https://www.surveymonkey.com/mp/policy/security/>].

Appendix B

Survey questions and response options

Category	Question	Response options
Extracts use patterns	How many days did you use marijuana concentrates in the last 30 days?	• 0 days
		• 1–2 days
		• 3–5 days
		• 6–9 days
		• 10–19 days
		• 20–29 days
		• 30 days
	About how old were you when you first used marijuana concentrates?	Please indicate your age in years and your best guess is fine.
	Do you use marijuana concentrates medically, recreationally, both? Check all that apply	• Medically, and I have a medical marijuana card or a doctor's prescription
		• Medically, but I do NOT have a medical marijuana card or doctor's prescription
		• Recreationally
	How difficult is it for you to get marijuana concentrates?	• Very difficult
		• Fairly difficult
		• Fairly easy
		• Very easy
	Where did you get the marijuana concentrates you used during the last 6 months? Mark all that apply.	• Took from a friend without asking
		• Took from a relative without asking
		• Given for free by a friend
		• Given for free by a relative
		• Bought from a friend
		• Bought from a relative
		• Used my own "medical marijuana" prescription to buy from a medical dispensary
		• Used someone else's "medical marijuana" prescription to buy from a medical dispensary
		• Bought from a recreational dispensary
		• Made my own
		• Bought from a drug dealer/stranger
		• Bought online/over the internet
		• Other (please specify)
	What methods have you used for taking marijuana concentrates in the last 6 months ? Mark all that apply. Examples of each method are provided below.	• Vape pen
		• Rig with electronic nail (e-nail) or blow torch
		• Other

Category	Question	Response options
Concomitant use of extracts with other substances	How many of the times when you used marijuana concentrates during the last 30 days did you use it along with <i>alcohol</i> —that is, so that their effects overlapped?	<ul style="list-style-type: none"> Once 2–5 times 6–10 times 11–20 times More than 20 times I have done this, but not in the past 30 days I have never done this
	How many of the times when you used marijuana concentrates during the last 30 days did you use it along with <i>another form of marijuana</i> (i.e., buds/flower, joints/blunts, edibles) – that is, so that their effects overlapped? Sometimes referred to as “twaxing”.	<ul style="list-style-type: none"> Once 2–5 times 6–10 times 11–20 times More than 20 times I have done this, but not in the past 30 days I have never done this
	How many of the times when you used marijuana concentrates during the last 30 days did you use it along with <i>any other drugs besides alcohol</i> – that is, so that their effects overlapped?	<ul style="list-style-type: none"> Once 2–5 times 6–10 times 11–20 times More than 20 times I have done this, but not in the past 30 days I have never done this <p>Please list any drug or medication that you have used (without a prescription/doctor's order) along with marijuana - that is, so that their effects overlapped.</p>
Extracts effects/dislikes	When you use marijuana concentrates, how strong are the effects?	<ul style="list-style-type: none"> Not at all strong A little strong Moderately strong Very strong
	When you use marijuana concentrates, how long do the effects last?	<ul style="list-style-type: none"> Usually don't feel any effects Less than an hour One to two hours Three to six hours Seven to 24 hours More than 24 hours
	When you use marijuana concentrates, how well do you feel that you can perform your everyday activities (i.e., work, school, errands, etc.)?	<ul style="list-style-type: none"> Not well at all Somewhat well Moderately well Very well

Category	Question	Response options
		<ul style="list-style-type: none"> I only use marijuana concentrates when I don't have any tasks to perform.
	Do you find that marijuana concentrates increase your tolerance so that you need more than you used to?	<ul style="list-style-type: none"> Not at all A little bit Somewhat Definitely
	What do you not like about marijuana concentrates? Check all that apply.	<ul style="list-style-type: none"> Cost – too expensive Potency Flavor Increases my tolerance too much Hard to access/make Side effects (e.g., coughing, headaches, nausea) Not as natural as other forms of marijuana; chemically processed There could be negative consequences/long-term health effects Intense effects/stronger high There isn't a lot known about this form of marijuana Illegal I like everything about dabbing
	Have you ever experienced any of the following effects after using marijuana concentrates? Check all that apply.	<ul style="list-style-type: none"> Altered sense of reality/confusion Lung pain Inability to move, paralysis, loss of body control Passing out, losing consciousness Severe paranoia Heart beating very fast/heart palpitations

