Who's Buying What and How Much? Correlates of Purchase Behaviors at Medical

Marijuana Dispensaries in Los Angeles, California

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Abstract

Venue-based distribution of marijuana has become the normative model in the United States to obtain marijuana. This study examines one-time purchase behaviors at medical marijuana dispensaries (MMDs) to identify potential venue- and individual-level targets for prevention. We used a two-stage, venue-based sampling approach to randomly select patrons exiting 16 MMDs in Los Angeles, California during the spring of 2013. Patrons ($N = 595$) reported their discrete purchase behaviors during their most recent visit to the sampled MMD. We used hierarchical linear modeling to examine the amount spent on marijuana products, regressed on characteristics of the sampled dispensaries and their patrons. We used hierarchical generalized linear modeling to examine the likelihood of purchasing specific types of marijuana products and total grams of loose-leaf buds purchased. Patrons spent US$41.73 on average, with a range of $0 to $330. We observed significant variation in purchase behaviors across MMDs and associations between venues located within high median income census tracts and a higher total amount spent and lower odds of purchasing only loose-leaf buds. The networked distance between a patron's home and the sampled MMD was positively associated with the total amount spent and total quantity of buds purchased. We also found significant relationships between medical conditions reported for use in three models: total amount spent, purchase of pre-rolled joints, and total grams of buds purchased. Policy makers may want to explore regulating the availability of specialty items that may be attractive to naïve users, such as pre-rolled joints or edibles, or high-concentration products that may be sought out by regular, heavy users.

Keywords: Medical marijuana dispensaries, Purchasing behaviors, Marijuana product type, Venue-based sampling

Internationally, marijuana policies are shifting towards social allowance, as evidenced by an increasing number of countries supporting decriminalization, medical use, and/or recreational use (Grund & Breeksema, 2013; Reuter, 2010). In the United States, this shift is indicated by the increasing number of states (now 31 states, the District of Columbia, Guam and Puerto Rico) that as of 2018 permit marijuana use for medicinal and/or recreational purposes (National Conference of State Legislatures, 2018). In addition, the use of venue-based distribution of marijuana is the normative model within most of these states (Berg, Henriksen, Caboszos-Reng, Haardoerrer, & Freisthler, 2018; National Conference of State Legislatures, 2018). In this context, policies that are aimed at regulating medical marijuana dispensaries (MMDs) to influence marijuana consumption behaviors need to be informed by data concerning who are using these venues, the types and quantities of products obtained through these venues, and MMD- and individual-level characteristics related to these purchase behaviors.

Our knowledge about medical marijuana users has increased dramatically in the past decade. Although users remain predominantly White and non-Hispanic males (Azofeifa, Sherman, Mattson, & Pacula, 2018; Lankenau et al., 2018; Lin, Ilgen, Jannausch, & Bohnert, 2016; O'Connell & Bou-Matar, 2007; Ryan-Ibarra, Induni, & Ewing, 2014), these demographics are not consistent across geographic regions and are not static over time. Prior work reported that the proportion of White and non-Hispanic users range between 29% to 85%, and these numbers likely are dependent on the sampling approach used, U.S. region, and range of ages sampled (Bohnert et al., 2018; Bonn-Miller, Boden, Bucossi, & Babson, 2014; Haug et al., 2017; Kepple & Freisthler, 2017; Kepple, Mulholland, Freisthler, & Schaper, 2016; Lankenau et al., 2018; Nunberg, Kilmer, Pacula, & Burgdorf, 2011; O'Connell & Bou-Matar, 2007). In addition, Fairman (2016) observed that the proportion of men (relative to women) registering for medical

marijuana participation has decreased over time in an analysis of 13 U.S. states and the District of Columbia. Recent trends also indicate a growing proportion of younger medical marijuana users (18–30 years old; Fairman, 2016).

Studies have consistently reported the following medical conditions for medicinal marijuana use (ranked from most to least common): pain (predominantly nonspecific chronic pain), mental health conditions (predominantly anxiety disorders and sleep problems), gastrointestinal problems (predominantly nausea or appetite stimulant), neurological problems (predominantly headaches), and other chronic conditions such as HIV/AIDS, cancer, or glaucoma (Abuhasira , Schleider, Mechoulam, & Novack, 2018; Lankenau et al., 2018; Nunberg et al., 2011; Park & Wu, 2017). For many of these conditions, individuals report medical marijuana use as a substitute for prescription medication (Piper et al., 2017). Regarding use patterns, the vast majority of studies have shown that medical marijuana users overwhelmingly indicate daily or near daily use of these products and average quantities between 2g to 8g per week (Bohnert et al., 2018; Bonn-Miller et al., 2014; Haug et al., 2017; Lin et al., 2016; O'Connell & Bou-Matar, 2007).

We know less about how MMDs are shaping purchase behaviors (e.g., the financial resources being spent, variation in products or quantity obtained) and how these behaviors may differ across the previously discussed user characteristics. Purchase behaviors matter, given that different marijuana user groups (defined by demographics, reason for use, and/or marijuana consumption patterns) are likely to respond differently to shifts in product supply such as pricing and potency (Pacula & Lundberg, 2014; Pacula & Sevigny, 2014). Market-specific factors, such as cost or product diversity, may influence new or light users more than heavy users with cannabis dependence (Aston, Metrik, & MacKillop, 2015). Recent work also suggests

dispensaries may be creating niche markets that attract individuals to their specific locations;

thus, venue-level factors, such as product diversity or external dispensary characteristics like its

physical condition or security features, may influence purchasing behaviors (Cooke, Freisthler,

& Mulholland, 2018; Kepple & Freisthler, 2017).

