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U.S. cannabis legalization and use of vaping and edible products among youth

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Abstract

Background—Alternative methods for consuming cannabis (e.g., vaping and edibles) have become more popular in the wake of U.S. cannabis legalization. Specific provisions of legal cannabis laws (LCL) (e.g., dispensary regulations) may impact the likelihood that youth will use alternative methods and the age at which they first try the method - potentially magnifying or mitigating the developmental harms of cannabis use.

Methods—This study examined associations between LCL provisions and how youth consume cannabis. An online cannabis use survey was distributed using Facebook advertising, and data were collected from 2630 cannabis-using youth (ages 14–18). U.S. states were coded for LCL status and various LCL provisions. Regression analyses tested associations among lifetime use and age of onset of cannabis vaping and edibles and LCL provisions.

Results—Longer LCL duration (OR_{vaping}: 2.82, 95% CI: 2.24, 3.55; $OR_{edibles}$: 3.82, 95% CI: 2.96, 4.94), and higher dispensary density (OR_{vaping}: 2.68, 95% CI: 2.12, 3.38; $OR_{edibles}$: 3.31,

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Author Disclosure

Contributors:

JTB, DCL, BSC, JDS, JLG and AJB designed the survey. DCL and JTB managed online recruitment and data cleaning efforts. JTB conducted the analyses of the data. JTB and AJB wrote the initial draft of the manuscript. All authors contributed to the writing and have approved the final manuscript.

Conflict of Interest:

The authors have no conflicts of interest to declare.

95% CI: 2.56, 4.26), were related to higher likelihood of trying vaping and edibles. Permitting home cultivation was related to higher likelihood (OR: 1.93, 95% CI: 1.50, 2.48) and younger age of onset (β: −0.30, 95% CI: −0.45, −0.15) of edibles.

Conclusion—Specific provisions of LCL appear to impact the likelihood, and age at which, youth use alternative methods to consume cannabis. These methods may carry differential risks for initiation and escalation of cannabis use. Understanding associations between LCL provisions and methods of administration can inform the design of effective cannabis regulatory strategies.

Keywords

Marijuana; Cannabis; Legalization; Vaping; Edibles; Adolescent

1. Introduction

Cannabis legalization is evolving rapidly in the United States. This has prompted a need to study how legal cannabis laws (LCL) such as medical cannabis laws (MCL) or recreational cannabis laws (RCL) may impact cannabis use patterns. Understanding how such laws affect youth is crucial because of this group's vulnerability to the adverse effects of cannabis. Chronic cannabis use during adolescence has been associated with impaired brain development, educational achievement, and psychosocial functioning (Hall and Degenhardt, 2015; Rigucci et al., 2016; Volkow et al., 2014), and early initiation of cannabis use elevates the risk of developing a cannabis use disorder (DeWit et al., 2000; Swift et al., 2008)

Cannabis legalization promotes the creation and proliferation of alternative cannabis use products such as edibles and vaping devices (Hopfer, 2014; Hunt and Miles, 2015; Subritzky et al., 2015). Access to such products may alter how cannabis is consumed by the close to two million adolescents and seven million young adults currently using cannabis (Center for Behavioral Health Statistics and Quality, 2015), and may impact age of onset of cannabis use. Edible products such as cannabis-infused baked goods, drinks, and candy, have become increasingly popular but are often inaccurately labeled and deliver variable doses of cannabis' primary psychoactive constituent, tetrahydrocannabinol (THC) (Subritzky et al., 2015; Vandrey et al., 2015). Most of the edible cannabis products currently marketed lack empirically-based safety standards and packaging regulations (Benjamin and Fossler, 2016; Cao et al., 2016; Subritzky et al., 2015), and products continue to be marketed in ways that are attractive to youth (MacCoun and Mello, 2015). Some LCL states have taken measures to limit products' attractiveness to youth and require child-resistant packaging (Marijuana Enforcement Division, 2017) in response to the sharp increase in edible cannabis overdoses among youth (Wang et al., 2016). Despite these critical issues, few data are available documenting patterns of use of cannabis edibles among youth.

E-cigarettes and other vaping devices are becoming increasingly popular among middle and high school aged youth in the United States (Anand et al., 2015; Krishnan-Sarin et al., 2015; Singh et al., 2016). These devices heat liquid or solid preparations of substances to allow a user to inhale the psychoactive compounds (e.g., nicotine, THC) from these substances in non-combusted forms. Vaping can significantly reduce carcinogenic toxins consumed when inhaling combustible cannabis and tobacco smoke (Polosa, 2015; Van Dam and Earleywine,

2010) and youth do perceive e-cigarettes to be healthier and less risky than traditional combustible cigarettes (Camenga et al., 2015; Kong et al., 2015). Cannabis vaping has received limited study but also appears to be on the rise among adolescents and young adults (Jones et al., 2016; Morean et al., 2015). Among e-cigarette users, cannabis vaping occurs more often in populations of high school aged youth than adults (Morean et al., 2015). Recent data suggest that adolescents who vape cannabis most often use highly potent cannabis oil, wax, or liquid preparations (Morean et al., 2015). How the use of these high-potency products impacts neurodevelopment is unknown, but of pressing concern as it may place youth at risk for psychosis (Di Forti et al., 2014) and cannabis use disorders (Freeman and Winstock, 2015). Moreover, vaping has the potential to contribute to increased rates of cannabis uptake, lower age of cannabis use onset (Budney et al., 2015), and increased public cannabis use (Giroud et al., 2015; Jones et al., 2016; Morean et al., 2015), all of which may prompt more frequent and perhaps larger quantities of cannabis use (Budney et al., 2015; Fischer et al., 2015). To date, however, few data exist on the use of vaping devices for cannabis consumption among youth despite these potential risks.