This survey is about marijuana concentrates. Concentrates generally contain a higher % of THC than other marijuana products (buds/hash). The common theme of all concentrates is they use some type of solvent to extract the THC. Examples of marijuana concentrates include shatter, wax, and oil. We are interested in VAPING or SMOKING (i.e. dabbing) marijuana concentrates, *NOT* use in an edible/drink or tincture/capsule form.

Please review the pictures below before answering the following questions.

Types of marijuana concentrates

shatter

wax/budder

oil

Some ways to use marijuana concentrates

vape pen

rig

Figure 1.

Description of concentrates provided at the beginning of the survey for participants.

Table 1

Demographic characteristics and use patterns of concentrates use (Total N = 234 unless otherwise noted).

Demographic variable	n (%)	Concentrates use patterns	n (%)
Gender (n = 233)		Reason for use	
Male	168 (72.1)	Medical use only	47 (20.1)
Female	65 (27.9)	Recreational use only	129 (55.1)
Age (year) (n = 233) Mean (SD)	25 (4.6)	Both reasons	58 (24.8)
Race (n = 229)		Frequency of use	
White	155 (67.7)	Intermittent (not in past 30 days, but in past 6 months)	66 (28.2)
Black	13 (5.7)	1–2 days in past 30 days	62 (26.5)
Hispanic	38 (16.6)	3–9 days in past 30 days	41 (17.5)
Other	23 (10.0)	10 days in past 30 days	65 (27.8)
Education		Age of first concentrates use (years) Mean (SD)	19 (4.9)
High school or less	86 (36.8)		
Some college	90 (38.5)	Difficulty in getting concentrates	24 (10.3)
Bachelor's degree or higher	58 (24.8)	Very difficult	
Employment		Fairly difficult	52 (22.2)
Employed	163 (69.7)	Fairly easy	88 (37.6)
Unemployed	21 (9.0)	Very easy	70 (29.9)
Other	50 (21.4)		
Income (n = 218)		Source of concentrates in past 6 months (n = 231) ^a	
\$0 to \$24,999	120 (55.0)	Took from a friend/relative without asking	13 (5.6)
\$25,000 to \$49,999	46 (21.1)	Given for free by a friend/relative	146 (63.2)
\$50,000 to \$74,999	24 (11.0)	Bought from a friend/relative	92 (39.8)
\$75,000	28 (12.8)	Used my own prescription to buy from a medical dispensary	32 (13.9)
Region of country (n = 226)		Used someone else's prescription to buy from a medical dispensary	10 (4.3)
Northeast	40 (17.7)	Bought from a recreational dispensary	30 (13.0)
Midwest	44 (19.5)	Made my own	34 (14.7)
South	42 (18.6)	Bought from a drug dealer / stranger	44 (19.0)
West	100 (44.2)	Bought online / over the internet	8 (3.5)
Legal status of cannabis in state (n = 226) ^a		Other source	2 (0.9)
Both recreational and medical use are legal	38 (16.8)	Method used for ingesting concentrates (n = 231) ^b	
Only medical use is legal	108 (47.8)	Vape pen	160 (69.3)
Use is not legal	80 (35.4)	Oil rig	114 (49.4)
		Other	37 (16.0)
		Concomitant use with other substances (among past month users, N = 168)	
		With other forms of cannabis	122 (72.6)
		With alcohol	97 (57.7)
		With other drugs	38 (22.6)

^aBoth recreational and medical use legal—AK, CO, OR, WA; only medical use legal—AZ, CA, CT, HI, IL, ME, MD, MA, MI, MN, MT, NV, NH, NJ, NY, VT; use not legal—AR, FL, GA, ID, IN, IA, KS, LA, MS, MO, NE, NC, ND, OH, OK, PA, SD, TN, TX, UT, VA, WI, WY.

^b Multiple responses could be selected, so sum is greater than total sample size.