Two prior studies provide a foundation for the importance of exploring correlates of

purchase behaviors. The first is a pilot study that used a convenience sample of four dispensaries

and a small sample of exiting patrons ($N = 106$); it observed higher amounts spent on a one-time

purchase among individuals who were older or who identified receiving a marijuana

recommendation for mental health symptoms, compared with those for a specified physical

condition (Kepple et al., 2016). Another study observed a higher likelihood of purchasing edibles

by patrons exiting dispensaries located in census tracts with higher median incomes and with a

higher number of surrounding dispensaries located within 0.5 km (Kepple & Freisthler, 2017).

The prior studies did not observe significant relationships between distance-travelled and amount

spent or purchase of edibles (Kepple & Freisthler, 2017; Kepple et al., 2016). Similarly, Caulkins

& Pacula (2006) observed that individuals who illicitly purchased marijuana at locations close to

their home did not differ in total purchase cost from those purchasing elsewhere. However, these

studies did not explore how the distance travelled by patrons may be associated with quantity of

the product obtained (Caulkins & Pacula, 2006; Kepple & Freisthler, 2017; Kepple et al., 2016).

In addition, these studies did not examine the purchase of specialty products like pre-rolled joints

or concentrates that have been made more accessible through MMDs (Borodovsky, Crosier, Lee,

Sargent, & Budney, 2016). Understanding these behaviors would help illuminate MMD- and

individual-level correlates associated with purchasing these easy-to-use products that can be

more attractive to the naïve user (Hancock-Allen, Barker, VanDyke, & Holmes, 2015) and with

purchasing high concentrate products that can have adverse and even toxic effects (Alzghari, Fung, Rickner, Chacko, & Fleming, 2017; Russell, Rueda, Room, Tyndall, & Fischer, 2018).

Study Aims

We sought to provide more comprehensive information about how patrons are using MMDs to better inform place-based regulations. To examine how patrons in Los Angeles, California were using MMDs, we asked the following exploratory research questions:

1. What are the types of one-time purchase behaviors that were observed among patrons exiting MMDs?

2. What venue- and patron-level characteristics are associated with the following one-time purchase behaviors from a MMD:

    a. Financial resources spent (i.e., total cost of purchase)?

    b. Type of medical marijuana product obtained?

    c. Total quantity (in grams) of loose-leaf buds obtained?

Methods

Study Design and Sampling Procedures

We used four sources of information: (a) a premises survey, (b) an exit survey, (c) online MMD directories, and (d) U.S. Census estimates (Geolytics, 2015). We conducted this study with the approval of the University of California, Los Angeles institutional review board.

Premises survey. We created a de-duplicated list of 875 unique dispensary locations by combining a list of registered dispensaries with the City of Los Angeles Department of Finance; registries of dispensaries from websites (e.g., Weedmaps); and trade publications with advertisements for dispensaries (e.g., *LA Weekly*). We geocoded dispensary locations using Arc GIS 10.3. Trained research staff verified that 475 locations were operating during the summer of

2012 through systematic observations using a premises survey of the exterior factors that included signage, exterior condition, and security features.

Exit survey. The exit survey used a two-stage, venue-based sampling procedure. First, we randomly sampled 16 MMDs from the list of 475 operating locations. A team of trained research staff conducted surveys outside each location during three different two-hour time periods between 10 am and 6 pm. We sampled exiting patrons using a random start (i.e., determined by a roll of a die) with systematic sampling (i.e., researchers approached the second person to exit dispensary after completing an interview) until 40 exit surveys were completed for each sampled MMD or the sampling time period ended. We approached a total of 705 dispensary patrons, 18 years of age or older. The survey response rate was 84%, resulting in 595 patrons reporting on their demographic characteristics, conditions associated with their medical marijuana recommendation, and items purchased during their most recent visit to a sampled dispensary. All participants completed a written informed consent. The in-person survey lasted 3 to 5 min, and we compensated participating individuals with $20 in cash. (See Table 1 for patron characteristics.)

<center><INSERT TABLE 1 ABOUT HERE></center>

A prior study examined sample bias arising from these procedures and determined that minimal nonresponse bias was present using these sampling techniques (Thomas & Freisthler, 2016). That being said, this study observed one key difference between nonparticipating ($n = 37$) and participating ($n = 16$) sampled MMDs: participating dispensaries tended to carry more novel products, such as concentrates (e.g., honey oil, hashish), which may influence the type of products patrons reported purchasing in this study. In this same analysis, a comparison of individuals who chose to participate in the exit survey with those who chose to decline indicated

that exiting patrons who self-identified as Black/African American or Hispanic were more likely to participate in the exit survey.

      Online directories and U.S. Census estimates. Using a computer script, we systematically pulled data from six online directories for MMDs. We triangulated information from these sources to record type of products sold and whether credit cards were accepted. When available, we tracked the low- and high-end prices per gram for three strains of marijuana buds (i.e., indica, sativa, and hybrid). These data represent a point-in-time snapshot based on data pulled during May 2013. Finally, we used 2012 GeoLytics estimates to obtain demographics of the census tract where each MMD was located (Geolytics, 2015). Table 2 shows a summary of characteristics for the 16 sampled MMDs.

<center><INSERT TABLE 2 ABOUT HERE></center>

Measures

      Purchase behaviors. Table 3 describes the types of purchase behaviors reported by respondents exiting sampled MMD locations. Respondents self-reported the *total amount spent* during their most recent visit in dollar amounts ($US). We operationalized the *type of products purchased* using a series of mutually nonexclusive dichotomized variables indicating whether respondents self-reported the purchase of: (a) loose-leaf buds, (b) edibles, (c) concentrates, (d) pre-rolled joints, (e) seeds or clones, (f) loose-leaf buds only, and (g) multiple types of products. For the subset of individuals who reported purchasing loose-leaf buds ($n = 500$), we calculated self-reported *quantity of loose-leaf buds purchased* (in grams). We also categorized self-reported *type of strain purchased* into the following mutually nonexclusive dichotomous variables: (a) indica, (b) sativa, (c) hybrid, and (d) multiple strains.

