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A Qualitative Analysis of Cannabis Vaporization among Medical Users

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Abstract

Cannabis vaporization is a prevailing mode of administration among medical users for symptom relief. Limited research to date has considered factors that contribute to vaporization in medical users, although initial evidence suggests that vaporization may provide unique therapeutic advantages relative to other modes. This study aimed to provide an in-depth qualitative examination of vaping behavior and use preferences among medical cannabis users. Qualitative interviews were conducted with Rhode Island medical cannabis registration card holders (n = 25). Interviews followed a semi-structured agenda, and were audio-recorded and transcribed for applied thematic analysis. Key vaporization themes were summarized. Several themes emerged related to (1) medication dosing and administration (flexible timing of medication delivery; ease when traveling; type of device/cannabis formulation), (2) physical health advantages of vaping (general health benefits; better for medical condition; promoting tobacco cessation), (3) general advantages of vaping (portability, concealability, efficiency), and (4) disadvantages (weaker medication delivery; device cost; technology-use barriers). Various factors contribute to cannabis vaporization among medical users that are both general and medical-specific. Certain aspects of vaping may also interfere with effective delivery of cannabis, including technology aspects and device cost. These findings highlight the heterogeneity in vaporization behavior. Future work is needed to further identify factors that contribute to the therapeutic efficacy of cannabis and its modalities of use.

Keywords

marijuana; vaping; cannabis; medicinal; dispensary

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Full Disclosure of Interests

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Introduction

Cannabis vaporization, or “vaping,” includes the heating of cannabis plant material or high potency concentrates in order to release aerosolized cannabinoids, which are typically combined with water and subsequently converted into vapor. There has been a substantial increase in the adoption of vaping in recent years (Jones, Hill, Pardini, & Meier, 2016; Morean, Kong, Camenga, Cavallo, & Krishnan-Sarin, 2015) and subsequent expansion in the availability and marketing of various vaping devices (Fischer, Russell, &Tyndall, 2015), which range from large tabletop units to small portable pen-shaped devices much like electronic cigarettes (Giroud et al., 2015). The rising popularity of vaping has been undoubtedly influenced in part by the recent shift in legalization of cannabis for both recreational and medical purposes in the United States.

Indeed, rates of vaping are approximately two times higher in states with cannabis legalization relative to those without (Borodovsky, Crosier, Lee, Sargent, & Budney, 2016) and vaporization rates have increased in states that permit both medical and recreational use relative to rates prior to legalization (Daniulaityte et al., 2015). One large online survey among current cannabis users reported lifetime and past-month prevalence of vaping as 61% and 37%, respectively, with 12% of respondents endorsing vaporization as their primary mode of cannabis administration (Lee et al., 2016). In particular, vaping is more common among medical cannabis card holders, relative to non-card holders (Cranford, Bohnert, Perron, Bourque, & Ilgen, 2016; Lankenau et al., 2017) with one study reporting past 90-day rates among young adults as 52% among medical cannabis patients compared to 34% among non-patient users (Lankenau et al, 2017).

Vaping appears to be especially common in in medical users who are male, Caucasian, younger in age, and of higher socioeconomic status (Cranford et al., 2016; Shiplo, Asbridge, Leatherdale, & Hammond, 2016). While vaping is commonly reported as a “secondary” mode of consumption, relative to smoking (Cranford et al., 2016), vaping is reported as the preferred mode of cannabis consumption in half of medical users (53%; Shiplo et al., 2016).

Despite the popularity of cannabis vaporization among medical users, limited research to date has considered factors that contribute to vaporization in these individuals. Initial evidence suggests that vaporization may provide unique therapeutic advantages relative to other modes. Laboratory studies indicate that vaporization of cannabis produces similar pulmonal uptake of THC relative to smoking but reduces the negative respiratory impact of smoking (Hazekamp, Ruhaak, Zuurman, van Gerven, & Verpoorte, 2005; Tetrault et al., 2007). Indeed, in a survey-based study of medical marijuana users, the majority of users (82.8%) perceived vaporizing as less harmful relative to smoking, and those who vape reported fewer respiratory symptoms compared to those who do not (Shiplo et al., 2016). Medical users reported several additional therapeutic advantages of vaping, relative to smoking or ingesting cannabis, including fewer side effects (40.1%), facilitation of correct dosing (39.6%), superior symptom relief (34.4%), faster effects (27.1%), and longer effects (23.4%; Shiplo et al., 2016). Moreover, medical users commonly report several general benefits vaporizing over other modes of consumption, including the absence of odor

associated with the combustion of cannabis, the ease of use, reduced cost due to more efficient use of cannabis use, and reduced second-hand exposure (Shiplo et al., 2016; Tetrault et al., 2007).

