HHS Public Access

Author manuscript

Drug Alcohol Depend. Author manuscript; available in PMC 2017 December 01.

Published in final edited form as:

Drug Alcohol Depend. 2016 December 01; 169: 41–47. doi:10.1016/j.drugalcdep.2016.10.008.

Prevalence and Correlates of "Vaping" as a Route of Cannabis Administration in Medical Cannabis Patients

James A. Cranford[1], **Kipling M. Bohnert**[1,2], **Brian E. Perron**[3], **Carrie Bourque**[1], and **Mark Ilgen**[1,2]

[1]Department of Psychiatry, University of Michigan, Rachel Upjohn Building, 4250 Plymouth Road, Ann Arbor, MI, 48109-2700, United States

[2]VA Center for Clinical Management Research (CCMR), Veterans Health Administration, 2215 Fuller Road, Mail Stop 152, Ann Arbor, MI, 48105, United States

[3]School of Social Work, University of Michigan, 1080 S University Ave, Ann Arbor, MI, 48109, United States

Abstract

Purpose—To examine the prevalence and correlates of vaporization (i.e., "vaping") as a route of cannabis administration in a sample of medical cannabis patients.

Procedures—Adults ages 21 and older (N = 1,485 M age = 45.1) who were seeking medical cannabis certification (either for the first time or as a renewal) at medical cannabis clinics in southern Michigan completed a screening assessment. Participants completed measures of route of cannabis administration, cannabis use, alcohol and other substance use.

Findings—An estimated 39% (n=511) of the sample reported past-month cannabis vaping, but vaping as the sole route of cannabis administration was rare. Specifically, only 30 participants (2.3% of the full sample and 5.9% of those who reported any vaping) indicated vaping as the sole route of cannabis administration. The majority (87.3%) of those who reported vaping also reported smoking (combustion) as a route of cannabis administration. Being younger than age 44, having more than a high school education, engaging in nonmedical stimulant use, being a returning medical cannabis patient, and greater frequency of cannabis use were associated with higher odds of vaping at the bivariate level and with all variables considered simultaneously.

Conclusions—Vaping appears to be relatively common among medical cannabis patients, but is seldom used as the sole route of cannabis administration. Results highlight the importance of

Corresponding Author: James A. Cranford, Department of Psychiatry, University of Michigan, Rachel Upjohn Building, 4250 Plymouth Road, Ann Arbor, MI, 48109-2700, United States, jcranfor@med.umich.edu.

Contributors: Dr. Ilgen (study principal investigator) conceptualized and designed the study. Drs. Cranford, Bohnert, Perron, and Ilgen drafted the manuscript. Ms. Bourque was responsible for data collection and review of study methods. Dr. Cranford was responsible for data analysis, and all authors contributed to and have approved the final manuscript.

Author Disclosures

Conflict of interest: No conflict declared.

monitoring trends in vaping and other substance use behaviors in this population and underscore the need for longitudinal research into the motives, correlates, and consequences of cannabis vaping in medical cannabis patients.

Keywords

medical cannabis; vaping; route of cannabis administration; correlates of cannabis vaping

1. INTRODUCTION

Since the appearance of electronic nicotine delivery systems in 2007, the use of electronic cigarettes or e-cigarettes (ECs), also known as “vaping,” has emerged as a growing public health concern (Benowitz, 2014; Pisinger and Dossing, 2014; Walton et al., 2015). More recently, vaporization as a route of cannabis administration has raised public health concerns similar to those for ECs. Specifically, vaping cannabis may be perceived as safer than smoking cannabis, which, in turn, might lead to greater initiation and/or use of cannabis (Budney et al., 2015; Cox, 2015; Fischer et al., 2015; Tashkin, 2015). Other potential concerns about cannabis vaping include the greater use of high-potency cannabis products, leading to increased risk of symptoms of cannabis use disorder, as well as the greater use of tobacco and cannabis together (Budney et al., 2015). By contrast, it was suggested that cannabis vaping could reduce the co-use of tobacco and cannabis (Gartner, 2015). The public health importance of understanding the potential risks and benefits of cannabis vaping takes on added significance in light of recent evidence that the prevalence of nonmedical cannabis use and cannabis use disorders increased sharply in the United States (US) in the 10-year period between 2001-2002 and 2012-2013 (Hasin et al., 2015).

Public health concerns about cannabis vaping are particularly relevant given the ongoing changes in cannabis legislation for medicinal purposes. As of July, 2016, twenty-five US states and the District of Columbia have passed legislation legalizing cannabis for medicinal purposes (National Conference of State Legislatures, 2016). In the state of Michigan, where the current research was conducted, the Michigan Medical Marihuana Act passed in 2008 legalized the use of cannabis for the treatment of debilitating medical conditions (e.g., cancer, glaucoma, severe or chronic pain). Qualifying patients or primary caregivers are required to obtain a registry identification card through a state registry program. As of January, 2016, 182,091 patients and 34,269 caregivers have been approved for medical cannabis registry identification cards in Michigan (Gaedeke, 2016).