<center><INSERT TABLE 3 ABOUT HERE></center>

Individual characteristics. Respondents self-reported their gender, age (in years), race, and ethnicity. Respondents identified the ethnic and racial identities that best defined them, which we then recoded into four categories: (a) White and non-Hispanic, (b) Black and non-Hispanic, (c) Hispanic, and (d) other racial/ethnic group.

Respondents reported the specific medical conditions for which they obtained their medical marijuana recommendation. We categorized these medical conditions into six mutually nonexclusive variables: (a) *pain*, which included chronic pain (nonspecific), arthritis, injury-related pain, neuropathy/nerve pain, or other pain-related conditions; (b) *mental health condition,* comprising sleep problems, anxiety, depression, bipolar disorder, PTSD, and/or ADD/ADHD; (c) *gastrointestinal condition,* for which respondents indicated use for stimulating appetite (nonspecific), Crohn's disease, anorexia, and/or other metabolic disorders; (d) *neurological condition,* which comprised migraines, MS/spasticity, epilepsy/seizures, and/or TMJ; (e) *other chronic medical condition,* comprising glaucoma or other eye condition, cancer-related symptoms, asthma, HIV/AIDS, tinnitus and/or autism; and (f) *nonmedical condition,* comprising stress, happiness, restlessness, and skin care.

Respondents also reported the nearest intersection to their home address. We calculated networked distances using ESRI U.S. and Canada Detailed Streets (ESRI, 2010) and ArcGIS 10.3 Network Analyst extension (ESRI, 2015) to obtain the shortest networked distance (in meters) from the respondent's approximate home location to the sampled dispensary's location. We winsorized the distance travelled for 22 respondents residing outside of Los Angeles (including outside the State of California) to the largest distance reported by respondents residing within Los Angeles County.

MMD characteristics. We used 2012 GeoLytics estimates (Geolytics, 2015) of population density (1,000 population per square mile), median income (in US$1,000), and percent of population who identified as White and non-Hispanic for the census tract where each MMD was located. We calculated the number of MMD locations within a 0.5 km buffer of each sampled MMD site using ArcGIS 10.3 Buffer Analysis. We categorized MMD licensure status to distinguish between locations that were (a) licensed prior to the 2007 City of Los Angeles moratorium and remained eligible for licensure, (b) licensed prior to 2007 but are no longer eligible for licensure due to change in management, and (c) not licensed.

During the premises survey, trained research staff rated exterior maintenance on a 4-point scale and provided textual descriptions of the site: (1) *excellent* (very clean, recent paint or remodel); (2) *good* (no trash or peeling paint); (3) *fair* (minor disrepair; some trash); and (4) *poor* (graffiti, broken windows, lots of trash). We recoded these responses into a categorical measure of poor exterior condition: *good to excellent* (0) or *poor to fair* (1). In addition, we summed the total number of outside security features that we coded by *presence* (1) or *absence* (0): (a) locked metal screen door, (b) pass-through door, (c) intercom, (d) doorman, (e) security cameras, and (f) signs about IDs/Rx requirements.

Using information from online directories, we categorized diversity of dispensary inventory into three levels: (1) *low* (sell primarily loose-leaf buds); (2) *moderate* (sell a mix of product types but not a full range of products); and (3) *high* (sell the full range of products that include loose-leaf buds, edibles, concentrates, pre-rolled joints, and seeds/clones). We also categorized whether credit cards were *accepted* (1) or *not accepted* (0).

Analytic Procedures

We examined correlates of a one-time purchase of marijuana products for the 517 patrons who reported making any purchase and provided complete data (35 per dispensary on average, range = 19 to 42). We used several multilevel models to estimate unadjusted and adjusted relationships for five dependent variables: (a) hierarchical linear model (HLM) for *total amount spent* (in natural log-transformed $US); (b) hierarchical generalized linear model (HGLM) using a Bernoulli sampling model and a log-link function for *purchase of loose-leaf buds only, pre-rolled joints, and concentrates*; and (c) HGLM using a Poisson sampling model and a log-link function for *total quantity of loose-leaf buds purchased* (in grams). Each model regressed the dependent variable on characteristics of sampled dispensaries (level 2) and their patrons (level 1); coefficients were exponentiated for all models (Raudenbush & Bryk, 2002).

We grand mean centered the Level 2 variables used in the final models (i.e., census tract median income and MMD density; Raudenbush & Bryk, 2002). Median income was significantly correlated with ratings of poor exterior maintenance of a building, $t(14) = 2.175$, $p < .047$, and high diversity of product, $t(14) = -2.359$, $p < .033$; median income was kept in the final models in lieu of the other two measures because it resulted in better model fit. Level 1 independent variables included patrons' demographics, medical conditions, and distance travelled (in natural log-transformed meters). Models also controlled for types of products purchased when appropriate. We conducted all analyses using HLM 7 with a default setting using restricted maximum likelihood to estimate the model (Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2011).

For all models, we removed cases with missing data ($n = 30$; 5.5% of sample). Missing data varied significantly across MMD locations, primarily driven by 10 respondents with missing

data at one dispensary location, χ^2 (15) = 57.044, $p < .001$; all other dispensaries had missing

data for a range of 0 to 3 respondents.

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Results

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All 16 dispensary locations sold loose-leaf buds and edibles at a minimum. The sample

was predominantly male and racially/ethnically diverse; the average age was 34 years old (see

Table 1 for more details). Patrons reported pain management (54%) or a mental health condition

(60%) as the primary reasons for medical marijuana use. *Pain* was primarily comprised of

chronic pain (46%), and *mental health condition* was primarily comprised of anxiety (32%) and

sleep problems (38%).

