*Cannabis*
2022, Volume 5 (3)

researchmj.org
DOI: 10.26828/cannabis/2022.03.004

# Adolescent Cannabis Use Among Youth in ZIP Codes with Medical Dispensaries

**Douglas C. Smith[1], Shahana Begum[1], Allison A. Carrington[1], Corey C. Campbell[1], Shaneil E. Taylor[1], Crystal A. Reinhart[1], James A. Swartz[2]**

[1]University of Illinois Urbana-Champaign, School of Social Work
[2]University of Illinois Chicago

## ABSTRACT

**Introduction.** In the United States, 19 states permit recreational use of cannabis, with 16 more permitting medical use (Marijuana Policy Project, 2021). Concerns remain about whether liberalized policies result in increased adolescent cannabis use. To date, limited evidence exists that the statewide prevalence of adolescent cannabis use increased in states with liberalized policies. However, analyses at local levels show some negative impacts. Thus, we analyzed if living in a ZIP code with a dispensary (ZCWD) was associated with adolescent cannabis use. **Methods.** Dispensary ZIP codes from public records were matched to self-reported ZIP codes on the Illinois Youth Survey (IYS). We compared past 30-day and past-year cannabis use among youth living in a ZCWD and not living in a ZCWD. **Results.** About one in eight adolescents (12.8%, n = 1,348) in the weighted sample (n=10,569) resided in a ZCWD. Overall, past 30-day use was lower among youth who lived in ZIP codes with dispensaries (OR = .69, $p < .05$), with variation by grade. For example, only 10th (OR = .62, $p < .05$) and 12th graders (OR = .59, $p < .05$) living in a ZCWD had lower odds of past 30-day cannabis use. Additionally, only 12th graders in a ZCWD had lower odds of past-year use (OR = .70, $p < .05$). Finally, suburban youth living in a ZCWD also had lower odds of cannabis use (OR = .54, $p < .01$). **Conclusion/Discussion.** Cannabis use was significantly lower among 10th and 12th graders living in a ZCWD. Additional research should continue to monitor evolving state policies and whether they are associated with adolescent cannabis use.

**Key words**: = adolescent; cannabis; marijuana dispensaries; epidemiology

Adolescent cannabis use represents a significant health issue, especially when high-frequency use (e.g., daily or multiple times per week) evolves into chronic use. Associated physiological and behavioral effects that adversely affect health outcomes include impaired short-term memory, motor coordination, and judgement (Volkow et al., 2014). Chronic, frequent use also increases the risk for deviant and risky behaviors, such as driving under the influence, unprotected sex, poor educational attainment, mental illness, and addiction (Moss et al., 2019). These behaviors have severe individual and community consequences, including poorer health outcomes, involvement with the criminal justice system, and economic impacts.

Given the behavioral sequelae of adolescents' heavy cannabis use, there is substantial interest in monitoring whether teen cannabis use increases due to its increasing legality. Nationally, however, there have not been major shifts in adolescent cannabis use in the United States despite a number of states adopting liberalized policies. Among adolescents aged 12 to 17, the percentage of past-year cannabis users decreased from 15.8% (or 3.9 million people) in 2002 to 13.2% (or 3.3 million people) in 2019. The 2019 estimate was lower than that for 2002-2004, but was similar to years 2005-2018. Approximately 1.4 million people initiated cannabis use in the past year, comparable to estimates from 2002-2018 (NSDUH, 2020). On average, about 3,700

Corresponding Author: Douglas C. Smith, Ph.D., University of Illinois Urbana-Champaign, 1010 W. Nevada St., Urbana, IL 61801, Office 2119. Phone: (217) 333-5308. Email: smithdc@illinois.edu

adolescents per day initiated cannabis use for the first time in 2019. Among adolescents in Illinois, the location of this study, past-month and past-year cannabis use among 8th, 10th, and 12th graders held steady from 2012 to 2018 (see Figure 1).

### *Why Dispensary Proliferation May Impact Adolescent Substance Use*

Two potential drivers of adolescent substance use are ease of access and perceived harmfulness. It is plausible that living in ZIP codes with medical cannabis dispensaries (ZCWD) influences these two drivers.

*Ease of access.* Access to cannabis may increase due to an elevated supply once dispensaries open. Cannabis has been accessible to high school students since the 1970s, with 80-90% of 12th graders reporting that cannabis was fairly easy or very easy to access (Johnston et al., 2010). Younger adolescents have less access to cannabis, with only 40% of 8th graders responding that it is fairly easy or very easy to obtain. With the passing of medical and recreational cannabis laws (MMLs and RMLs, respectively), adolescent access may actually decline due to difficulties obtaining cannabis through dispensaries instead of drug dealers. That is, if legalized and regulated, it may be riskier to sell to adolescents (Anderson & Rees, 2014).