The current study aimed to build upon the existing research on vaping in medical users. To our knowledge, no prior studies have utilized qualitative methodologies to understand factors contributing to vaping behavior in medical cannabis users. There are numerous benefits and advantages to employing qualitative methodologies in research studies. Such methods can be used to attain an in-depth understanding of a given practice by soliciting feedback directly from members of the population of interest. Moreover, qualitative methods provide valuable information regarding central issues and concepts to be investigated in subsequent quantitative research (Neale, Allen, & Coombes, 2005). These approaches produce detailed descriptions of participants' feelings, opinions, and experiences, as well as explanation regarding why certain decisions are made or why behaviors occur (Denzin, 1989). In contrast, quantitative surveys are designed by researchers, thus task questions and response options may not accurately reflect language and concepts traditionally used and understood by medical cannabis users. In this regard, qualitative methodologies can provide rich data regarding vaporization which may aid in our understanding of the therapeutic efficacy of cannabis and its modalities of use. Such detailed information is particularly important considering the heterogeneity in the topographical features of cannabis vaping (i.e., variability in cannabis formulation and device characteristics). Our primary aim was to collect data to illustrate both the breadth and depth of cannabis vaporization among medical cannabis users (i.e., the scope of this practice) via individualized semi-structured qualitative interviews.

Method

Participants

Medical cannabis users were recruited in 2016 from Rhode Island to take part in individualized semi-structured interviews to discuss their cannabis use, purchasing behaviors, beliefs about legalization, and impact of medical cannabis card on use. Potential participants were recruited through newspaper advertisements, flyers, and social media websites. At the time of data collection, cannabis for medical purposes was legal and recreational cannabis use was illegal. The interviews took place at Brown University and were conducted as part of a larger experimental laboratory study examining cannabis demand.

Participants were required to meet the following inclusion criteria: English speaking, 18–70 years of age (to account for the broad age range among medical cannabis patients), not seeking treatment or currently looking to quit cannabis use, and were current medical cannabis registration card holders.

Procedure and Measures

Study procedures were approved by the Institutional Review Board at Brown University (Protocol #: 1502001185; *Behavioral Economic Analysis of Demand for Marijuana*) and all

participants provided informed consent prior to study participation. Prior to the interview, participants provided demographic information and completed the Marijuana History and Smoking Questionnaire to assess age of onset of cannabis use, typical cannabis use quantity, typical mode of self-administration, medical conditions for using cannabis, and other questions related to cannabis use patterns (Metrik et al., 2009). Interviews were moderated by the study's Principal Investigator. The interviews followed a semi-structured agenda designed to collect information from participants about cannabis use. Participants were queried about vaporizers using the following language: "Tell me about use of vaporizers." Probe questions were asked to expand upon the topic: "Why do some users prefer vaporizers to other methods?" and "Are there times when vaporizers are better or more convenient?" Additional vaporization content was subsequently probed and expanded upon as discussions progressed. All interviews were audio recorded and lasted between 22 and 85 minutes (*Mean* = 53 min). Interviews continued until data saturation (i.e., the point at which the data collection process no longer offers any new or relevant data) on key topics was achieved. Based on recommendations concerning sample sizes in qualitative research, 12 interviews are typically considered sufficient to achieve saturation among homogenous samples (Guest, Bunce, & Johnson, 2006). While the current sample was homogenous with respect to medical cannabis use, it was heterogeneous with respect to qualifying medical condition. As such, 25 interviews were conducted to ensure data saturation, within the optimal recommended range of 20 – 30 qualitative interviews typically recommended (Dworkin, 2012; Marshall, Cardon, Poddar, & Fontenot, 2013). All participants were compensated $40 for their time and participation in this study.