Range of Purchase Behaviors

Descriptive statistics reported in Table 3 show the diverse range of purchase behaviors.

Approximately 92% of respondents reported making a purchase during their most recent visit to

the dispensary. Of those who reported obtaining products, exiting patrons spent US$41.73 on

average (SD = US$43.90) with a range of US$0 (obtaining free promotional items) to US$330

(on marijuana buds only) during a one-time visit. The great majority of patrons reported

purchasing loose-leaf buds only (n = 381; 76% of sampled reporting any purchase). Among the

166 patrons who reported purchasing other products besides buds, we observed a high amount of

variability in the types and combination of products purchased.

Correlates of Total Amount Spent (Natural Log-Transformed US$)

Table 4 shows the results of the final conditional HLM for total amount spent (i.e.,

adjusted for level-1 predictors plus conditional random slopes and intercept coefficient for level-

2). The geometric mean of the total amount spent at a "typical" dispensary is US$17.70 when

holding all variables constant. The exponentiated coefficients reported in Table 4 indicate the

proportion of increase or decrease in this geometric mean. For example, a 10-unit (or $10,000)

increase in census tract median income is associated with an expected increase in total amount

by about 7% when holding all other variables constant. Reporting use for gastrointestinal and

neurological conditions is associated with an expected decrease in total amount spent by about

23% and 29%, respectively. Patrons identifying as an age category older than 24 or having

travelled a further distance are associated with higher total amount spent. Identifying as White

and non-Hispanic is associated with higher amount spent compared with identifying as Hispanic

or Black and non-Hispanic.

<center><INSERT TABLE 4 ABOUT HERE></center>

Correlates of Type of Marijuana Product

We only report the significant results for the analyses discussed in this section; detailed

tables are available as online supplemental files. In the final conditional HGLM for purchasing

only loose-leaf buds, we observed no significant associations with any individual-level factors;

in contrast, we observed that the MMD-level factor of census tract median income is associated

with lower odds of purchasing buds only ($OR = 0.983$, 95% CI [0.969,0.997], $p = 0.021$). In the

final conditional HGLM for purchase of pre-rolled joints, patrons who reported use for other

chronic medical conditions are more likely to purchase pre-rolled joints ($OR = 2.518$, 95% CI

[1.006, 6.300], $p = .048$).

The number of respondents who reported purchasing concentrates was too low to

establish reliable multivariate models; we describe the significant findings from our exploratory

bivariate models here. The unadjusted HGLMs for purchasing concentrates indicated that men

are 75% more likely to purchase concentrates than women ($OR = 3.019$, 95% CI [1.046, 8.714],

$p = .041$) and respondents who self-identified as White and non-Hispanic are associated with

double the odds of purchasing concentrates compared to all other racial/ethnic groups (*OR* =

2.196, 95% CI [1.138, 4.238], p = .019). In addition, respondents who purchase multiple types of

products are more likely to purchase concentrates (*OR* = 16.478, 95% CI [7.509, 36.165], *p* <

.001), and patrons who purchase buds are less likely to purchase concentrates (*OR* = 0.152, 95%

CI [0.071, 0.329], *p* < .001).

Correlates of Total Grams of Loose-Leaf Buds (in Grams)

Table 5 shows the results of the final conditional HGLM for total grams of buds

purchased with event rate ratios (ERR) reported; ERRs should be interpreted as the change in

expected quantity of buds purchased (in grams). For example, the expected quantity of buds (in

grams) for a one-time purchase is 11% lower for individuals who purchased only loose-leaf

buds; in contrast, it is double the amount for individuals who purchased multiple strains of

marijuana. The expected quantity of buds (in grams) is 18% lower for patrons reporting use for

gastrointestinal conditions (compared with other medical conditions). The final model estimated

that a higher count of buds in grams is expected for a patron identifying as male, in age

categories older than 24, or having travelled a farther distance. Finally, identifying as White and

non-Hispanic is associated with higher expected counts in grams compared with identifying as

Black and non-Hispanic or other racial/ethnic groups.

<center><INSERT TABLE 5 ABOUT HERE></center>

<center>**Discussion**</center>

We observed a high diversity of products sold across dispensaries and a diverse range of

purchase behaviors across individuals. The descriptive analyses highlighted that while average

costs and quantity of buds purchased are relatively low; approximately a quarter of the sample

spent anywhere from $50 to $330 at one time. In addition, 14% of individuals who purchased

buds reported obtaining higher than the average weekly quantities that were reported across prior studies (Bohnert et al., 2018; Bonn-Miller et al., 2014; Haug et al., 2017; Lin et al., 2016; O'Connell & Bou-Matar, 2007). Approximately a quarter of all purchasers selected specialty products that require simpler modes of preparation (i.e., ready-made edibles or pre-rolled joints) or higher concentration of THC (i.e., edibles or concentrates like hash oil). About 17% of all bud purchasers obtained multiple strains of marijuana, which mirrors prior findings that individuals are likely to report the use of multiple strains (Piper et al., 2017).

Interestingly, patrons who purchased multiple strains of marijuana are expected to purchase a larger quantity of buds than patrons purchasing one strain. This association makes sense in light of a minimum 1g purchase quantity within these stores and prior work suggesting user perceptions of differential strain effects (Corral, 2001; Piper et al., 2017). Further work should explore why individuals are selecting strains of marijuana, such as correspondence to specific conditions and/or combination of conditions, to understand their need for multiple strains (Corral, 2001; Piper et al., 2017).