Although a large body of evidence indicated that non-medical cannabis use was associated with a number of adverse health effects (Hall and Degenhardt, 2009; Volkow et al., 2014), results from recent narrative and meta-analytic reviews suggest that medical cannabis use may be associated with reductions in pain, nausea due to chemotherapy, and spasticity (Aggarwal, 2013; Borgelt et al., 2013; Hill, 2015; Koppel et al., 2014; Whiting et al., 2015). However, results from these reviews also showed that medical cannabis use was associated with increased odds of several adverse events, including risk of motor vehicle accidents, nausea and fatigue, gastrointestinal disorders, and psychiatric symptoms. More broadly, very little evidence exists to guide the method of administration, dosing, potential “strain” of

cannabis or other domains related to dose/scheduling that are typical of FDA-approved medications.

The possibility that cannabis effects may vary by route of administration (Borgelt et al., 2013) highlights the importance of examining the prevalence and correlates of cannabis vaping in medical cannabis patients. Some potential benefits to vaping cannabis compared to smoking have been noted. For example, results from two randomized controlled trials showed that vaping cannabis compared to placebo was associated with reductions in neuropathic pain (Wallace et al., 2015; Wilsey et al., 2013). Other studies found that cannabis vaping was associated with lower likelihood of reporting respiratory problems (Earleywine and Barnell, 2007) and improved respiratory function (Van Dam and Earleywine, 2010) compared to smoking. Some evidence also showed that cannabis vaping was associated with lower total cannabis use (Etter, 2015). Cannabis users might be particularly attracted to the potential of vaping as a means of reducing others' exposure to secondhand cannabis smoke, and cannabis vaping might also reduce the simultaneous use of tobacco and cannabis (Gartner, 2015). However, evidence also indicated that vaping cannabis was associated with impaired cognitive performance (Wallace et al., 2017). It has also been argued that any beneficial effects of cannabis vaping on respiratory function are likely to be small and do not offset potential risks of vaping (Tashkin, 2015). In addition, vaping is often presented as an alternative to smoking cannabis, but little is known about the extent to which vaping occurs independently from, or in addition to, cannabis smoking.

Existing data have only provided a partial view of the potential prevalence of cannabis vaping. An early study based on a large sample of past-month cannabis users found that the prevalence of cannabis vaping was relatively low at 2.2% (Earleywine and Barnell, 2007). A more recent study of 3,847 students from five Connecticut high schools found that 5.4% of all students and 18.4% of all lifetime cannabis users reported ever using electronic cigarettes to vaporize cannabis (Morean et al., 2015), and the 2015 Monitoring the Future study found that, among adolescents who reported any lifetime use of electronic vaporizers, between 6-7% inhaled marijuana or hash oil when they last used an electronic cigarette (Johnston et al., 2016). A study based on a nationally representative consumer sample of U.S. adults showed that the prevalence of vaping among current (past one-month) cannabis users was 7.6% (Schauer et al., 2016), and results from a large study of past 12-month cannabis users in the 2014 Global Drug Survey indicated that 11.2% of US participants reported vaping as their most common current route of cannabis administration (Hindocha et al., 2016). By contrast, results based on a sample of lifetime cannabis users indicated that the past 1-month prevalence of any cannabis vaping was 37% (Lee et al., 2016), with lifetime vaping rates exceeding 50% (Borodovsky et al., 2016). Evidence also showed that vaping rates were higher among lifetime cannabis users residing in states with medical marijuana laws, and vaping rates increased as a function of states' duration of medical cannabis legislation and the number of cannabis dispensaries (Borodovsky et al., 2016).

To our knowledge, only one study has documented prevalence rates of cannabis vaping among medical cannabis users. Pacula et al. (2016) collected data from an internet panel survey of a probability sample of adults residing in four states that have legalized medical cannabis use (Colorado, Washington, Oregon and New Mexico). Among medical cannabis

users, the prevalence of vaping cannabis was 18%, compared to 3% among recreational cannabis users. The prevalence of vaping was highest (36.3%) among medical cannabis users who reported using both medically and recreationally.

There are few data available on the correlates of cannabis vaping. A small study found that a substantial percentage (45%) of cannabis users reported that vaping helped them to stop or reduce cannabis use (Etter, 2015). Those who use cannabis may also perceive that vaping is safer than smoking (Etter, 2015; Lau et al., 2015) and that vaping may confer health benefits (Malouff et al., 2013). Although there are concerns that vaping will lead to more frequent use of tobacco and cannabis together, evidence showed that vapers were less likely to combine tobacco and cannabis when vaping (Malouff et al., 2013; also see Lee et al., 2016). In addition, some data indicated that cannabis users perceive that vaping enhances the effects of cannabis (Malouff et al.), although Abrams et al. (2007) found no difference between smoking and vaping cannabis in terms of plasma THC concentration, and vaping had lower carbon monoxide exposure.