Data Analysis Plan

Debriefs pertaining to interview content were completed immediately following each interview. The interviews were transcribed verbatim and all identifiers were removed. A qualitative coding structure was developed from the semi-structured agenda. This coding structure was refined throughout the coding process to include emergent topics. Each transcript was individually coded by two research assistants using an open coding process, where each line of the data was examined and evaluated to identify topics (Glaser & Strauss, 2017). Codes were refined as the analysis progressed, and related codes were grouped to form themes within the data. Codes were entered into NVivo qualitative data analysis software for thematic analysis. After the initial open-coding review of transcripts was complete, all codes pertaining to vaporization of cannabis were reviewed. In addition, data mining tools in the software package were used to ensure that all passages relative to vaporization were included. Specifically, the following search terms were queried: "vape", "vaping", "vaporization", and "vaporizer". The vaporization-related content was then subjected to a secondary coding and analysis process: that is, additional, vaporization-specific codes were created and applied to the data. These codes were then reviewed and summarized to identify key themes reported here. Consistent with presentation of emergent data, we describe themes but do not quantify data collected within individual interviews as this would not be an accurate representation of the prevalence of a given behavior or belief (Hannah & Lautsch, 2011). Illustrative quotes were subsequently selected to reflect each theme and the assigned participant study number is presented in parentheses following each quote.

Results

Preliminary analyses

Participants (*n* = 25; mean (*sd*) age = 47 (*12*), range 24–67; 40% male) reported using cannabis on average 6 (*2*) days per week. Median individual annual income bracket was 10,000 – 19,999. Participant characteristics can be found in Table 1 and cannabis use variables can be found in Table 2.

Qualitative Themes

A summary of qualitative themes is presented in Table 3. Three cannabis vaporization-specific topics were queried during individual interviews: 1) use of vaporizers, 2) preferences for vaping relative to smoking cannabis, and 3) advantages and disadvantages of vaporizing cannabis. Four key themes emerged during discussions: a) medication dosing and administration, b) physical health advantages, c) general advantages, and d) disadvantages.

Medication Dosing and Administration

Flexible timing of medication delivery.: Many participants discussed their preference for vaporization because it allowed for easy and timely delivery of cannabis for medical use. Patients reported that with a handheld vaporizer, it is you can easily "*vape a couple of quick hits*" (#11) which can provide "*immediate*" management of medical symptoms, like nausea (#23). Relatedly, patients reported that they time their vaping around activities, with one patient who stated "*I'm very specific on what I use for certain different things and the amounts I use depending on what I need to be doing for the day…it depends on what I'm going to be doing*" (e.g., yard work; #4). Others described vaping as "*less relaxing, less sedating…which is good for some people…it would be good for the morning*" (#3). Moreover, handheld vaporizers appear to allows patients to medicate in situations wherein they would not be otherwise able to do so. One patient explained that he uses in his car after driving, and said "*once I got myself into that parking space and didn't hit anything … you can [vape] in the privacy of your car…yes I know legally I'm not supposed to do that but I'm not gonna medicate at home and then get on the road and drive*" (#4). Additionally, the flexibility of vaping emerged an important aspect for titrating medication dose. For example, one patient said "*if symptoms hit me I'll use whatever I need to use to make it go away*" and "*if you don't feel the effect within two minutes you can take more*" (#23).

Easier for dosing when traveling.: Many participants reported that vaping facilitates medication administration while traveling – a process that can be difficult for individuals who use cannabis for medical purposes due to variation in medical laws by state. One participant explained that he has a vape specifically for "*travel, so I'm not carrying marijuana on me that I'm not supposed to*" (#12). Other participants explained that vaporizers are easy to travel with, especially with respect to oil concentrates, because security workers "*don't really know what that is yet so you could pass it off as any kind of vaporizer…a lot of people are afraid to travel and have their medicine*" (#10). One participant discussed the fact that hotels in some states with more lenient medical and recreational cannabis laws advertise permissive regulations regarding cannabis use. The participant explained that some hotels allow you to "*vape in your room and…there's a form*

that…I'd have to have filled out by my doctor…so I don't have to worry about my vape being taken away" (#4).