This study also provided insights into patron- and venue-level characteristics associated with a range of one-time purchase behaviors reported by individuals exiting a random sample of MMDs. Regarding demographic correlates, 18 to 24-year-old patrons spent less and obtained smaller quantities of loose-leaf buds on average than older age categories. These are important findings to further explore, given the demographic trends that younger age groups may be increasing their use of medical marijuana (Fairman, 2016). In addition, we observed different patterns in purchase behaviors by racial and ethnic identification. Specifically, Black and non-Hispanic patrons spent less and purchased less grams of buds on average than White and non-Hispanic patrons. While we observed that Hispanic patrons spent less during a one-time visit,

they did not purchase fewer grams than White and non-Hispanic patrons. Further exploration is needed to evaluate how differences in purchase behaviors for these demographic groups may be better explained by patrons' availability of discretionary income, frequency of visits to a dispensary, level of experience (i.e., naïve vs. regular), and frequency of use of products (i.e., light vs. heavy).

We observed that men are more likely than women to purchase higher quantities of buds (in grams). Our exploratory bivariate analyses also suggested that men are more likely to purchase concentrates, which is consistent with prior work (Daniulaityte et al., 2017). Concentrate users typically are more experienced and are heavy users (Daniulaityte et al., 2017), which would also align with our bivariate findings that patrons purchasing concentrates have higher odds of purchasing multiple types of products. Finally, distance travelled was positively correlated with amount spent and quantity of buds obtained. Our findings differ from prior studies that observed no correlation between distance and amount spent, possibly due to our use of a more precise distance measure, randomly selected MMDs from which to sample, or a larger sample size (Caulkins & Pacula, 2006; Kepple & Freisthler, 2017; Kepple et al., 2016).

For medical conditions, patrons who reported use for gastrointestinal and neurological conditions spent less, on average. For gastrointestinal conditions, we also observed lower counts of buds (in grams) than those not reporting these conditions. It may be that users reporting these conditions engage in lighter use of marijuana products than those who report use for pain management, mental health, other chronic conditions, or non-medical conditions. In addition, specialty products like pre-rolled joints were associated with use for other chronic medical conditions, like symptoms related to HIV/AIDs or cancer. Pre-rolled joints may provide easier access for naïve users, which could be beneficial for individuals who are new to use and need it

for medical conditions. The lack of significant differences for individuals reporting pain or

mental health conditions may be that medicinal use to treat some conditions is driven by personal

choice (e.g., preference for mode of consumption), needs specific to the severity or chronicity of

the condition, or available financial resources. These larger variations in purchase behaviors

within medical condition categories are concerning in light of the lack of clear guidelines

available for marijuana use by specific conditions (MacCallum & Russo, 2018). Future research

is needed to better understand how these unmeasured factors may contribute to potential

disparities in access to and quality of medical marijuana products.

At the venue level, we observed the median income of the surrounding census tract was

correlated with several purchase behaviors. Specifically, the census tract median income was

associated with a higher total amount spent and a lower likelihood of purchasing only loose-leaf

buds. These findings are similar to those observed for purchase of edibles (Kepple & Freisthler,

2017). Given its correlation with product diversity and exterior maintenance, census tract median

income may be serving as a proxy for the overall appeal of the location to consumers and the

diversity of products being offered. Future work on venue-level features should explore

developing refined measures of perceived popularity or legitimacy of a location, product

diversity, promotional deals, and niche market indicators to build upon these findings.

Strengths and Limitations

Although these findings provide insight into purchase behaviors and their correlates,

readers should interpret them in light of the study's limitations. First, data for this study included

a single visit to a sampled MMDs. They cannot address whether purchase behavior varied based

on how often the patron visited the dispensary. We also do not know whether the purchases we

captured were typical for those patrons. This limitation is offset by the reduction of recall bias

and ability to identify venue-specific traits through asking patrons to report on purchase behaviors at the time of their exit from the dispensary. Second, we did not examine correlates of price per gram for marijuana buds or other variations in potency within each product type. These measures may provide insight into MMD- and individual-level correlates related to patrons who obtain higher potency or higher quality products. Third, the study did not include measures that can help us better understand factors influencing purchase behavior, such as the comparative costs of products across dispensary locations, specific marketing strategies used within the venue, patrons' motivations for purchase, or patrons' intent to share with others. Further work exploring more precise measures of venue- and patron-specific characteristics is important if we are to understand the ways that place influences behaviors and how this information can be leveraged for effective place-based regulations and targeted prevention efforts.

Finally, California passed legislation in 2016 that permits recreational use in addition to medical use of marijuana (National Conference of State Legislatures, 2018). As a result, future dispensary models and purchasing behaviors may shift with changing policies. For example, states that have recreational use laws generally have separate systems for medical users (e.g., taxed less, required to register) and separate licensure and site requirements for dispensaries. That being said, MMDs currently remain the prevailing licit distribution model for marijuana across the United States (National Conference of State Legislatures, 2018).

Implications

Our study's findings can help policy makers and community practitioners begin to think about the nature and function of this newer type of drug outlet in order to create more effective place-based policies and target prevention efforts. For example, policy makers may want to explore regulating the availability of specialty items that may be attractive to naïve users (e.g.,

pre-rolled joints) or high-concentration products that may be sought out by regular, heavy users. In addition, caps on quantities obtained may help to mitigate marijuana-related harms. These caps would align with recommendations against consumption of high doses to address medical conditions and with concerns that these doses may suggest tolerance or misuse (MacCallum & Russo, 2018). Further, caps would affect a small proportion of users given the vast majority of patrons reported relatively low quantities per purchase (1g to 8g). Regulations focused on limiting the quantity of a single purchase or purchases within a specified time frame—which is how pseudoephedrine is currently administered—might also reduce the possible consequences of maintaining a large supply of cannabis, such as overconsumption or an unintentional diversion of the product. Thirdly, inconsistencies in local licensing practices may be contributing to patrons travelling considerable distances because of limited availability of dispensaries near their homes or limited product diversity at dispensaries proximal to their homes. Finally, prevention efforts, such as those focused on deterring driving while under the influence of cannabis or educating individuals about safe consumption of concentrates, are likely to reach their intended audience if they target their efforts in areas surrounding dispensary sites (Berg et al., 2018).