Overall, vaping has become a common mode of administration for tobacco and appears to be increasing for cannabis. Recent changes in legislation related to medical use of cannabis have raised numerous questions about efficacy and safety (Hill, 2015). However, no prior research has studied the prevalence and correlates of cannabis vaping in a sample of medical cannabis patients. Accordingly, the current research focused on medical cannabis patients and examined the extent to which they engage in vaping, whether vaping occurs instead of or in addition to cannabis use by other routes of administration, and the variables that are associated with cannabis vaping. Given that this is among the first studies to examine correlates of cannabis vaping among medical cannabis patients, we limited the covariates to demographic and substance use variables.

2. MATERIAL AND METHODS

The current research is based on cross-sectional data from a project examining patterns of cannabis use. Adults ages 21 and older who were seeking medical cannabis at medical cannabis clinics in Michigan completed a screening assessment during a medical cannabis clinical visit.

Participants completed the screening assessment during the recruitment period for this study, which began in February, 2014 and ended in June, 2015. Of the 2,569 participants who presented to the study sites during this period, a total of 1,485 participants (57.8%) completed the screening survey. Measures in the screening survey included the following:

Demographics included questions about sex, race/ethnicity, education (highest grade completed in school), current marital status, and current employment status, whether the participant was a first-time or returning patient (assessed with an item asking if the participant currently had a medical marijuana card), and reasons for seeking medical marijuana.

Frequency of Past 6-Months Cannabis and Other Substance Use was assessed with the question “In the past 6 months, how often have you used cannabis (marijuana, pot, grass,

hash, etc.)?" Response options were: 0 = *Never*, 1 = *Once or twice*, 2 = *Monthly*, 3 = *Weekly*, 4 = *Daily or almost daily*. Using the same response options, participants were also asked how often during the past 6 months they had used 1) cocaine (coke, crack etc.); 2) methamphetamine (speed, crystal meth, ice, ecstasy, etc.); 3) prescription stimulants nonmedically (i.e., used to get high, used more than was prescribed, or that belonged to someone else); 4) prescription sedatives nonmedically; and 5) prescription opioids nonmedically.. Due to low frequencies, scores on the variables for cocaine, methamphetamine, and nonmedical stimulant, sedative, and opioid use were collapsed into five binary indicators, one for each substance.

Frequency of Past 6-Months Alcohol Use was assessed with the question "In the past 6 months, how often did you have a drink containing alcohol)?" Response options were: 0 = *Never*, 1 = *Monthly or less*, 2 = *2-4 times a month*, 3 = *2-3 times a week*, 4 = *4+ times a week*. Any Past 6-Months Heavy Alcohol Use was assessed with the question "In the past 6 months, how often did you have 6 or more drinks on one occasion?" Response options ranged from 0 = *Never* to 4 = *daily/almost daily*, and scores on this variable were collapsed into a binary indicator. Both questions were taken from the Alcohol use Disorders Identification Test (AUDIT; Babor et al., 2001).

Average Quantity of Weekly Cannabis Use in the Past Month was assessed with the question "During the past month, on average, how much marijuana (for medical or non-medical use) did you use per week?" Response options were: 0 = *None*, 1 = *Less than an eighth of an ounce,* 2 = An eighth to slightly less than a quarter of an ounce, 3 = A quarter to slightly less than a half of an ounce, 4 = *A half to slightly less than one ounce,* 5 = *One or more ounces*.

Duration of Cannabis Intoxication on an Average Day in the Past Month was assessed with the question "During the past month, how many hours, on an average day, do you feel high or stoned?" Response options were: 1) *0 hours,* 2) *1-2 hours,* 3) *3-4 hours,* 4) *5-6 hours,* 5) *7-8 hours,* 6) *9 or more hours*.

Route of Cannabis Administration in the Past Month was determined by a single question that asked "During the PAST MONTH, what are the different ways you have used any marijuana? Please **select all** that apply." Response options were: 1) *By mouth, eating, drinking, or ingesting*; 2) *Smoking (combustion)*; 3) *Used through vaporizer or e-cig*; and 4) *Used on your skin (i.e., through lotions)*.

2.1 Statistical Analysis

To address our research questions, we calculated descriptive statistics and estimated the prevalence of cannabis vaping as a route of administration. Correlates of vaping were tested with bivariate and multiple logistic regression analysis (Agresti, 2013). Responses to the questions about 1) past 1-month routes of cannabis administration and 2) past 1-month number of hours felt high or stoned were contingent on responses to the question about past 1-month quantity of cannabis use. As shown in Table 1, n = 140 participants (9.7%) responded "0 = *None*" to the question about past 1-month quantity of cannabis use, and these participants were not asked about routes of past 1-month cannabis administration. Of the remaining n = 1345 participants, there were n = 25 cases (1.9%) with missing data on the

question about routes of cannabis administration, leaving a total $n = 1320$ with valid data on this variable. The multiple logistic regression analysis with 11 covariates used listwise deletion of missing data and included $n = 1214$ cases (92.0% of the cases with data on past 1-month routes of cannabis administration).