States have passed unique LCL each with different combinations of legal provisions (Hunt and Miles, 2015) - creating a heterogeneous landscape of cannabis regulatory models across the U.S. (Bestrashniy and Winters, 2015; Pacula et al., 2014a). Some states only allow medicinal cannabis use while other states allow both medicinal and recreational cannabis use. Within these two regulatory frameworks, access and distribution mechanisms vary dramatically. Some states permit for-profit cannabis dispensaries or home cultivation (HC) of cannabis while other states do not. Limits on personal possession amounts range from 1 – 24 ounces or are ambiguously defined as a “30-day” or “60-day” supply. In some states, cannabis can only be vaporized or used in edible form (not smoked). Equivocal results in the literature concerning the effect of cannabis legalization on public health are likely a product of poor accounting for this diversity among LCLs (Pacula et al., 2015; Sevigny et al., 2014). Each LCL provision has the potential to affect patterns and consequences of use, and interaction among LCL provisions may yield additive, synergistic, or counter effects.

In a previous study, we used Facebook sampling methods to demonstrate strong cross-sectional relations between the presence of LCL provisions and increased likelihood of vaping and edible use among adults (Borodovsky et al., 2016). Specifically, we found that adults from states with (1) higher numbers of cannabis dispensaries per person and (2) longer durations of having an MCL in place were significantly more likely to have tried vaping cannabis and cannabis edibles. Age of onset of vaping and edibles use was not related to these LCL provisions. In the present study, we used this same valid and reliable sampling method (Ramo et al., 2012) to examine these same associations in a youth sample and explore the impact of two additional LCL provisions (home cultivation and recreational legalization) on vaping and edible use. We hypothesized that longer durations of having an MCL in place, a greater number of dispensaries per 100,000 people, the presence of a recreational cannabis law, and the presence of a home cultivation provision would be associated with higher likelihood of lifetime use and younger age of onset of cannabis vaping and edibles.

2. Methods

2.1 Survey

An anonymous online survey hosted by Qualtrics collected information on demographics (including state residence) and cannabis use. Cannabis use items focused on lifetime use, current use, and age of onset of both cannabis use in general and of different methods of cannabis administration (smoking, vaping, and eating). Qualtrics data quality functions prevented multiple responses from a single individual and ensured that responses came from people and not internet bots. The survey required all items to be answered, and no compensation was provided. The study was approved by the Dartmouth Committee for the Protection of Human Subjects.

2.2 Recruitment and Consent

The survey URL link was administered via Facebook advertising methods (Ramo et al., 2014). To target cannabis using youth, advertisements with cannabis-related imagery were sent to the screens of youth ages 14 – 18 who had endorsed cannabis-related interests on their Facebook profile. Examples of these interests included cannabis-related organizations (e.g., Marijuana Policy Project), magazines (e.g., High Times Magazine), music (e.g., Pink Floyd), and notable individuals (e.g., Tommy Chong). Advertisements were distributed from April 29th, 2016 to May 18th, 2016 and shown to 126,945 individuals. Of these individuals, 5480 (4.3%) clicked the advertisement and were redirected to the survey's informed consent/assent page. Among those, 33 (0.6%) did not consent, and 210 (3.8%) were not within the targeted age. Of those who started the survey, 3035 (57.9%) completed it and passed data quality checks. Of these, 405 (13.3%) had never used cannabis and were excluded from the present analyses, resulting in a final sample size of n=2630. Among those who initiated the survey, comparisons between those who did and did not complete the survey revealed no significant differences in age, race, education, lifetime days of cannabis use, likelihood of lifetime vaping or edible use, and age of onset of vaping. Those who completed were more likely to be female (53% vs. 46%, $p<0.05$) and had a slightly older age of onset of edibles (14.9 years vs. 14.6 years, $p<0.05$) than those who did not. Parental consent was waived because youth were surveyed anonymously. The consent page explained that anyone between the ages of 14 and 18 inclusive could take our anonymous survey. It also explained that researchers at the Geisel School of Medicine at Dartmouth were conducting the survey and stressed the importance of being cautious about providing personal information on the internet. Finally, the consent explained that our research group was not encouraging cannabis use and youth should consider first discussing the survey with a parent before taking it.