Conclusions

As licit distribution of marijuana through placed-based venues expands, there is an ongoing need to understand how patrons are engaging these outlets and accessing marijuana products. This study provided insight into products purchased from MMDs within one regional context, emphasizing the importance of understanding the places where marijuana is being distributed as well as the individuals who obtain these products.

Conflict of Interest

The authors declare they have no conflicts of interest.

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Table 1

Sample Characteristics for Respondents (N = 595)

Sample Characteristics	*n*(%) or *M(SD)*	Min	Max
Gender			
Male	457 (76.8)		
Female	136 (22.9)		
Missing	2 (0.3)		
Age (in years)	34.1 (12.9)	18	80
18 to 24	177 (29.7)		
25 to 34	182 (30.6)		
35 to 54	181 (30.4)		
55 or older	53 (8.9)		
Missing	2 (0.3)		
Race/Ethnicity			
White NH	188 (31.6)		
Black NH	183 (30.8)		
Hispanic/Latino	158 (26.6)		
Asian/Pacific Islander NH	22 (3.7)		
American Indian/Alaskan Native NH	4 (0.7)		
Other race NH	23 (3.9)		
Two or more races NH	16 (2.7)		
Missing	1 (0.2)		
Has medical marijuana recommendation?			
No	4 (0.7)		
Yes	588 (98.8)		
Missing	3 (0.5)		
Reason for medical marijuana use			
Pain	323 (54.3)		
Mental health condition	354 (59.5)		
Gastrointestinal condition	95 (16.0)		
Neurologic condition	72 (12.1)		
Other chronic medical condition	43 (7.2)		
Non-medical conditions	9 (1.5)		
Not Reported	7 (1.2)		
Distance from Home to MMD (km)	13.2 (23.9)	0.0	110.7

Note. NH = Non-Hispanic

Table 2

Sample Characteristics for MMDs (N = 16)

Sample Characteristics	n(%) or M(SD)	Min	Max
Census tract pop density (1,000 pop per sq mi)	14.7 (9.6)	3.0	36.4
Census tract median income (in US $1,000)	57.1 (29.0)	23.6	119.9
Census tract % pop White and non-Hispanic	30.1 (30.1)	0.1	78.7
Surrounding MMD density (count within 0.5 km)	2.6 (1.8)	1.0	8.0
MMD licensure status			
Opened pre-ICO and remains eligible	2 (12.5)		
Opened pre-ICO but now ineligible	4 (25.0)		
Opened post-ICO	10 (62.5)		
MMD exterior maintenance			
Poor to fair	5 (31.3)		
Good to excellent	11 (68.8)		
MMD number of security features	2.1 (1.3)	0.0	4.0
Locked metal screen door	6 (37.5)		
Pass-through door	8 (50.0)		
Intercom	2 (12.5)		
Doorman	1 (6.3)		
Security cameras	15 (93.8)		
Signage about IDs/Rx required	2 (12.5)		
MMD payment options			
Cash only	11 (68.8)		
Credit card accepted	5 (31.3)		
Diversity of products sold			
Low (primarily buds)	2 (12.5)		
Moderate (mix of products)	7 (43.8)		
High (all types of products sold)	7 (43.8)		
Average price for 1g of indica (in US $) (*n* = 12)			
Low end average	6.5 (2.9)	1.0	10.0
High end average	20.4 (2.5)	17.0	25.0
Average price for 1g sativa (in US $) (*n* = 12)			
Low end average	8.4 (3.9)	2.0	15.0
High end average	17.3 (3.7)	10.0	25.0
Average price for 1g hybrid (in US $) (*n* = 10)			
Low end average	7.7 (4.5)	0.0	15.0
High end average	17.5 (3.8)	10.0	22.0

Note. MMD = medical marijuana dispensary

Table 3

Respondent Self-Reported Discrete Purchase Behaviors

Purchase Behaviors	*n*(%) or *M(SD)*	Min	Max
Purchased any item? (*n* = 595)			
No	47 (7.9)		
Yes	547 (91.9)		
Missing	1 (0.2)		
Among purchasers (*n* = 547)			
Total amount spent in $US (*n* = 535)	41.7 (43.9)	0.0	330.0
Type of products purchased			
Buds	500 (91.4)		
Edibles	66 (12.1)		
Pre-rolled joints	62 (11.3)		
Concentrates	46 (8.4)		
Seeds or clones	17 (3.1)		
Multiple types purchased			
Zero to one type of product	421 (77.0)		
Two or more types of products	126 (23.0)		
Among bud purchasers (*n* = 500)			
Quantity of buds in grams (*n* = 492)	4.4 (6.0)	1.0	56.0
Strain of buds purchased			
Indica	278 (55.6)		
Sativa	185 (37.0)		
Hybrid	128 (25.6)		
Number of strains purchased			
One strain	416 (83.2)		
Two or more strains	84 (16.8)		