Type of device/cannabis formulation.: Participants reported varying circumstances and reasons for why they choose to use certain vaporization devices and cannabis formulations. First, participants described that their decisions about the mode of consumption was dependent on the symptoms they were trying to treat. One patient said "*I have two different conditions that I use it for medically. For the pain the preferred use is edible because it last longer and it's just more constant and gradual relief. For the nausea I smoke or vaporize because it's immediate and if I feel like I'm about to start vomiting I [can] stop it immediately*" (#23). Another patient reported that "*while the edibles are more for the body … with the vaporizer there's a difference … I'm not really interested in the euphoria or the high… I would rather have a clear head, so I only use to get to sleep*" (#19). It is also worth noting that although the majority of participants endorsed vaporization as a preferred method of cannabis administration, there were a subset of patients who preferred smoking because it produced a better results and a preferred psychoactive high (#14, 16 17), illustrating heterogeneity and individual differences across medical users. Second, participants discussed their decision making when selecting the type of vaporization device, stating that a table-top vaporizer "*changes your high to a body high… it's a longer high if you, if you're smoking it the right*" (#5), whereas a handheld device, like a pen, might have a shorter high that "*just doesn't last long enough for me*" (#9). Third, patients discussed benefits of vaping certain formulations of cannabis. One participant described his experience with vaping hash oil, saying "*that's a lot stronger…it gives a different effect than smoking*" (#3). He went on to explain that "*the oil is strong enough where I won't need to medicate in another way*" but if vaping plant material "*it just doesn't…feel like…I'm…getting all the cannabinoids*" (#3).

Physical Health Advantages

General health advantages.: Many participants conveyed strong beliefs that cannabis vaporization is better for various medical conditions as compared to traditional smoked cannabis. One participant captured this sentiment in saying "*it's a cleaner experience…the high is the same, but it filters out a lot…so it's actually a healthier way of your lungs processing it and it hits your bloodstream more quickly…for someone who smokes as much as I do, it just makes sense from a health point of view*" (#2). Other participants echoed this belief, indicating that vaping is "*better for you because you're not inhaling a lot of smoke"* (#5) and it is *"nice and smooth…it's definitely better for you because you're not burning off all the leaf matter…all you're getting out is actually more medicine than tar and nicotine or whatever comes from the leaf when they burn it*" (#1). Similarly, another participant stated that "*vaping totally gets rid of the bad effects of the smoke…all you're getting is the good stuff*" (#4). Other medical users explained that "*it doesn't taste the same, so I'm not as crazy about it…it's a little easier on my lungs*" (#20). Vaporizing is preferred by many medical users because it is "*clean*" (#24), doesn't cause "*worry about secondhand smoke*" (#22), and it is perceived to be "*the healthiest way to use [marijuana]*" (#22). While the majority of patients perceived vaporization to be a healthy way to medicate, other participants had divergent beliefs. One participant stated that believed "*the vapor might be better but if you keep doing it too much it seems like you might get water in your lungs*" (#18). Another

participant summarized this concept well, saying "*I am still in the process of smoking too but ideally, I would like to get to just vape and edibles…I do it for health because smoking is not good for you*" (#11).

Better for medical condition.: Some participants believed vaping to be an optimal administration mode for several specific health conditions. For example, one participant stated "*if you have a heart condition you should not be smoking…but you can vape and it will actually help your heart condition because it will bring your stress down*" (#4). Another participant indicated that his "*girlfriend likes [vaporizers] because she has asthma so she doesn't cough as much…it's not as harsh*" (#12). Other participants mentioned a desire or attempt to switch to vaporization due to medical conditions including emphysema (#6), chronic bronchitis (#19), and prior to surgical operations (#7, #13). Although many medical users described the benefits of switching from smoking to vaping cannabis, one patient explained that because of their medical condition, they switched from vaping to using edibles. The patient explained that he "*used to [vape] but I developed chronic bronchitis so I had to stop doing anything … using my lungs*" (#19).

Vaping for tobacco smoking cessation.: Some participants also mentioned the utility of cannabis vaporization to aid tobacco smoking cessation or to maintain their prior tobacco cessation abstinence. One participant explained that vaping is "*good for people that are smoking that are trying, smokers that need to get rid of smoking*" (#5). Another participant reported "*I didn't want to smoke. I used to be a smoker. I quit 28 years ago. I figured [vaping] was the safest way to use it*" (#22). Similarly, another participant stated "*I prefer not to put smoke in my lungs anyway. I've been trying to quit smoking cigarettes too and I've been using this vape pen*" (#24).