2.3 Primary Outcome Variables

A survey item asked, "What ways have you used marijuana? (check all that apply)" and listed three response options: (1) Smoking, (2) Vaporizing (3) Eating. Examples of each method of administration were included next to each response option. Those who reported lifetime vaping or edible use were asked how old they were when they tried the method for the first time.

2.4 LCL Provision Classifications (Primary Independent Variables)

Multiple sources were reviewed to classify all 50 U.S. States and Washington D.C. as having specific LCL provisions (or not). Sources included peer-reviewed papers (Pacula et al., 2015), state government and cannabis legislation-related websites (ProCon.org, 2016), and communications with state government officials involved in administration and coordination of medical and recreational cannabis programs. States were classified by: (1) LCL status (yes/no) (2) LCL status duration (0–5 years, 6–10 years, >10 years) (3) permitting dispensaries (yes/no) and density of dispensaries (<1dispensary per 100,000 people, ≥1dispensary per 100,000 people) (U.S. Census Bureau Population Division, 2016) (4) recreational cannabis law (RCL) or medical cannabis law-only (MCL-only) and (5) home cultivation (HC) status (yes/no) (Table 1). Non-LCL states were defined as states with no current MCL or RCL. Ohio, North Dakota, Florida, and Arkansas were categorized as Non-LCL states because data were collected before LCL were enacted in these states (Table 1).

2.5 Analytical approach

Our aim was to examine the relation between LCL provision variables described above and vaping and edible use. First, descriptive statistics of the sample were calculated (Table 2). Then unadjusted bivariate analyses were performed using t-tests, ANOVAs, and chi-squared analyses to test for differences in the prevalence of use of a method of administration between LCL provisions (Table 3). Subsequent multiple logistic and linear regression analyses further examined these associations (Tables 4 and 5). To account for demographic differences across states and cannabis user heterogeneity, analyses adjusted for sociodemographic covariates (age, gender, race, grade level), lifetime days of cannabis use, and age of onset of any cannabis use. LCL provision variables were dummy coded, and analyses were performed first using Non-LCL states as the reference group, and then, among only LCL states, using the “lowest level” category of each provision variable as the reference group (e.g., comparing LCL states that prohibit home cultivation (reference) to LCL states that permit home cultivation). Analyses were conducted using Stata® version 14 (StataCorp, 2015)

3. Results

3.1 Sample Description

Table 2 displays overall characteristics of the sample and characteristic comparisons between Non-LCL vs. LCL states. The mean age of the entire sample was 16.36 years (SD=1.09), and approximately 46% were male. Minorities were somewhat underrepresented (approx. 3% African-American, and 14% Hispanic). Approximately 84% were between 9th and 12th grade. Participants from LCL and Non-LCL differed significantly across current education level, lifetime days of cannabis use, and age of cannabis use onset (Table 2). A comparison with 2015 United States Census data indicated that the proportion of study participants from each state corresponded closely to the proportion of the total U.S. population represented in each state (Pearson’s r=0.82, p<0.0001) (U.S. Census Bureau Population Division, 2016). Compared to a sample of lifetime cannabis-using youth (ages 14 to 18) from the 2014 National Survey on Drug Use and Health (NSDUH), our sample contained a higher proportion of past-month users (12.4% vs. 83.1% respectively) who had

on average used more frequently in the past month (11.2 days (SD=13.5) vs. 16.7 days (SD=11.1) respectively) (Center for Behavioral Health Statistics and Quality, 2014).

3.2 Unadjusted Bivariate Analyses

3.2.1 Lifetime Use of Vaping and Edibles—Lifetime prevalence of cannabis vaping and edible use was approximately 15 percentage points greater among youth in LCL states than youth in Non-LCL states (Table 3). Across LCL duration categories, the prevalence of lifetime vaping and edible use ranged from 35.6% to 56.5% ($p<0.001$) and 52.0% to 77.7%, ($p<0.001$) respectively. Across dispensary density categories the prevalence of lifetime vaping and edible use ranged from 35.6% to 54.4% ($p<0.001$) and 52.0% to 74.8% ($p<0.001$) respectively. Across types of law (Non-LCL, MCL-only, RCL) the lifetime prevalence of vaping and edible use ranged from 35.6% to 57.4% ($p<0.001$) and 52.0% to 75.2% ($p<0.001$) respectively. Across HC status categories the prevalence of lifetime vaping and edible use ranged from 35.6% to 52.5% ($p<0.001$) and 52.0% to 73.3% ($p<0.001$) respectively (Table 3).

3.2.2 Age Onset of Vaping and Edible Use—The age of onset of vaping did not differ across any LCL provision variables. Age of onset of edible use ranged from 14.6 to 15.3 years across LCL duration categories ($p<0.0001$), 14.7 to 15.2 years across dispensary density categories ($p<0.001$), and 14.7 to 15.3 years across HC status categories ($p<0.0001$) (Table 3).