Table 4

Correlates of Total Amount Spent (LN$US) (n = 517)

	b	SE	p	exp(b)
Model for Level 2 (MMD Means)				
Intercept	2.873	0.233	< .001	17.697
Mean CT median income (US $1,000)	0.007	0.002	.007	1.007
MMD density (count within 0.5 km)	0.011	0.040	.781	1.011
Models for Level 1 (Variable Slopes)				
Patron demographics				
Male	-0.045	0.083	.589	0.956
Age (in years)				
18 to 24	ref			
25 to 34	0.228	0.091	.013	1.256
35 to 54	0.276	0.094	.003	1.318
55 or older	0.297	0.136	.029	1.346
Race/ethnicity				
White and non-Hispanic	ref			
Black and non-Hispanic	-0.409	0.102	< .001	0.664
Hispanic	-0.266	0.100	.008	0.766
Other race/ethnicity	-0.037	0.121	.759	0.964
Purchase behaviors				
Purchased edibles	-0.322	0.140	.022	0.725
Purchased seeds/clones	-0.162	0.219	.460	0.850
Purchased pre-rolled joints	-0.717	0.138	< .001	0.488
Purchased concentrates	0.095	0.146	.514	1.100
Multiple types of products	0.624	0.142	< .001	1.866
Medical conditions				
Use for Pain	-0.119	0.079	.132	0.888
Use for mental health condition	-0.043	0.081	.597	0.958
Use for gastrointestinal condition	-0.261	0.096	.007	0.770
Use for neurological condition	-0.339	0.106	.001	0.713
Use for other chronic medical condition	-0.240	0.135	.075	0.786
Travel distance				
Distance from home to MMD (log-meter)	0.082	0.021	< .001	1.085

Random Effects	Variance Component	df	χ^2	p
MMD Means, u_0	0.043	13	44.094	< .001
Level-1 effect, r	0.579			

Note. Dependent variable is transformed using a natural log function to approximate a normal distribution and analyzed using a hierarchical linear model; MMD = medical marijuana dispensary; CT = census tract.

Table 5

Correlates of Total Grams of Marijuana Buds Purchased (N = 483)

	b	*SE*	*p*	ERR
Model for Level 2 (MMD Means)				
Intercept	-0.142	0.186	0.459	0.867
Mean CT median income (US $1,000)	0.000	0.003	0.952	1.000
MMD density (count within 0.5 km)	-0.011	0.057	0.844	0.989
Models for Level 1 (Variable Slopes)				
Patron demographics				
Male	0.111	0.055	0.043	1.118
Age (in years)				
18 to 24	ref			ref
25 to 34	0.337	0.062	< .001	1.401
35 to 54	0.333	0.064	< .001	1.395
55 or more	0.512	0.092	< .001	1.669
Race/ethnicity				
White and non-Hispanic	ref			ref
Black and non-Hispanic	-0.502	0.072	< .001	0.605
Hispanic	-0.004	0.061	.949	0.996
Other race/ethnicity	-0.200	0.078	.011	0.819
Purchase behaviors				
Purchased buds only	-0.117	0.052	.025	0.890
Purchased multiple strains	0.694	0.053	< .001	2.002
Medical conditions				
Use for pain	0.031	0.052	.547	1.032
Use for mental health condition	-0.024	0.055	.659	0.976
Use for gastrointestinal condition	-0.198	0.068	.004	0.820
Use for neurological condition	0.077	0.066	.244	1.080
Use for other chronic medical condition	-0.013	0.091	.888	0.987
Travel distance				
Distance from home to MMD (log-meter)	0.156	0.014	< .001	1.169

Random Effects	Variance Component	*df*	χ^2	*p*
MMD means, u_0	0.137	13	321.677	< .001

Note. Dependent variable is modeled as a count in grams and analyzed using a hierarchical generalized linear model with Poisson sampling and log-link function; ERR = event rate ratio; MMD = medical marijuana dispensary; CT = census tract.

Supplemental Table A1

Adjusted HGLM for Purchasing Buds Only (N = 517)

	b	*SE*	*p*	*OR*
Model for Level 2 (MMD Means)				
Intercept	1.253	0.723	.106	3.503
Mean CT median income (US $1,000)	-0.017	0.007	.021	0.983
MMD density (count within 0.5 km)	-0.161	0.116	.187	0.851
Models for Level 1 (Variable Slopes)				
Patron demographics				
Male	-0.287	0.263	.277	0.751
Age (in years)				
18 to 24	ref			
25 to 34	-0.242	0.284	.394	0.785
35 to 54	-0.103	0.291	.724	0.902
55 or more	0.470	0.436	.282	1.600
Race/ethnicity				
White and non-Hispanic	ref			
Black and non-Hispanic	0.563	0.310	.070	1.755
Hispanic	0.404	0.295	.171	1.498
Other race/ethnicity	0.011	0.347	.976	1.011
Medical conditions				
Use for pain	0.036	0.242	.882	1.036
Use for mental health condition	0.269	0.251	.285	1.309
Use for gastrointestinal condition	0.185	0.297	.535	1.203
Use for neurological condition	-0.345	0.314	.274	0.708
Use for other chronic medical condition	-0.433	0.391	.269	0.649
Travel distance				
Distance from home to MMD (log-meter)	-0.048	0.066	.470	0.954

Random Effects	Variance Component	*df*	χ^2	*p*
MMD means, u_0	0.362	13	39.626	< .001

Supplemental Table A2

Adjusted HGLM for Purchasing Pre-Rolled Joints (N = 517)

	b	SE	*p*	OR
Model for Level 2 (MMD Means)				
Intercept	-2.068	0.961	.051	0.126
Mean CT median income (US $1,000)	0.007	0.008	.441	1.007
MMD density (count within 0.5 km)	0.022	0.150	.884	1.022
Models for Level 1 (Variable Slopes)				
Patron demographics				
Male	0.290	0.360	.422	1.336
Age (in years)				
18 to 24	ref			
25 to 34	-0.615	0.407	.132	0.541
35 to 54	-0.196	0.377	.603	0.822
55 or more	-0.268	0.559	.631	0.765
Race/ethnicity				
White and non-Hispanic	ref			
Black and non-Hispanic	-0.226	0.417	.589	0.780
Hispanic	-0.225	0.398	.572	0.799
Other race/ethnicity	-0.937	0.584	.110	0.392
Medical conditions				
Use for pain	-0.287	.330	.386	0.751
Use for mental health condition	-0.520	.334	.120	0.593
Use for gastrointestinal condition	-0.130	.416	.756	0.878
Use for neurological condition	0.520	.399	.193	1.682
Use for other chronic medical condition	0.923	.467	.048	2.518
Travel distance				
Distance from home to MMD (log-meter)	0.057	.088	.519	1.059