General Vaporization Advantages

Device characteristics.: Many participants mentioned portability and discretion as primary advantages of cannabis vaporization, particularly with respect to small handheld devices. They explained that handheld vaporizers can easily be used in establishments where smoking is not permitted (#3) and in public (#17, 18) due to the decreased odor produced by vaporizers as compared to traditional smoked cannabis (#5, 21), even explaining a desire to spare others from the potentially unwanted odor (#24). Participants also explained that handheld vaporizers are "*less noticeable especially now that everyone the vaping nicotine*" (#11) and that "*you can get away in public with more…because electronic cigarettes…look like [a vape]*" (#17). Participants mentioned ease of use in theme parks (#18), the movies (#20), and during and after driving (#3, 4). Overall, participants agreed that vaping is "*more discreet and socially acceptable*" (#23) and provides more convenience. One participant captured this sentiment, explaining "*you don't have to pack a bowl you don't have to roll up anything you can just hit it and put it back*" (#21). However, it is worth noting that some medical users did not express a preference for a handheld vaporizer, and instead indicated that they more commonly used a desktop vaporization device (# 1, 8, 11, 20), which suggests that medical users may be less concerned about discretionary aspects of device types than recreational users (Aston et al., in press) perhaps because cannabis can be used legally and less restrictive.

Cost/Efficiency.: Participants discussed low cost and increased efficiency as advantages to vaporization relative to smoking cannabis. One patient explained that vaping "*conserves the marijuana better that's for sure…if you had to try to save money you know the vaporizer would help you save money after you bought it*" (#1). This is due to using "*a lot less product with vaping*" (#4) and the ability to recycle "*already been vaped*" flower, or "*ABV*" (#3, 5). Many participants endorsed this practice, explaining "*now [that] I found out what you can do with the stuff I saved after I've already medicated… there's no way I'd go back to burning the stuff off*" (#4). Patients explained that "*people that vape actually stretch their marijuana longer*" (#5) and agreed that "*it's more efficient…you use so much less dry herb*" (#24).

Disadvantages of Cannabis Vaporization

Reduced effectiveness of medication delivery.: While vaping cannabis was preferred by many patients, some explained that this mode of administration could negatively impact medication delivery. Patients explained that vaping "*doesn't deliver enough medicine as smoking does, in my opinion…takes a lot more of a marijuana to vape*" (#15) and that they "*would prefer to vape, use a vape pen, but it's not as effective… If it were more effective I would use only that*" (#22). Patients conveyed a belief that "*vaporizing seems to have some of the compounds but not all of the compounds as the smoking does*" (#23) and indicated that vaping "*doesn't give me the same effects…I would like to [vape], it just doesn't give me the same effects for some reason*" (#25) or it "*just doesn't last long enough for me*" (#9). One participant conveyed dislike for vaporization, explaining "I've tried a few of them and I'm like this is horrible. It burns it off. It tastes gross and I don't even know what you're getting in it…they heat up really bad…so I'm not…for the vaporizers like that" (#8).

Device/concentrate cost as barrier to use.: While many patients indicating that overall, vaping is less expensive than other modes of administration for various reasons, they explained that the initial cost of equipment can be prohibitive. Participants explained that vaporizers are "*expensive*" and "*costly*" (#5, 22). For example, one patient reported that vaping might be more costly in the long run because of needing vape more frequently, and specifically stated "*if you use a vape pen you have to do a lot more, I found. And it really never produced the same result as a water pipe or…a joint…It just ends up being very expensive*" (#22). Cost was often prohibitive to vaporization, with several participants indicating that "*if money wasn't an option I would be vaping honestly*" (#24).

Technology barriers to use.: Participants discussed the fact that vaporization technology requires improvement, and that vaporization equipment can be somewhat of a hassle. Specifically, participants indicated that "*the technology is not up to where it should be…I've used the volcano, which is a really good one and that one has a decent effect, but it can never get, no matter how high the temperature goes up, you can never get it up to the same effect as when you're smoking it*" (#3). In fact, participants reported that they would use vaporizers more if the technology improved, explaining that "*they're still working on the science behind how they work, I think they will be better, last longer, be more durable. I'm sure eventually will get to that*" (#11). Additionally, participants discussed the hassle of using vaporizers. One patient stated "*if I use the vaporizer all of the time, it gets to be like a*