3.3 Multivariable Logistic and Linear Regression Analyses

3.3.1 Lifetime Use of Vaping and Edibles

3.3.1.1 LCL vs. Non-LCL and LCL Duration: Youth in LCL states were over twice as likely to have tried vaping (OR: 2.14, 95% CI: 1.80, 2.55) and edibles (OR: 2.24, 95% CI: 1.88, 2.68) than youth in Non-LCL states. Youth from each LCL duration category were more likely to have tried vaping and edibles than youth from Non-LCL states (see Table 4 for odds ratios). Compared to youth from the shortest LCL duration category (0–5 years), youth from states with the longest LCL duration (>10 years) were more likely to have tried vaping (OR: 1.52, 95% CI: 1.18, 1.96) and over twice as likely to have tried edibles (OR: 2.48, 95% CI: 1.86, 3.31) (Table 4).

3.3.1.2 Dispensary Density: Youth from each dispensary density category were up to twice as likely to have tried vaping and up to three times more likely to have tried edibles than youth from Non-LCL states (see Table 4 for odds ratios). However, the odds ratios showed a linear increase across dispensary density categories (prohibited to <1 to ≥1) in the vaping model but were “U-shaped” in the edible model (i.e., states that prohibit dispensaries and states with ≥1 dispensary per 100,000 people, had similarly elevated odds ratios). Compared to youth from LCL states that prohibit dispensaries, youth from LCL states with the highest dispensary density were more likely to have tried vaping (OR: 1.76, 95% CI: 1.15, 2.69) while youth from lower dispensary density LCL states were half as likely to have tried edibles (OR: 0.53, 95% CI: 0.33, 0.83) (Table 4).

3.3.1.3 Medical-Only and Recreational Laws: Youth from MCL-only states were significantly more likely to have tried vaping and edibles than youth from Non-LCL states (OR_{vaping}: 1.98, 95% CI: 1.65, 2.38; $OR_{edibles}$: 2.05, 95% CI: 1.70, 2.46) as were youth from RCL states (OR_{vaping}: 3.13, 95% CI: 2.30, 4.24; $OR_{edibles}$: 3.57, 95% CI: 2.55, 5.01). Youth from RCL states were significantly more likely to have tried vaping (OR: 1.59, 95% CI: 1.17, 2.15) and edibles (OR: 1.78, 95% CI: 1.26, 2.51) than youth from MCL-only states (Table 4).

3.3.1.4 LCL Home Cultivation Status: Compared to youth from Non-LCL states, youth from LCL states that prohibit home cultivation (OR_{vaping}: 1.95, 95% CI: 1.56, 2.43; $OR_{edibles}$: 1.60, 95% CI: 1.28, 2.00) and from LCL states that permit home cultivation (OR_{vaping}: 2.30, 95% CI: 1.88, 2.81; $OR_{edibles}$: 2.95, 95% CI: 2.38, 3.64, respectively) were more likely to have tried vaping and edibles. Youth from LCL states that permit home cultivation were approximately twice as likely to have tried edibles (but not vaping) than youth from LCLs that prohibit home cultivation (Table 4).

3.3.2 Age of Onset of Vaping and Edible Use

3.3.2.1 LCL vs. Non-LCL and LCL Duration: Youth from LCL states began vaping 1.7 months earlier (15.27 years vs. 15.41 years, $p<0.05$) and began using edibles 2.3 months earlier (14.83 years vs. 15.02 years, $p<0.01$) than youth from Non-LCL states. Youth from states in the ≥10 years LCL duration category began using edibles approximately 5 months earlier than youth from Non-LCL states (14.60 years vs. 15.02, $p<0.001$) and youth from states in the 0–5 year category (14.60 years vs. 15.02 years, $p<0.001$) (Table 5)

3.3.2.2 Dispensary Density: Youth from high dispensary density LCL states began vaping 2.2 months earlier (15.23 years vs. 15.41 years, $p<0.05$) and began using edibles 4.2 months earlier (14.67 years vs. 15.02 years, $p<0.001$) than youth from Non-LCL states (Table 5).

3.3.2.3 Medical-Only and Recreational: Youth from MCL-only states began using edibles 2.1 months earlier than youth from Non-LCL states (14.85 years vs. 15.02 years, $p<0.01$). Youth from RCL states began using edibles 3.1 months earlier than youth from Non-LCL states (14.76 years vs. 15.02 years, $p<0.01$) (Table 5).

3.3.2.4 LCL Home Cultivation Status: Youth from LCL states that permit HC began using edibles 3.7 months earlier than Non-LCL state youth (14.71 years vs. 15.02 years, $p<0.001$) and 3.6 months earlier than youth from LCL states that prohibit HC (14.71 years vs. 15.01 years, $p<0.001$) (Table 5).

4. Discussion

This study examined relations among specific provisions of LCL and cannabis vaping and use of edibles in youth ages 14–18. Consistent with our previous study of adult cannabis users recruited via Facebook, the present analyses indicated that longer LCL duration and higher dispensary density were related to a higher likelihood of lifetime vaping and edible use. The current study extended those findings by showing that provisions for recreational cannabis use and for permitting home cultivation were also related to a higher likelihood of

lifetime vaping and edible use. Some of these increased likelihoods were substantial. For example, living in a high dispensary density state doubled the likelihood of trying vaping and tripled the likelihood of trying edibles.