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Table 2

Significant associations with frequent concentrates use (≥ 10 days/month).

	Used concentrates ≥ 10 days in past month? ^a		Bivariable association ^b OR (95% CI)	Multivariable model ^c aOR (95% CI)
	No n (%)	Yes n (%)		
Age (mean [<i>SD</i>])	25 (4.4)	27 (5.0)	1.09 (1.02, 1.16) **	1.07 (0.996, 1.14)
Legal status of cannabis				
Both recreational and medical use are legal	22 (13.6)	16 (25.0)	2.9 (1.2, 6.8) *	2.5 (1.05, 6.0) *
Only medical use is legal	76 (46.9)	32 (50.0)	1.7 (0.8, 3.3)	1.4 (0.7, 2.8)
Use is not legal	64 (39.5)	16 (25.0)	Ref.	Ref.
Reason for use				
Recreational use only	102 (60.4)	27 (41.5)	Ref.	Ref.
Medical use only	27 (16.0)	20 (30.8)	2.8 (1.4, 5.7) **	2.2 (1.1, 4.7) *
Both reasons	40 (23.7)	18 (27.7)	1.7 (0.8, 3.4)	1.5 (0.7, 3.1)

*
 $p < 0.05$.**
 $p < 0.01$.***
 $p < 0.001$.^a 65 participants used concentrates ≥ 10 days/month, 169 participants did not.^b Variables not significant in bivariable analysis included gender, race, education, employment, income, age of first concentrates use, and method of ingestion (vape pen, oil rig).^c Only variables shown were included in the multivariable model. Model c-statistic = 0.64.

Table 3

Significant associations with combining concentrates and other substances to experience overlapping effects, among those use used concentrates in the past month.

	Used concentrates with other substance in past month?		Bivariable association OR (95% CI)	Multivariable model aOR (95% CI)
	No n (%)	Yes n (%)		
<i>Used concentrates with other cannabis^a</i>				
Gender				
Female	18 (39.1)	28 (23.1)	Ref.	Ref.
Male	28 (60.9)	93 (76.9)	2.1 (1.03, 4.4) *	2.0 (0.9, 4.5)
Legal status of cannabis				
Both recreational and medical use are legal	4 (8.9)	26 (21.9)	4.6 (1.4, 15.1) *	4.1 (1.2, 14.0) *
Only medical use is legal	19 (42.2)	62 (52.1)	2.3 (1.1, 4.9) *	2.5 (1.1, 5.6) *
Use is not legal	22 (48.9)	31 (26.1)	Ref.	Ref.
Uses oil rig to ingest concentrates				
Yes	14 (30.4)	69 (56.6)	3.0 (1.4, 6.1) **	2.8 (1.3, 5.9) **
No	32 (69.6)	53 (43.4)	Ref.	Ref.
Concentrates use 10 days/month				
Yes	12 (26.1)	53 (43.4)	2.2 (1.03, 4.6) *	1.8 (0.8, 4.0)
No	34 (73.9)	69 (56.6)	Ref.	Ref.
<i>Used concentrates with alcohol or other drugs^b</i>				
Legal status of cannabis				
Both recreational and medical use are legal	11 (17.5)	19 (18.8)	2.1 (0.8, 5.2)	2.5 (0.96, 6.6)
Only medical use is legal	23 (36.5)	58 (57.4)	3.0 (1.5, 6.3) **	3.6 (1.7, 7.9) **
Use is not legal	29 (46.0)	24 (23.8)	Ref.	Ref.
Reason for use				
Recreational use only	27 (40.3)	59 (58.4)	Ref.	Ref.
Medical use only	16 (23.9)	26 (25.7)	0.74 (0.34, 1.61)	0.55 (0.24, 1.26)
Both reasons	24 (35.8)	16 (15.8)	0.31 (0.14, 0.67) **	0.28 (0.12, 0.64) **

* $p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$.

^a 122 participants used concentrates with other forms of cannabis, 46 participants did not. Variables not significant in bivariable analysis included age, race, education, employment, income, reason for use, age of first concentrates use, and using a vape pen to ingest concentrates. Only variables significant in bivariable analysis are shown and were included in the multivariable model. Multivariable model c-statistic = 0.74.

