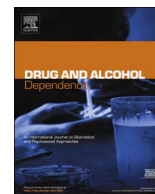




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U.S. cannabis legalization and use of vaping and edible products among youth

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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, 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.

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).

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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 ^a	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

MCL = Medical Cannabis Law, RCL = Recreational Cannabis Law.

^a Range of estimates based on combination of multiple sources.

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 to 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; Seigny 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

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