In contrast to the previous adult study, age of onset of edibles and vaping was related to certain LCL provisions. Specifically, among youth, longer LCL duration, higher dispensary density, medical and recreational cannabis laws, and permitting home cultivation of cannabis were associated with younger age of onset of edibles. Additionally, higher dispensary density was associated with younger age of onset of vaping. The different age of onset findings between the current sample and our previous adult sample may be due to youths' particular vulnerability to changes in cannabis norms that accompany cannabis legalization. However, in the present analyses, relatively small differences of between 2 to 5 months in age of onset of vaping and edibles, translated into statistically significant differences across LCL provisions because of the large sample size; the functional importance of this magnitude of difference is unclear.

We also observed multiple instances of results demonstrating a unique relationship between home cultivation provisions and edible use. First, only the LCL states that permit home cultivation were associated with younger and more probable use of edibles and not associated with vaping (Tables 4 and 5). Second, the LCL of states that prohibit dispensaries, and of states with ≥1 dispensary per 100,000 people, both permit home cultivation, but the majority of LCL of states with <1 dispensary per 100,000 people prohibit home cultivation. This seems to help explain why youth in states that prohibit dispensaries and in states with ≥1 dispensary per 100,000 people were both over three times more likely to have used edibles, while youth from states with <1 dispensary per 100,000 people were only slightly more likely to have used edibles. Notably, the odds ratio trend for likelihood of vaping across dispensary densities maintained a linear dose-response pattern (Table 4). One theory for the observed relationship between home cultivation and earlier and more probable initiation of use of edible (but not vaping) products is that adults may condense the low-THC "leftover" parts of the plants they grow, to extract enough THC to make edible products. This may make edible products more commonly used and available, potentially increasing the risk of diversion to youth.

The potential implications of the observed relationships between dispensary density, home cultivation, and methods of cannabis use warrant comment. Some data indicate that adolescents and young adults receive diverted legally-purchased cannabis (Boyd et al., 2015; Lankenau et al., 2017; Salomonsen-Sautel et al., 2012; Thurstone et al., 2011) despite qualifying medical condition or minimum purchase age (21 and up)(Hall and Lynskey, 2016) requirements. States that do not place limits on the number of medical or retail dispensaries permitted may experience a proliferation of dispensaries, and without strict oversight, vaping and edible products may also be directly sold to youth or diverted from adult users to youth users. To mitigate demand and diversion of these products to youth, regulatory strategies previously utilized for alcohol and tobacco products (Pacula et al., 2014b) should be considered, such as limiting product flavoring, packaging, and marketing that appeal to youth (Ashley and Backinger, 2012; Mosher and Johnsson, 2005) as well as regularly conducting dispensary compliance checks (Wagenaar et al., 2005). Similarly, LCL

provisions such as home cultivation may normalize household cannabis use and increase exposure, access, or diversion to youth making it more difficult for state governments to effectively prevent youth from engaging in cannabis use (Caulkins et al., 2012; Pacula et al., 2015) or cultivation (Bouchard et al., 2009). More generally, lack of effective control over patterns of access to cannabis products may elevate population levels of cannabis initiation and risks of problematic cannabis use among youth.

Facebook has been demonstrated to be a reliable and valid method for sampling young cannabis users (Ramo et al., 2012; Ramo and Prochaska, 2012), nonetheless several sampling related limitations of the present study should be considered. First, data were provided by a self-selected convenience sample of social media users. Cannabis-using youth sampled with other methods may respond differently. Second, our targeted sampling strategy identified potential respondents based on their online endorsement of cannabis culture-related topics. This is likely the reason that the present sample contained primarily regular, heavy cannabis users. Thus, the observed associations may not generalize to subgroups of light cannabis users or heavy users who do not affiliate themselves with cannabis culture-related topics online. Going forward, it will be important to investigate how different cannabis access models (e.g., home cultivation or dispensaries) impact patterns of cannabis use among these other subgroups. It is also important to note that our lifetime use outcome variable is only one of multiple ways of measuring the use of different methods of cannabis administration. Other, more fine-grained indices of current cannabis use behaviors, may uncover important relationships between LCL provisions and use of vaping and edible products not observed in the present study. Last, a substantial number of youth did not complete the survey. While those who did and did not complete the survey did not differ on multiple demographic and outcome variables, it is possible that unmeasured characteristics caused systematic attrition and may have limited the generalizability of the observed results. Despite these limitations, this study provided an examination of important associations between cannabis-related legalization provisions and cannabis use in a sample at high risk for future problems, a population that can be difficult to access via other research methodologies.

Study of other provisions of LCLs and their association with changes in population-level patterns of cannabis use may reveal additional findings with potentially significant public health implications. The effects of various provisions are not likely to occur in isolation, and thus it will be important to focus on separating the effects of LCL provisions that are designed to serve similar functions (e.g., dispensaries and home cultivation are both regulatory strategies for providing access to cannabis). By examining characteristics that pertain specifically to each access-related provision, it may be possible to untangle potential additive, synergistic, or offsetting effects of LCL provisions. For example, future research might investigate behavioral patterns of making edibles at home versus purchasing edibles in dispensaries. The present study provides a small sampling of the types of data that are needed to help guide policy decisions to effectively regulate legal cannabis. Social media is a potentially useful research tool for facilitating such study because it provides the ability to rapidly collect data on novel cannabis-legalization related questions not addressed by traditional survey methods.