pain because you have to grind it up and play with it, take it apart and all that other stuff" (#1). Others discussed their perception that vaporizers are "*bothersome to use*" and they don't "*need all this equipment and this gear…it's more of a hassle than [smoking]…I get the same results and I don't have to go through all that and all I'm doing is eliminating the actual smoke, which doesn't seem to give me any issues…so it's more of a convenience factor…when I medicate I like to go sit down and relax…I don't want to have to be around a table and have equipment that I've gotta clean up*" (#7). Some patients referred to vaping as a "*generational thing*" (#2) and preferred the "*old-school*" way of smoking (#7), with others explaining that "*nowadays [vaporizers] have all these things that gotta go with it and… gadgets besides just the regular pipe…and all this process that you have to go through*" (#1).

Discussion

The present qualitative study found that vaporization of cannabis is a commonly used mode of cannabis delivery among medical cannabis users. In fact, vaporization of cannabis was identified as the preferred and often primary route of administration for many medical users, which is consistent with previous quantitative studies (Abrams et al., 2007; Shiplo et al., 2016). Four overarching themes emerged from the qualitative interviews: (1) medication dosing and administration, (2) physical health advantages, (3) general advantages, and (4) disadvantages of cannabis vaporization.

Many patients conveyed a preference for cannabis vaporization specifically because of flexibility of use. Prior research indicates that handheld devices are the most popular type of vaporization devices compared to larger tabletop devices in part because of their discreet nature and portability (Lee, Crosier, Borodovsky, Sargent, & Budney, 2015; Shiplo 2016); these features may also enhance the therapeutic efficacy of vaping among medical cannabis users. Specifically, portable handheld vaporization devices were highly valued by patients for their ability to deliver medication quickly and at the exact moment it is needed. Patients appear to carefully tailor how (i.e., administration mode) and what (i.e., cannabis formulation) they use based on the time of day, upcoming daily events, and the nature of medical symptoms they are trying to manage. Indeed, patients reported that they modify their use behavior based on the desired and necessary effect (e.g., body high, short/long duration, immediacy) for symptom management. These findings also underscore the important of considering within-person variability in vaporization practices, particularly with respect to ongoing management of state changes in physical symptoms, which is likely just as important as consideration of between-person differences.

Flexibility of vaporization is also pertinent to the ability to travel with medication, particularly when traveling to states that may not permit the use of cannabis for medical purposes. Vaporizers with pre-loaded cartridges may be desirable given that they are less readily identifiable (i.e., could pass as an electronic cigarette). Additionally, the absence of combustion can minimize concern about odors resulting from using cannabis for medical purpose. Consistent with previous literature (Budney, Sargent, & Lee, 2015), findings also indicated that patients vape in order to be respectful to others and to minimize secondhand exposure to cannabis smoke. Thus, the discreet nature of cannabis vaporization can facilitate easier use and medication delivery. It is worth noting that the discreet nature of vaporization

devices is a commonly reported benefit of vaporization in recreational cannabis users (e.g., Aston et al., in press; Jones et al., 2016; Lee et al., 2016; Morean et al., 2017), though the desire for discretion may be driven more by legal implications of use for recreational users than medical users.

Vaporization is also preferred by patients for cost and efficiency, which has been reported in prior studies in medical (Shiplo et al., 2016) and recreational users (Aston et al., in press). Recycling and reusing cannabis that has already been vaporized, or "ABV," appears to be a common practice among medical cannabis users, which has important implications for patients who may experience several barriers to assessing cannabis (e.g., financial strain, transportation, physical limitations).