3. RESULTS

Descriptive statistics reported in Table 1 show that the sample was mostly white, about 57% male, with a mean age of 45 years, and relatively well-educated (~65% reported “at least some college”). The majority (56%) of participants were either currently married or in a long-term relationship, almost half (46.9%) were currently employed, and most (62%) were returning patients. Results in Table 1 also show that participants reported relatively frequent use of cannabis in the past 6 months, with about 74% of the sample reporting daily or almost daily use. By contrast, rates of other substance use (i.e., cocaine, methamphetamine, and nonmedical stimulant and sedative use) were relatively low (< 6%). Results not shown in Table 1 indicated that the top two reasons for seeking medical marijuana were 1) severe and chronic pain (91.1%) and 2) severe and persistent muscle spasms (25.9%). These were also the top two conditions reported by qualifying patients in the state of Michigan approved for medical cannabis registry identification cards as of January, 2016 (Gaedeke, 2016), and the prevalence rates were very similar to those in our sample (92.9% and 23.4% for severe and chronic pain and severe and persistent muscle spasms, respectively).

In terms of routes of cannabis administration, 90.8% (n=1199) of the sample reported smoking; 44% (n=587) reported eating, drinking, or ingesting; 39% (n=511) reported vaping; and 10.9% (n=144) reported skin/topical use as a route of cannabis administration in the past month. However, these were not mutually exclusive categories, and more than 50% of the sample indicated more than one administration route for past month cannabis use. The most prevalent single route of cannabis administration was “by smoking (combustion) only”, endorsed by 36.8% (n=486) of the sample. Table 1 depicts the co-use of vaping with other routes of administration. Vaping as the sole route of administration was rare and reported by 30 participants (2.3% of the full sample and 5.9% of those who reported any vaping). Notably, the majority (n=446, 87.3%) of those who reported vaping also reported smoking (combustion) as a route of cannabis administration.

Results from bivariate and multiple logistic regression analyses of demographic and substance use correlates of vaping are presented in Table 2. Being younger than age 44, having more than a high school education, any past 6-months nonmedical stimulant use, being a returning medical cannabis patient, and greater frequency of past 1-month cannabis use were associated with higher odds of vaping at the bivariate level and with all variables included simultaneously. Being male, white, working full- or part-time (relative to being retired), any past 6-months nonmedical sedative use, greater quantity of cannabis use, and duration of cannabis intoxication were associated with higher odds of vaping in bivariate analysis but not when other correlates were statistically controlled. Current marital status and past 6-months cocaine, methamphetamine, nonmedical opioid, alcohol, and heavy alcohol use were not associated with cannabis vaping at the bivariate level and were not included in the multiple logistic regression analysis.

4. DISCUSSION

To our knowledge, this study is the first to examine prevalence and correlates of vaping as a route of cannabis administration in a sample of medical cannabis patients. Results suggest that among medical cannabis patients, vaping is highly prevalent in combination with other modes of cannabis administration (e.g., smoking), but it rarely serves as the sole route of administration. Vaping is also more common among returning medical cannabis patients and those who are younger and better educated. In addition, those medical cannabis patients who engage in vaping tend to use cannabis with a greater frequency than other medical cannabis patients and had higher odds of any past 6-months nonmedical stimulant use. These findings indicate that those who engage in vaping may be a unique group of medical cannabis patients with quite frequent cannabis use and may have unique features and potential problems relative to other adults who use medical cannabis.

Results showed that the prevalence of past-month cannabis vaping in this sample of medical cannabis patients was about 39% and increased to 43% among those who already had certification for medical cannabis and were seeking to renew their certification. These prevalence rates are more than five times higher than the prevalence rate of cannabis vaping in a representative sample of U.S. adults (Schauer et al., 2016), but are similar to the past 1-month cannabis vaping rate among lifetime cannabis users (37%; Lee et al., 2016), and to the cannabis vaping rate among medical cannabis users who reported using both medically and recreationally (36.3%; Pacula et al., 2016). Taken together, data from these studies suggest that the current past 1-month prevalence of cannabis vaping among medical cannabis users could be between 35-45%. In this context it is noteworthy that rates of cannabis vaping are higher in states that have legalized cannabis, and increase as a function of the duration of medical cannabis laws and the density of medical cannabis dispensaries (Borodovsky et al., 2016).

Although we found that vaping is relatively common among medical cannabis patients, vaping as the sole route of administration was very rare. Indeed, in this sample the vast majority (87%) of vapers also reported smoking as a route of cannabis administration. Prior findings have indicated that vaping might be motivated by a desire to reduce one's own or others' exposure to cannabis smoke (Budney et al., 2015). The present findings cast doubt on whether vaping may be an effective harm reduction strategy if smoking remains common in those who engage in vaping. However, detailed data on the frequency of use by specific routes of administration are lacking in the present sample, leaving open the possibility that smoking became less frequent over time among those who engaged in vaping.