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Highlights

- Online survey of cannabis vaping and edibles use among adolescent cannabis users
- Examined relationships between vaping, edible use, and legal cannabis laws (LCL)
- Allowing dispensaries predicts lifetime vaping (OR: 2.7) and edible use (OR: 3.3)
- Allowing home growing predicts lifetime vaping (OR: 2.3) and edible use (OR: 3.0)
- Facebook can facilitate measurement of the impact of cannabis legalization

Table 1

U.S. States with Medical or Recreational Cannabis Laws (May 2016)

State	Has MCL	MCL duration (years)	Has RCL	Permit home cultivation	Permit dispensary	# de jure operating dispensaries	U.S. Census Population (2015)	Dispensary per 100,000 people
AK	Yes	18	Yes	Yes	No	0	738,432	0.00
AZ	Yes	6	No	Yes	Yes	93	6,828,065	1.36
CA	Yes	20	No	Yes	Yes	1000–2000 *	39,144,818	2.55–5.11
CO	Yes	16	Yes	Yes	Yes	949	5,456,574	17.39
CT	Yes	4	No	No	Yes	6	3,590,886	0.17
DC	Yes	6	Yes	Yes	Yes	5	945,934	0.53
DE	Yes	5	No	No	Yes	1	672,228	0.15
HI	Yes	16	No	Yes	Yes	0	1,431,603	0.00
IL	Yes	3	No	No	Yes	36	12,859,995	0.28
ME	Yes	17	No	Yes	Yes	8	1,329,328	0.60
MD	Yes	2	No	No	Yes	0	6,006,401	0.00
MA	Yes	4	No	Yes	Yes	6	6,794,422	0.09
MI	Yes	8	No	Yes	No	0	9,922,576	0.00
MN	Yes	2	No	No	Yes	3	5,489,594	0.05
MT	Yes	12	No	Yes	No	0	1,032,949	0.00
NV	Yes	16	No	Yes	Yes	26	2,890,845	0.90
NH	Yes	3	No	No	Yes	0	1,330,608	0.00
NJ	Yes	6	No	No	Yes	6	8,958,013	0.07
NM	Yes	9	No	Yes	Yes	23	2,085,109	1.10
NY	Yes	2	No	No	Yes	17	19,795,791	0.09
OR	Yes	18	Yes	Yes	Yes	423	4,028,977	10.50
PA	Yes	0.1	No	No	Yes	0	12,802,503	0.00
RI	Yes	10	No	Yes	Yes	3	1,056,298	0.28
VT	Yes	12	No	Yes	Yes	4	626,042	0.64
WA	Yes	18	Yes	Yes	Yes	237	7,170,351	3.31

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* Range of estimates based on combination of multiple sources

MCL = Medical Cannabis Law, RCL = Recreational Cannabis Law

Table 2

Participant characteristics (n=2630)

		Legal Cannabis Law (LCL) Status	
	Overall Sample	**Non-LCL States (n=1178)**	**LCL States (n=1452)**
Age, m (SD)	16.36 (1.09)	16.35 (1.12)	16.37 (1.06)
Gender			
Male, n (%)	1201 (45.7)	523 (44.4)	678 (46.7)
Female, n (%)	1337 (50.8)	616 (52.3)	721 (49.7)
Trans, n (%)	49 (1.9)	20 (1.7)	29 (2.0)
Other, n (%)	43 (1.6)	19 (1.6)	24 (1.7)
Race and Ethnicity			
Caucasian, n (%)	2067 (78.6)	935 (79.4)	1132 (78.0)
African American, n (%)	89 (3.4)	47 (4.0)	42 (2.9)
Hispanic, n (%)	355 (13.5)	151 (12.8)	204 (14.1)
Other, n (%)	119 (4.5)	45 (3.8)	74 (5.1)
Level of Education *			
6th grade, n (%)	4 (0.2)	2 (0.2)	2 (0.1)
7th grade, n (%)	35 (1.3)	18 (1.5)	17 (1.2)
8th grade, n (%)	257 (9.8)	120 (10.2)	137 (9.4)
9th grade, n (%)	542 (20.6)	261 (22.2)	281 (19.4)
10th grade, n (%)	738 (28.1)	293 (24.9)	445 (30.7)
11th grade, n (%)	657 (25.0)	300 (25.5)	357 (24.6)
12th grade, n (%)	279 (10.6)	135 (11.5)	144 (9.9)
Started college, n (%)	118 (4.5)	49 (4.2)	69 (4.8)
Lifetime days cannabis use *			
Once, n (%)	60 (2.3)	36 (3.1)	24 (1.7)
2–5 days, n (%)	179 (6.8)	81 (6.9)	98 (6.8)
6–10 days, n (%)	139 (5.3)	66 (5.6)	73 (5.0)
11–30 days, n (%)	268 (10.2)	106 (9.0)	162 (11.2)
31–100 days, n (%)	337 (12.8)	131 (11.1)	206 (14.2)
101–365 days, n (%)	572 (21.8)	256 (21.7)	316 (21.8)
>365 days, n (%)	1075 (40.9)	502 (42.6)	573 (39.5)
Age first use cannabis, m (SD) *	13.71 (1.83)	13.57 (1.98)	13.83 (1.70)
Past month use, n (% yes)	2185 (83.1)	968 (82.7)	1217 (84.2)
Days used in past month, m (SD) †	16.7 (11.1)	17.0 (11.1)	16.4 (11.2)