Random Effects	Variance Component	*df*	χ^2	*p*
MMD means, u_0	0.499	13	32.040	.003

Supplemental Table A3

Unadjusted HGLMs for Purchasing Concentrates (N = 517)

	b	SE	p	OR
By gender				
Intercept	-3.398	0.526	< .001	0.033
Male	1.105	0.539	.041	3.019
By age				
Intercept	-2.800	0.372	< .001	0.061
Age (in years)				
18 to 24	Ref			
25 to 34	0.736	0.432	.089	2.088
35 to 54	0.227	0.465	.626	1.254
55 or more	-0.001	0.699	.999	0.999
By race/ethnicity[a]				
Intercept	-2.754	0.241	< .001	0.064
White and non-Hispanic	0.786	0.335	.019	2.196
Obtained multiple types of products?				
Intercept	-3.780	0.352	< .001	0.023
Multiple types	2.802	0.400	< .001	16.479
Obtained loose-leaf buds?				
Intercept	-0.856	0.348	.027	0.425
Buds	-1.882	0.391	< .001	0.152
Medical conditions				
Intercept	-2.629	0.437	< .001	0.072
Use for pain	0.056	0.358	.876	1.057
Use for mental health	0.093	0.376	.806	1.097
Use for gastrointestinal	-0.038	0.445	.931	0.962
Use for neurological	-0.351	0.447	.433	1.420
Use for other chronic medical	0.346	0.576	.549	1.413
Distance travelled				
Intercept	-2.956	0.852	.003	0.052
Distance travelled (log-meter)	0.053	0.099	.556	1.060

[a] Model does not converge with expanded categories.

Supplemental Table B1

Zero Order Correlation of Medical Conditions (N = 517)

	Pain	Mental Health	Gastro	Neuro	Other Chronic	Non-medical
Pain	--					
Mental Health	- .417*	--				
Gastro	- .123*	.145*	--			
Neuro	- .086	.038	.070	--		
Other Chronic	- .062	- .149*	.066	- .064	--	
Non-medical	- .026	.045	- .019	.083	- .038	--

*$p < .05$

Supplemental Table B2

Unadjusted HLMs for Medical Conditions & Total Amount Spent (N = 517)

	b	*SE*	*p*
Used for pain			
Intercept	3.371	0.111	< .001
Pain	-0.067	0.075	.372
Used for mental health			
Intercept	3.330	0.114	< .001
Mental health	0.008	0.077	.916
Used for gastrointestinal conditions			
Intercept	3.381	0.107	< .001
Gastrointestinal	-0.301	0.101	.003
Used for neurological conditions			
Intercept	3.370	0.105	< .001
Neurological	-0.289	0.111	.010
Used for other chronic medical Conditions			
Intercept	3.340	0.104	< .001
Other chronic medical	-0.074	0.140	.595
Used for non-medical conditions			
Intercept	3.333	0.103	< .001
Non-medical	0.106	0.284	.709

Supplemental Table B3

Model Building for Adjusted HLMs for Total Amount Spent (N = 517)

	No Medical Conditions b (*SE*)	Gastro + Neuro b (*SE*)	All Med Conditions
Model for Level 2 (MMD Means)			
Intercept	**2.70 (0.22)**	**2.82 (0.22)**	**2.87 (0.23)**
Mean CT median income ($1,000)	**0.01 (0.00)**	**0.01 (0.00)**	**0.01 (0.00)**
MMD density (count w/in 0.5 km)	0.02 (0.04)	0.02 (0.04)	0.01 (0.04)
Models for Level 1 (Variable Slopes)			
Patron demographics			
Male	-0.01 (0.08)	-0.04 (0.08)	-0.05 (0.08)
Age (in years)			
18 to 24	ref	ref	ref
25 to 34	**0.22 (0.09)**	**0.22 (0.09)**	**0.23 (0.09)**
35 to 54	**0.24 (0.09)**	**0.25 (0.09)**	**0.28 (0.09)**
55 or more	0.26 (0.14)	**0.27 (0.13)**	0.29 (0.14)
Race/ethnicity			
White and non-Hispanic	ref	Ref	Ref
Black and non-Hispanic	**-0.44 (0.10)**	**-0.43 (0.10)**	**-0.41 (0.10)**
Hispanic	**-0.28 (0.10)**	**-0.28 (0.10)**	**-0.27 (0.10)**
Other race/ethnicity	-0.06 (0.12)	-0.05 (0.12)	-0.04 (0.12)
Purchase behaviors			
Purchased edibles	**-0.33 (0.14)**	**-0.32 (0.14)**	**-0.32 (0.14)**
Purchased seeds/clone	-0.17 (0.22)	-0.16 (0.22)	-0.16 (0.22)
Purchased pre-rolled joints	**-0.75 (0.14)**	**-0.73 (0.14)**	**-0.72 (0.14)**
Purchased concentrates	0.07 (0.15)	0.08 (0.15)	0.10 (0.15)
Multiple types of products	**0.64 (0.14)**	**0.63 (0.14)**	**0.62 (0.14)**
Medical conditions			
Use for pain			-0.12 (0.08)
Use for mental health condition			-0.04 (0.08)
Use for gastrointestinal condition		**-0.24 (0.10)**	**-0.26 (0.10)**
Use for neurological condition		**-0.31 (0.10)**	**-0.34 (0.11)**
Use for other chronic medical			-0.24 (0.14)
Travel distance			
Distance from home to MMD (log-meter)	**0.08 (0.02)**	**0.08 (0.02)**	**0.08 (0.02)**

Note: Significant coefficients are bolded.