Several health-specific advantages to cannabis vaporization were also identified. Patients recognized that cannabis vaporization is less harmful than traditional combustible cannabis administration methods (Abrams et al., 2007; Aston et al., in press; Jones et al., 2016; Lee et al., 2016; Morean et al., 2017; Shiplo et al., 2016). Indeed, laboratory research indicates that vaporization of cannabis produces similar pulmonal uptake of THC relative to smoking but reduces the negative respiratory impact of smoking (Hazekamp et al., 2005; Tetrault et al., 2007) and may significantly reduce carcinogenic toxins inhaled from smoke (Polosa, 2015; Van Dam & Earleywine, 2010). Moreover, patients recognized that smoke inhalation can exacerbate certain medical symptoms and conditions, and identified several medical conditions for which vaporization is the optimal mode for cannabis consumption, including cardiac and pulmonary conditions (e.g., emphysema, chronic bronchitis). In fact, many patients reported that they switched from smoking to vaporization as a strategy to reduce further exacerbation of already existing medical symptoms (e.g., respiratory distress). This common behavioral pattern of switching from smoking to vaporization is noteworthy, particularly among medical users, given that the therapeutic advantage of switching modes is likely unique to those with pre-existing conditions (e.g., asthma, chronic obstructive pulmonary disease; Tashkin, 2015). Although it was not an intended focus of this study, some patients also discussed ingesting cannabis as yet another mode and strategy for attenuating the exacerbation of pulmonary symptoms. More research is need on the nature of transitioning between cannabis use modalities among medical cannabis users (i.e., from smoking, to vaporization, to ingestion) to understand the therapeutic advantages. Finally, a related, yet unique theme emerged about the health benefits of cannabis vaporization as it pertains to tobacco cessation. Patients identified cannabis vaporization as a tool for maintaining tobacco smoking abstinence or as a strategy for promoting cessation presumably because of reduced presence of combustible smoking cues. Overall, medical cannabis users tend to be acutely aware of the health implications of vaporization, and endorse this mode frequently to reduce further negative impact on health.

There were also notable disadvantages of vaporization. One prominent disadvantage was reduced effectiveness of medication delivery from vaporization relative to smoked cannabis. In fact, many participants relayed a desire to use vaporizers exclusively; however, reduced effectiveness prevented a complete transition to this mode. Cranford and colleagues (2016) noted that vaporization as a primary route of cannabis administration is rare, a phenomenon that may be attributed to reduced effectiveness of medication delivery. Notably though,

reduced effectiveness of medication delivery was reported almost exclusively in reference to portable handheld vaporizer devices, and not larger tabletop devices, suggesting that differences across vaporization devices might impact the therapeutic efficacy. It is also likely that perceived difference in the effectiveness of medication delivery was influenced by cannabis formulation (i.e., vaporization of cannabis concentrates versus flower). Further research is needed in this area to explicate the role of vaporization device type, cannabis formulation, and their interaction in the perceived effectiveness of medication delivery, and comparative efficacy to traditional combustible modes.

Another disadvantage of vaporization was cost. While vaporization may be cost-effective in the long-term, the initial cost of the device, and often the product (e.g., high potency hash oil), is often prohibitive. Likewise, Shiplo and colleagues (2016) found that high vaporization cost was a disadvantage to this administration mode, with 19.5% of non-vaporizer users reporting that the affordability of vaporization was their primary reason for abstaining from this mode. Finally, technology barriers were also cited as a disadvantage of cannabis vaporization. Some patients found the process of using a vaporizer to be technologically challenging and taxing (e.g., handling various components and attachments for the device), and expressed a preference for the simplicity of smoked cannabis. Prior quantitative data indicate that 9.8% of medical users who do not vape reported that perceived difficulty with device operation was a barrier to use (Shiplo et al., 2016). Thus, technology-related barriers may be reported only among a small proportion of users. Patients who are older in age may be one sub-set of users who experience more technology use-related barriers to vaporization, due to lower computer/technology literacy and/or long-term familiarity with combustible modes that outweigh desire to adopt vaporization. The aforementioned technological and age-related barriers are supported by the documented inverse association between age and vaporization frequency (Lee et al., 2016; Shiplo et al., 2016).

There are several points of inquiry that were limited in the current study. First, this sample was limited to medical cannabis registration card holders living in in Rhode Island, thus findings may not generalize to individuals who use cannabis for medical purposes who live in states with varying medical cannabis laws. Second, although all participants were medical cannabis registration card holders, patients were not asked to distinguish between their use of cannabis for medical versus recreational purposes. Differences in use practices may be apparent among individuals who use cannabis for medical purposes despite not having a medical card, or among medical users who also use cannabis recreationally. Third, the current study exclusively recruited individuals with a medical cannabis registration card, thus individuals who may be using cannabis for medical purposes without a card were not included. A recent study examined two groups of medical cannabis users attending a dispensary: those with a current medical card (i.e., returning patients), and those without a card (i.e., first-time patients). Among individuals using cannabis for medical purposes, 43% with a medical card reported past month vaping, compared to 28% of first-time patients (Cranford et al., 2016). Use behavior, including preferred administration modes and formulations among individuals using cannabis for medical purposes without a medical card is an area worthy of future study. Finally, the sample included patients with various medical conditions. While the heterogeneity in the sample allowed for a broad understanding of

vaporization practices, future work should examine specific subgroups of medical users to increase the specificity of emergent themes and reduce between-person variability in vaporization practices.