* Analysis of differences for this variable comparing Non-LCL states vs. LCL states was significant ($p<0.05$)

† Among those who had used in the past month

Chi-squared and T-Tests used to calculate p values

Table 3

Comparisons of method of administration outcomes within each legal cannabis law (LCL) provision variable

LCL provision variables	% with lifetime vaping	% with lifetime edible use	Age onset vaping mean (sd)**	Age onset edible mean (sd)**	# states per category*
LCL Status					
No LCL	**35.6**	**52.0**	15.34 (1.70)	14.88 (1.73)	26
LCL	**50.8**	**67.8**	15.31 (1.38)	14.92 (1.60)	25
Duration of LCL					
No LCL	**35.6**	**52.0**	15.34 (1.70)	**14.88 (1.73)**	26
0–5 years	**48.1**	**60.7**	15.37 (1.34)	**15.27 (1.42)**	9
6–10 years	**45.4**	**64.7**	15.16 (1.70)	**14.90 (1.80)**	6
> 10 years	**56.5**	**77.7**	15.31 (1.30)	**14.60 (1.61)**	10
Dispensary (per 100k people)					
No LCL	**35.6**	**52.0**	15.34 (1.70)	**14.88 (1.73)**	26
LCL: prohibit dispensaries	**46.7**	**74.1**	15.38 (1.07)	**14.77 (1.80)**	3
< 1	**49.0**	**62.0**	15.34 (1.41)	**15.16 (1.54)**	16
≥ 1	**54.4**	**74.8**	15.26 (1.42)	**14.66 (1.57)**	6
MCL-Only vs. RCL Status ***					
No LCL	**35.6**	**52.0**	15.34 (1.70)	14.88 (1.73)	26
MCL-Only	**49.3**	**66.2**	15.33 (1.40)	14.97 (1.63)	20
RCL	**57.4**	**75.2**	15.24 (1.31)	14.73 (1.43)	5
Home cultivation (HC)					
No LCL	**35.6**	**52.0**	15.34 (1.70)	**14.88 (1.73)**	26
LCL: prohibits HC	**48.4**	**60.2**	15.33 (1.47)	**15.25 (1.54)**	9
LCL: permits HC	**52.5**	**73.3**	15.30 (1.33)	**14.72 (1.60)**	16

Bold numbers = significant difference ($p<0.05$) in outcome (e.g., % lifetime use of vaping) when compared across categories of an LCL provision variable (No LCL vs. LCL that prohibits HC vs. LCL that permits HC)

Chi-squared tests used for % with lifetime method use analyses, T-tests and ANOVA used for age onset analyses

*Washington DC counted as a state

**Among lifetime users of that method

***MCL = Medical cannabis law, RCL = Recreational cannabis law

Table 4

Adjusted logistic regressions: likelihood of lifetime use of alternate method of administration (vaping and edibles) across legal cannabis law (LCL) provisions*

	Ever Vaped Cannabis	Ever Used Cannabis Edibles
	OR (95% CI)	**OR (95% CI)**
LCL Status		
No LCL	ref	ref
LCL	**2.14 (1.80, 2.55)**	**2.24 (1.88, 2.68)**
Duration of LCL		
No LCL	ref	ref
0–5 years	**1.91 (1.54, 2.37)**	**1.63 (1.32, 2.03)**
6–10 years	**1.61 (1.19, 2.17)**	**1.88 (1.38, 2.57)**
>10 years	**2.82 (2.24, 3.55)**	**3.82 (2.96, 4.94)**
Duration of LCL		
0–5 years	ref	ref
6–10 years	0.84 (0.61, 1.17)	1.21 (0.86,1.70)
>10 years	**1.52 (1.18, 1.96)**	**2.48 (1.86, 3.31)**
Dispensary (per 100k people)		
No LCL	ref	ref
LCL: prohibit dispensaries	**1.59 (1.08, 2.35)**	**3.15 (2.03, 4.88)**
< 1	**1.96 (1.60, 2.40)**	**1.69 (1.38, 2.07)**
≥ 1	**2.68 (2.12, 3.38)**	**3.31 (2.56, 4.26)**
Dispensary (per 100k people)		
LCL: prohibit dispensaries	ref	ref
< 1	1.24 (0.83,1.85)	**0.53 (0.33, 0.83)**
≥ 1	**1.76 (1.15, 2.69)**	1.11 (0.69, 1.80)
MCL-Only vs. RCL Status**		
No LCL	ref	ref
MCL-Only	**1.98 (1.65, 2.38)**	**2.05 (1.70, 2.46)**
RCL	**3.13 (2.30, 4.24)**	**3.57 (2.55, 5.01)**
MCL-Only vs. RCL Status		
MCL-Only	ref	ref
RCL	**1.59 (1.17, 2.15)**	**1.78 (1.26, 2.51)**
Home cultivation (HC)		
No LCL	ref	ref
LCL: prohibits HC	**1.95 (1.56, 2.43)**	**1.60 (1.28, 2.00)**
LCL: permits HC	**2.30 (1.88, 2.81)**	**2.95 (2.38, 3.64)**