In a recent review, the authors suggested that cannabis vaping could lead to greater frequency and quantity of cannabis use and a higher risk of cannabis use disorder, particularly if vaping devices enhance the potency of cannabis (Budney et al., 2015). Evidence from other studies showed that cannabis vaping was associated with more frequent cannabis smoking (Lee et al., 2016), and using multiple routes of cannabis administration was associated with cannabis use problems (Baggio et al., 2014). These previous findings are broadly consistent with our results indicating that individuals who reported vaping also reported greater frequency of cannabis use; however, the cross-sectional design of our study

makes it impossible to assess the temporal direction of these associations. For example, it may be that more frequent and heavier cannabis use leads to use of a wider range of routes of administration, including vaping. Another possibility is that the inefficiency of currently available vaporizing devices may lead to greater frequency of cannabis use. It is also possible that the association is due to some third variable that predicts vaping and greater frequency and quantity of cannabis use, such as greater severity of symptoms that initially motivated medical cannabis use. Consequently, longitudinal data are needed to better understand the temporal order of associations between modes of cannabis administration (including vaping) and cannabis use outcomes (Fischer et al., 2015).

Several individual characteristics differentiated medical cannabis patients who engaged in vaping from those who did not. Specifically, those who reported vaping were more likely to be returning medical cannabis patients, younger, and more highly educated. Other evidence also suggested that vaping is inversely associated with age (Lee et al., 2016). The specific devices used for vaping cost money and could be conceptualized as a new technology. It is possible that these individual features (younger age and higher education) may also be associated with being able to afford and willing to adopt this newer method of administration. However, findings also suggest that experience with medical cannabis plays an important role, and higher rates of vaping among returning medical cannabis patients might signify greater willingness to experiment with alternative administration modes (e.g., Ilgen et al., 2013). Finally, while the association between nonmedical stimulant use and vaping was statistically significant and generally consistent with some previous research (Compton et al., 2016), the relatively small number of nonmedical stimulant users who reported vaping in the current sample ($n = 24$) suggests that larger samples are needed to understand this relationship.

We acknowledge several limitations to this study. First, the current research is based on cross-sectional data, making it impossible to discern the temporal direction of associations. Also, our measure of route of cannabis administration did not ask about frequency of vaping. Several of the measures we used, including route of cannabis administration, were developed for this study and their psychometric properties have not been established. Further, our study is based on a sample of medical cannabis users from clinics in one Midwestern state, and given the considerable variability in state laws related to medical cannabis, the results may not generalize to other locations. For example, anecdotal evidence from our study sites suggested that some physicians may be advising patients to adopt vaping as a rout of administration, which might have resulted in higher rates of vaping in this sample. Finally, recent work showed some differences between medical and recreational cannabis users (Lin et al., 2016; Pacula et al., 2016), but we were unable to distinguish between medical and recreational use in the current study.

Nonetheless, our results serve as an important initial glimpse at cannabis vaping among medical cannabis users. Against the backdrop of a sharp increase in the prevalence of nonmedical cannabis use in recent years (Hasin et al., 2015), the emergence of medical cannabis has raised numerous medical and public health questions (Budney et al., 2015; Hill, 2015). At the same time, the use of “vaping” as a route of administration for tobacco has escalated dramatically since 2007 (Arrazola et al., 2015), and there are concerns that

cannabis vaping will show a similar increase (Budney et al., 2015). The current study represents one of the first investigations of vaping in a sample of medical cannabis users, and findings indicate that vaping is a relatively prevalent mode of administration in this population. The associations we observed between vaping and greater frequency of cannabis use highlight the importance of future research using longitudinal designs that can address questions about temporal precedence and long-term health outcomes, along with additional clinical trials to investigate the efficacy of vaporization compared to other administration routes for medical cannabis patients.

Acknowledgements

We gratefully acknowledge Kierstdea Furey for her assistance with data collection and management.

Role of Funding Source: This research was supported by grant R01 DA033397 from the National Institute on Drug Abuse (NIDA), National Institutes of Health. NIDA had no role in the study design; in the collection, analysis or interpretation of data; in the writing of the report; or in the decision to submit the article for publication.

REFERENCES

Abrams DI, Jay CA, Shade SB, Vizoso H, Reda H, Press S, Kelly ME, Rowbotham MC, Petersen KL. Cannabis in painful HIV-associated sensory neuropathy: a randomized placebo-controlled trial. Neurology. 2007; 68:515–521. [PubMed: 17296917]

Agresti, A. Categorical Data Analysis. 3rd ed.. John Wiley & Sons, Inc.; Hoboken, NJ.: 2013.

Aggarwal SK. Cannabinergic pain medicine: a concise clinical primer and survey of randomized-controlled trial results. Clin. J. Pain. 2013; 29:162–171. [PubMed: 22367503]

Arrazola RA, Singh T, Corey CG, Husten CG, Neff LJ, Apelberg BJ, Bunnell RE, Choiniere CJ, King BA, Cox S. Tobacco use among middle and high school students – United States, 2011–2014. MMWR. 2015; 64:381–385. [PubMed: 25879896]

Babor, TF.; Higgins-Biddle, JC.; Saunders, JB.; Monteiro, MG. The Alcohol Use Disorders Identification Test: Guidelines For Use In Primary Care. 2nd ed.. World Health Organization; Geneva, Switzerland: 2001.