Overall, there are several features of cannabis vaporization that promote the use of this mode among medical users, including therapeutic efficacy (e.g., flexible medication dosing, ease of use), device features (e.g., discreet, convenient), physical health advantages, and economic efficiency. Among medical cannabis users, these positive factors of cannabis vaporization contrasted with reported disadvantages of cannabis vaporization. However, interviews clearly indicated that certain vaporization barriers, including reduced medication delivery effectiveness and technological issues, reduced exclusive preference for this mode among some patients. It is likely that in the wake of alterations in both social and legislative policy regarding cannabis use, the cost of vaporizers will ultimately decrease, resulting in an increase in the adoption of this mode among medical patients (Malouff et al., 2014). As a result, it will be crucial to understand various vaporization device and cannabis formulation considerations so that medication can be effectively and safely delivered among patients who use cannabis for management of medical symptoms. Additional quantitative research is needed to understand under what circumstances and for whom vaping yields its most therapeutic effect, particularly with respect to acute changes in negative symptoms which trigger moment-to-moment alterations in cannabis delivery demands.

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Public Health Statement

Findings from this study suggest that cannabis vaporization ("vaping") is a preferred and often primary route of cannabis administration for many medical users. Medical cannabis users are aware of the positive health implications of vaping compared to smoking cannabis, and often utilize vaping to reduce further negative impact on health. There are several factors within and between persons that appear to influence vaping preferences, including the type of medical condition and nature of symptoms that are being treated, which require additional research to further understand.

Table 1.

Participant characteristics

Variable	*n (%)*
Race	
American Indian/Alaska Native	0 (0%)
Asian	1 (4%)
Black or African American	0 (0%)
White	18 (72%)
More than one race	5 (20%)
Unknown or Not Reported	1 (4%)
Qualifying medical condition *	
Cancer	2 (8%)
Glaucoma	0 (0%)
HIV/AIDS	0 (0%)
Hepatitis C	2 (8%)
Cachexia	1 (4%)
Severe, debilitating, chronic Pain	18 (72%)
Nausea/ Vomiting	8 (32%)
Epilepsy	2 (8%)
Multiple Sclerosis or Crohn's Disease	10 (40%)
Alzheimer's Disease	1 (4%)
Other	8 (32%)
Current Tobacco Use	
Smoked cigarettes in past month	7 (28%)

Note:

*Conditions reported are not mutually exclusive

Table 2.

Cannabis use variables

Variable	***Mean (SD)***
Age at initiation of cannabis use	20 (13)
Age at initiation of regular cannabis use	27 (16)
Hours per day under the influence of cannabis	4 (2)
Variable	***n (%)***
Amounts of cannabis used per week	
≤ 1/16th ounce	5 (20%)
1/8th ounce	1 (4%)
1/4th ounce	4 (16%)
3/8th ounce	1 (4%)
½ ounce	4 (16%)
≥1 ounce	10 (40%)
Typical Mode of Cannabis Administration *	
Joint	17 (68%)
Pipe	15 (60%)
Bong	12 (48%)
One-Hitter	9 (36%)
Edible	20 (80%)
Blunt	8 (32%)
Spliff	1 (4%)
Vaporizer	14 (56%)

Note:

* Modes reported are not mutually exclusive

Table 3.

Summary of qualitative themes

Theme	Sub-Theme
1. Medication Dosing and Administration	1a. Flexible timing of medication delivery
	1b. Easier for dosing when traveling
	1c. Type of device/cannabis formulation
2. Physical Health Advantages	2a. General health advantages
	2b. Better for medical condition
	2c. Vape for tobacco smoking cessation
3. General Advantages	3a. Device characteristics (portable, discrete)
	3b. Cost/Efficiency
4. Disadvantages	4a. Reduced effectiveness of medication delivery
	4b. Device cost as barrier to use
	4c. Technology barriers to use