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	Ever Vaped Cannabis	Ever Used Cannabis Edibles
	OR (95% CI)	**OR (95% CI)**
Home cultivation (HC)		
LCL: prohibits HC	ref	ref
LCL: permits HC	1.20 (0.95,1.52)	**1.93 (1.50, 2.48)**

Bolded odds ratios = statistical significance ($p<0.05$)

*All models adjusted for age, race, gender, education, age onset of cannabis use, and lifetime days of cannabis use

**MCL = Medical cannabis law, RCL = Recreational cannabis law

Table 5

Adjusted linear regression coefficients and adjusted mean age of onset of vaping and edibles across legal cannabis law (LCL) provisions *

	Age Onset Vaping		Age Onset Edible	
	β Coeff (95% CI)	**Mean Age Onset ***	**β Coeff (95% CI)**	**Mean Age Onset ***
LCL Status				
No LCL	ref	15.41	ref	15.02
LCL	**−0.14 (−0.28, −0.006)**	15.27	**−0.19 (−0.31, −0.07)**	14.83
Duration of LCL				
No LCL	ref	15.41	ref	15.02
0–5 years	−0.12 (−0.29, 0.04)	15.29	0.02 (−0.14, 0.17)	15.04
6–10 years	−0.19 (−0.41, 0.04)	15.23	−0.10 (−0.3, 0.10)	14.92
>10 years	−0.14 (−0.31, 0.02)	15.27	**−0.42 (−0.57, −0.27)**	14.60
Duration of LCL				
0–5 years	ref	15.29	ref	15.02
6–10 years	−0.06 (−0.28, 0.16)	15.23	−0.09 (−0.3, 0.11)	14.93
>10 years	−0.02 (−0.19, 0.15)	15.27	**−0.43 (−0.59, −0.27)**	14.60
Dispensary (per 100k people)				
No LCL	ref	15.41	ref	15.02
LCL: prohibit dispensaries	0.08 (−0.22, 0.37)	15.48	−0.24 (−0.49, 0.01)	14.78
< 1	−0.15 (−0.31, 0.004)	15.26	−0.05 (−0.19, 0.09)	14.97
≥ 1	**−0.18 (−0.35, −0.01)**	15.23	**−0.35 (−0.5, −0.2)**	14.67
Dispensary (per 100k people)				
LCL: prohibit dispensaries	ref	15.49	ref	14.78
< 1	−0.22 (−0.5, 0.06)	15.27	0.18 (−0.07, 0.42)	14.96
≥ 1	−0.26 (−0.55, 0.02)	15.22	−0.12 (−0.37, 0.13)	14.67
MCL-Only vs. RCL Status **				
No LCL	ref	15.41	ref	15.02
Only MCL	−0.14 (−0.28, 0.004)	15.28	**−0.17 (−0.3, −0.05)**	14.85
RCL	−0.16 (−0.38, 0.05)	15.25	**−0.26 (−0.46, −0.07)**	14.76
MCL-Only vs. RCL Status				
Only MCL	ref	15.28	ref	14.84
RCL	−0.04 (−0.23, 0.15)	15.24	−0.09 (−0.27, 0.09)	14.76
Home cultivation (HC)				
No LCL	ref	15.41	ref	15.02
LCL: prohibits HC	−0.15 (−0.31, 0.02)	15.26	0.01 (−0.15, 0.16)	15.03
LCL: permits HC	−0.14 (−0.29, 0.01)	15.27	**−0.31 (−0.44, −0.17)**	14.71

	Age Onset Vaping		Age Onset Edible	
	β Coeff (95% CI)	**Mean Age Onset***	**β Coeff (95% CI)**	**Mean Age Onset***
Home cultivation (HC)				
LCL: prohibits HC	ref	15.26	ref	15.01
LCL: permits HC	0.01 (−0.14, 0.17)	15.27	**−0.30 (−0.45, −0.15)**	14.71

Bolded β coefficients = significant ($p<0.05$)

*Adjusted for age, race, gender, education, age onset of cannabis use, and lifetime days of cannabis use

**MCL = Medical cannabis law, RCL = Recreational cannabis law

Note: some adjusted mean age estimates change slightly due to inclusion/exclusion of Non-LCL states in the model