Baggio S, Deline S, Studer J, Mohler-Kuo M, Daeppen J-B, Gmel G. Routes of administration of cannabis used for nonmedical purposes and associations with patterns of drug use. J. Adolesc. Health. 2014; 54:235–240. [PubMed: 24119417]

Benowitz NL. Emerging nicotine delivery products: implications for public health. Ann. Am. Thorac. Soc. 2014; 11:231–235. [PubMed: 24575992]

Borgelt LM, Franson KL, Nussbaum AM, Wang GS. The pharmacologic and clinical effects of medical cannabis. Pharmacotherapy. 2013; 33:195–209. [PubMed: 23386598]

Borodovsky JT, Crosier BS, Lee DC, Sargent JD, Budney AJ. Smoking, vaping, eating: is legalization impacting the way people use cannabis? Int. J. Drug Policy. 2016; 36:141–147. [PubMed: 26992484]

Budney AJ, Sargent JD, Lee DC. Vaping cannabis (marijuana): parallel concerns to e-cigs? Addiction. 2015; 110:1699–1704. [PubMed: 26264448]

Compton WM, Han B, Jones CM, Blanco C, Hughes A. Marijuana use and use disorders in adults in the USA, 2002–14: analysis of annual cross-sectional surveys. Lancet Psychiatry. 2016 epub ahead of print.

Cox B. Can the research community respond adequately to the health risks of vaping? Addiction. 2015; 110:1708–1709. [PubMed: 26471153]

Earleywine M, Barnwell SS. Decreased respiratory symptoms in cannabis users who vaporize. Harm Reduct. J. 2007; 4:11. [PubMed: 17437626]

Etter JF. Electronic cigarettes and cannabis: an exploratory study. Eur. Addict. Res. 2015; 21:124–130. [PubMed: 25613866]

Fischer B, Russell C, Tyndall MW. Cannabis vaping and public health—some comments on relevance and implications. Addiction. 2015; 110:1705–1706. [PubMed: 26471151]

Gaedeke, K. Health Licensing Division, Bureau of Professional Licensing. Michigan Department of Licensing and Regulatory Affairs; Lansing, MI.: 2016. Medical Marihuana Act statistical report for fiscal Year 2015 (pursuant to MCL 333.26426 (i) (1), (2), (3), (4) and (5))..

Gartner CE. Mull it over: cannabis vaporizers and harm reduction. Addiction. 2015; 110:1709–1710. [PubMed: 26471154]

Hall W, Degenhardt L. Adverse health effects of non-medical cannabis use. Lancet. 2009; 374:1383–1391. [PubMed: 19837255]

Hasin DS, Saha TD, Kerridge BT, Goldstein RB, Chou SP, Zhang H, Jung J, Pickering RP, Ruan J, Smith SM, Huang B, Grant BF. Prevalence of marijuana use disorders in the United States between 2001-2002 and 2012-2013. JAMA Psychiatry. 2015; 72:1235–1242. [PubMed: 26502112]

Hill KP. Medical marijuana for treatment of chronic pain and other medical and psychiatric problems: a clinical review. JAMA. 2015; 313:2474–2483. [PubMed: 26103031]

Hindocha C, Freeman TP, Ferris JA, Lynskey MT, Winstock AR. No smoke without tobacco: a global overview of cannabis and tobacco routes of administration and their association with intention to quit. Front. Psychiatry. 2016 epub ahead of print.

Ilgen MA, Bohnert K, Kleinberg F, Jannausch M, Bohnert ASB, Walton M, Blow FC. Characteristics of adults seeking medical marijuana certification. Drug Alcohol Depend. 2013; 132:654–659. [PubMed: 23683791]

Johnston, LD.; O'Malley, PM.; Miech, RA.; Bachman, JG.; Schulenberg, JE. Monitoring The Future National Survey Results On Drug Use, 1975-2015: Overview, Key Findings On Adolescent Drug Use. Institute for Social Research, The University of Michigan; Ann Arbor, MI.: 2016.

Koppel BS, Brust JCM, Fife T, Bronstein J, Youssof S, Gronseth G, Gloss D. Systematic review: efficacy and safety of medical marijuana in selected neurologic disorders: report of the Guideline Development Subcommittee of the American Academy of Neurology. Neurology. 2014; 82:1556–1563. [PubMed: 24778283]

Lau N, Sales P, Averill S, Murphy F, Sato SO, Murphy S. Responsible and controlled use: older cannabis users and harm reduction. Int. J. Drug Policy. 2015; 26:709–718. [PubMed: 25911027]

Lee DC, Crosier BS, Borodovsky JT, Sargent JD, Budney AJ. Online survey characterizing vaporizer use among cannabis users. Drug Alcohol Depend. 2016; 159:227–233. [PubMed: 26774946]

Lin LA, Ilgen MA, Jannausch M, Bohnert KM. Comparing adults who use cannabis medically with those who use recreationally: Results from a national sample. Addict. Behav. 2016; 61:99–103. [PubMed: 27262964]

Malouff JM, Rooke SE, Copeland J. Experiences of marijuana-vaporizer users. Subst. Abuse. 2013; 35:127–128.