^b 101 participants used concentrates with alcohol or other drugs, 67 participants did not. Variables not significant in bivariable analysis included age, gender, race, education, employment, income, age of first concentrates use, method of ingestion (vape pen, oil rig), and using concentrates frequently (10 times/month). Only variables significant in bivariable analysis are shown and were included in the multivariable model. Multivariable model c-statistic = 0.68.

Table 4Effects of concentrates use (Total $N = 234$ unless otherwise noted).

Variable	n (%)
Strength of the effects	
Not at all strong	9 (3.9)
A little strong	62 (26.5)
Moderately strong	103 (44.0)
Very strong	60 (25.6)
How long the effects last	
Don't feel any effects	4 (1.7)
Less than an hour	45 (19.2)
One to two hours	115 (49.2)
Three or more hours	70 (29.9)
How well can perform everyday activities when using concentrates	
Not well at all	13 (5.6)
Somewhat or moderately well	66 (28.2)
Very well	122 (52.1)
I only use concentrates when I don't have tasks to perform	33 (14.1)
Increase in tolerance due to concentrates use ($n = 233$)	
Not at all	87 (37.3)
A little bit	60 (25.8)
Somewhat	55 (23.6)
Definitely	31 (13.3)
What participants dislike about concentrates ^a	
Cost	96 (41.0)
It's illegal (in some states)	71 (30.3)
Not as natural as other forms of cannabis/chemically processed	63 (26.9)
Hard to access/make	55 (23.5)
Increases tolerance too much	52 (22.2)
Not much known about this form of cannabis	38 (16.2)
Potential for negative consequences/long-term health effects	37 (15.8)
Side effects	27 (11.5)
Flavor	23 (9.8)
Potency	16 (6.8)
Intense effects/stronger high	13 (5.6)
Specific effects experienced after using concentrates ($n = 232$) ^a	
Altered sense of reality/confusion	54 (23.3)
Heart beating very fast/heart palpitations	26 (11.2)
Lung pain	23 (9.9)
Severe paranoia	16 (6.9)
Inability to move, paralysis, loss of body control	12 (5.2)
Passing out, losing consciousness	8 (3.5)

Variable	<i>n</i> (%)
None of the above	149 (64.2)

^aMultiple responses could be selected, so sum is greater than total sample size

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Table 5

Significant associations with reporting side effects from concentrates use.

	Reported side effects ^a		Bivariable association ^b OR (95% CI)	Multivariable model ^c aOR (95% CI)
	No n (%)	Yes n (%)		
Legal status of cannabis				
Both recreational and medical use are legal	20 (14.0)	18 (22.2)	2.8 (1.3, 6.5) *	2.6(1.1,6.1) *
Only medical use is legal	63 (44.1)	44 (54.3)	2.2 (1.2, 4.2) *	1.9 (0.9, 3.8)
Use is not legal	60 (42.0)	19 (23.5)	Ref.	Ref.
Reason for use				
Recreational use only	76 (51.0)	51 (61.5)	Ref.	Ref.
Medical use only	36 (24.2)	11 (13.3)	0.46 (0.21, 0.98) *	0.38 (0.17, 0.84) *
Both reasons	37 (24.8)	21(25.3)	0.85 (0.45, 1.61)	0.83 (0.41, 1.70)
Used along with either alcohol or drugs				
No	84 (59.6)	35 (45.5)	Ref.	Ref.
Yes	57 (40.4)	42 (54.6)	1.8 (1.01, 3.1) *	1.6 (0.9, 2.9)

* $p < 0.05$,** $p < 0.01$,*** $p < 0.001$.

^a 83 participants reported side effects (i.e., altered sense of reality/confusion, heart palpitations, lung pain, severe paranoia, inability to move, or passing out), 149 participants did not.

^b Variables not significant in bivariable analysis included gender, age, race, education, employment, income, age of first concentrates use, method of ingestion (vape pen, oil rig), and use 10 days/month.

^c Only variables shown were included in the multivariable model. Model c-statistic = 0.66.