Morean ME, Kong G, Camenga DR, Cavallo DA, Krishnan-Sarin S. High school students' use of electronic cigarettes to vaporize cannabis. Pediatrics. 2015; 136:611–616. [PubMed: 26347431]

Michigan Medical Marihuana Act. 2008:26421–.26430. Initiated law 1 of 2008, MCL §§ 333.

National Conference of State Legislatures. [20 September 2016] State medical marijuana laws. 2016. from http://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx

Pacula RL, Jacobson M, Maksabedian EJ. In the weeds: a baseline view of cannabis use among legalizing states and their neighbours. Addiction. 2016; 111:973–980. [PubMed: 26687431]

Pisinger C, Døssing M. A systematic review of health effects of electronic cigarettes. Prev. Med. 2014; 69:248–260. [PubMed: 25456810]

Schauer GL, King BA, Bunnell RE, Promoff G, McAfee TA. Toking, vaping, and eating for health or fun: marijuana use patterns in adults, U.S., 2014. Am. J. Prev Med. 2016; 50:1–8. [PubMed: 26277652]

Tashkin DP. How beneficial is vaping cannabis to respiratory health compared to smoking? Addiction. 2015; 110:1706–1707. [PubMed: 26471152]

Van Dam NT, Earleywine M. Pulmonary function in cannabis users: support for a clinical trial of the vaporizer. Int. J. Drug Policy. 2010; 21:511–513. [PubMed: 20451365]

Volkow ND, Baler RD, Compton WM, Weiss SRB. Adverse health effects of marijuana use. N. Engl. J. Med. 2014; 370:2219–2227. [PubMed: 24897085]

Wallace MS, Marcotte TD, Umlauf A, Gouaux B, Atkinson JH. Efficacy of inhaled cannabis on painful diabetic neuropathy. J. Pain. 2015; 16:616–627. [PubMed: 25843054]

Walton KM, Abrams DB, Bailey WC, Clark D, Connolly GN, Djordjevic MV, Eissenberg TE, Fiore MC, Goniewicz ML, Haverkos L, Hecht SS, Henningfield JE, Hughes JR, Oncken CA, Postow L, Rose JE, Wanke KL, Yang L, Hatsukami DK. NIH electronic cigarette workshop: developing a research agenda. Nicotine Tob. Res. 2015; 17:259–269. [PubMed: 25335949]

Whiting PF, Wolff RF, Deshpande S, et al. Cannabinoids for medical use: a systematic review and meta-analysis. JAMA. 2015; 313:2456–2473. [PubMed: 26103030]

Wilsey B, Marcotte T, Deutsch R, Gouaux B, Sakai S, Donaghe H. Low-dose vaporized cannabis significantly improves neuropathic pain. J. Pain. 2013; 14:136–148. [PubMed: 23237736]

Highlights

- About 39% of adults seeking medical cannabis certification reported vaping cannabis.
- The majority (87.3%) of those who reported vaping also reported smoking cannabis.
- Returning medical cannabis patients were more likely to report cannabis vaping.
- Younger age, higher education, and frequency of cannabis use were related to vaping.

Table 1

Demographic and Cannabis Use Variables at Screening (N = 1,485)[1]

	N (%) or Mean (SD)
Age	45.1 (13.0)
Gender	
Female	634 (42.7%)
Male	850 (57.2%)
Transsexual	1 (0.1%)
Race/Ethnicity	
African American	141 (9.5%)
Caucasian	1293 (87.1%)
Other	51 (3.4%)
Education	
Less than high school/High school graduate	508 (34.2%)
Some college/College graduate	977 (65.8%)
Marital Status	
Married or long-term relationship	819 (55.9%)
Divorced/separated/widowed	326 (22.2%)
Never married	321 (21.9%)
Employment Status	
Work full-time or part-time	686 (46.9%)
Disability	426 (29.1%)
Retired	166 (11.4%)
Unemployed	100 (6.8%)
Other	84 (5.7%)
Past 6 Months Cocaine Use	
No	1417 (96.9%)
Yes	46 (3.1%)
Past 6 Months Methamphetamine Use	
No	1443 (98.8%)
Yes	18 (1.2%)
Past 6 Months Nonmedical Stimulant Use	
No	1421 (97.2%)
Yes	41 (2.8%)
Past 6 Months Nonmedical Sedative Use	
No	1383 (94.7%)
Yes	77 (5.3%)
Past 6 Months Nonmedical Opioid Use	
No	1397 (96.3%)

	N (%) or Mean (SD)
Yes	53 (3.7%)
Frequency of Past 6 Months Alcohol Use	1.2 (1.3)
Any Past 6 Months Heavy Alcohol Use	
No	1049 (72.5%)
Yes	398 (27.5%)
Currently Have a MMJ Card	
No	498 (33.9%)
Yes	972 (62.1%)
Past 6 Months Frequency of Cannabis Use	
Never	90 (6.1%)
Monthly	37 (2.5%)
Weekly	176 (12.0%)
Daily or almost daily	1084 (74.0%)
Past 1 Month Quantity of Cannabis Use in	
None	140 (9.7%)
Less than 1/8 of an oz.	228 (15.8%)
1/8 to slightly less than ¼ of an oz	302 (21.0%)
¼ to slightly less than ½ of an oz	326 (22.6%)
½ to slightly less than 1 oz	236 (16.4%)
One or more ounces	208 (14.5%)
Past 1 Month Number of Hours Felt High	2.8 (1.3)
Past 1 Month Cannabis Vaping	
Yes	511 (38.7%)
No	809 (61.3%)
Routes of Cannabis Administration in Past 1 Month Among Vapers (n = 511)	
Vaping only	30 (5.9%)
Vaping and smoking	182 (35.6%)
Vaping and eating	28 (5.5%)
Vaping and topical	2 (0.4%)
Vaping, smoking, and eating	186 (36.4%)
Vaping, smoking, and topical	11 (2.1%)
Vaping, eating, and topical	5 (1.0%)
Vaping, smoking, eating, and topical	67 (13.1%)

[1]Due to missing data and panned missingness, Ns ranged from 1,310 to 1,468.

Table 2

Multiple Logistic Regression Analysis of Correlates of Cannabis Vaping (N = 1,214)

	Vaping as a Route of Cannabis Administration in Past 1 Month		
	%	OR (95% CI)	AOR (95% CI)
Overall	**38.7**		
1. Sex			
Female	35.3	—	—
Male	41.1	1.3* (1.02 – 1.6)	1.2 (0.9 – 1.6)
2. Age			
18-44	46.6	1.9* (1.6 – 2.4)	1.9* (1.4 – 2.5)
45 and older	30.9	—	—
3. Race/Ethnicity			
White	40.1	1.6* (1.1 – 2.4)	1.4 (0.9 – 2.2)
Non-White	29.2	—	—
4. Current Marital Status			
Married/Relationship	39.0	1.1 (0.8 – 1.5)	NA
Never married	41.5	1.2 (0.9 – 1.7)	NA
Divorced/Separated/Widowed	36.7	—	NA
5. Education			
More than high school	40.8	1.3* (1.02 – 1.6)	1.4* (1.1 – 1.8)
Completed high school	34.8	—	—
6. Employment Status			
Work full-time or part-time	44.2	1.9* (1.3 – 2.7)	1.2 (0.8 – 1.9)
Disability	34.9	1.2 (0.8 – 1.9)	1.2 (0.8 – 2.0)
Retired	29.9	—	—
Unemployed	36.4	1.3 (0.8 – 2.3)	1.1 (0.6 – 2.0)
Other	39.7	1.5 (0.9 – 2.8)	1.1 (0.6 – 2.2)
7. Past 6 Months Cocaine Use			
Yes	52.3	1.7 (0.9 – 3.2)	NA
No	38.6	—	NA
8. Past 6 Months Methamphetamine Use			
Yes	55.6	2.0 (0.8 – 5.0)	NA
No	38.8	—	NA
9. Past 6 Months Nonmedical Stimulant Use			
Yes	63.2	2.8* (1.4 – 5.4)	2.2* (1.1 – 4.4)
No	38.3	—	—
10. Past 6 Months Nonmedical Sedative Use			
Yes	52.9	1.8* (1.1 – 3.0)	1.5 (0.9 – 2.7)

	Vaping as a Route of Cannabis Administration in Past 1 Month		
	%	OR (95% CI)	AOR (95% CI)
No	38.3	—	—
11. Past 6 Months Nonmedical Opioid Use			
Yes	44.4	1.3 (0.7 – 2.3)	NA
No	38.7	—	NA
12. Frequency of Past 6 Months Alcohol Use		1.0 (0.9 – 1.1)	NA
13. Any Past 6 Months Heavy Alcohol Use			
Yes	41.1	1.1 (0.9 – 1.4)	NA
No	38.4	—	NA
14. Currently Have a MMJ Card			
Yes	43.2	1.9* (1.5 – 2.5)	1.8* (1.3 – 2.4)
No	28.1	—	—
15. Frequency of Past 6 Months Cannabis Use		1.7* (1.4 – 2.0)	1.4* (1.1 – 1.8)
16. Quantity of Weekly Cannabis Use in Past 1 Month		1.2* (1.1 – 1.3)	1.1 (0.9 – 1.2)
17. Number of Hours in Average Day High/Stoned Past 1 Month		1.1* (1.04 – 1.2)	1.0 (0.9 – 1.1)

Note. OR = odds ratio from bivariate logistic regression analysis. AOR = adjusted odds ratio from multiple logistic regression analysis. CI = confidence interval. — = reference group. NA = not applicable, variable was not associated with cannabis vaping at the bivariate le el and was excluded from multiple logistic regression analysis.

* $p < .05$.