Thus, the presence of a legal market could plausibly increase or decrease supplies to adolescents. Adolescents may have more access to illicit markets, which have no age restrictions on purchases. Conversely, if excess competition from dispensaries decreases the size of the illicit market, adolescents may ultimately have less access. Ease of access could also increase due to diversion of cannabis purchased by adults at dispensaries.

Regarding diversion, adolescents obtain cannabis from dispensaries, dealers, friends, family members, and strangers (Reed et al., 2020). King and colleagues (2016) found that 59% of adolescents obtained cannabis free of charge, whereas 39% purchased cannabis. Whether they paid for it or not, most adolescents receive cannabis from friends (King et al., 2016). Existing self-report measures do not capture diversion from dispensaries very well. Notably, however, Kelleghan and colleagues (2022) found that adolescents who purchased cannabis from family members, friends, or a medical dispensary exhibited a higher frequency of use. Therefore, it is important to determine whether MMLs increase diversion, and in turn, increase adolescents' use of cannabis.

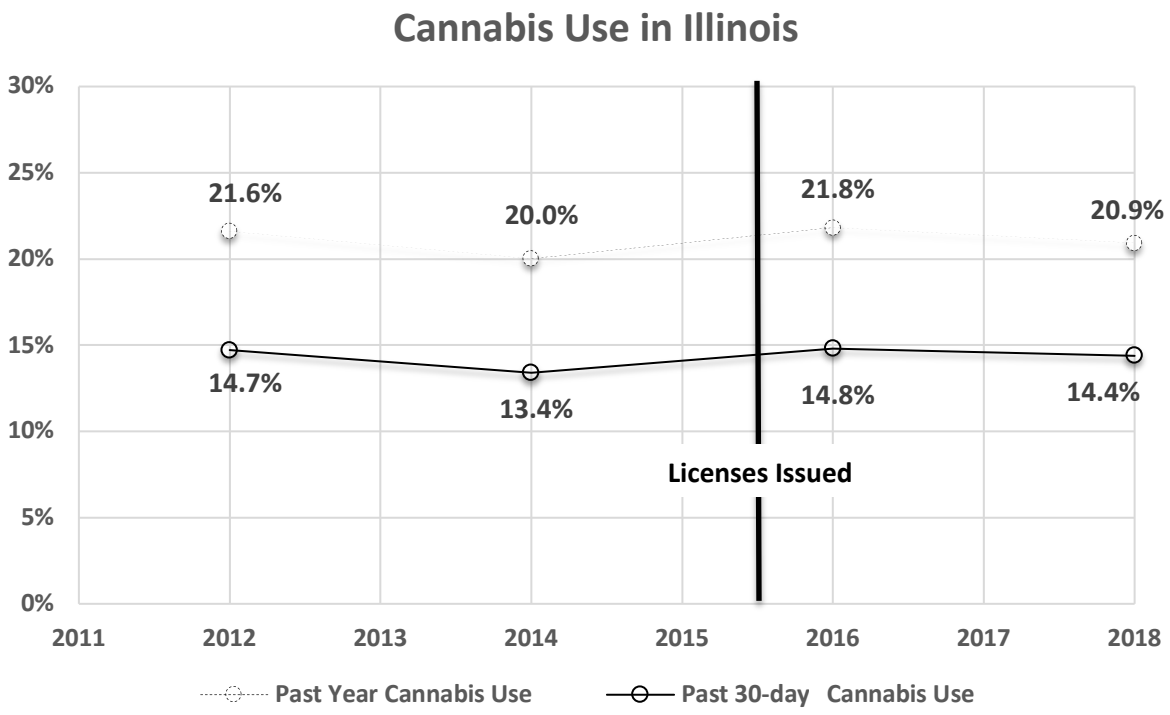
*Perceived harm.* The presence of dispensaries may also lower perceived harmfulness of cannabis among adolescents. Monitoring trends in perceived harmfulness is important, as it is negatively associated with adolescent cannabis use (Bachman et al., 1998; Johnston, O'Malley et al., 2010). However, Keyes and colleagues (2016) showed that perceived harmfulness increased and cannabis use decreased after the passage of MMLs. Perceived harmfulness generally declined with the passage of MMLs among older adolescents. Among states with recreational cannabis laws, Cerdá and colleagues (2017) found that 8th and 10th graders in the State of Washington had decreased levels of perceived harmfulness and increased use after the passage of RMLs. However, findings did not replicate in Colorado, another early adopter of legalized recreational use.

### *Cannabis Outlet Density and Adolescent Use*

Alcohol and tobacco retail outlet density, as well as residential proximity to outlets, are positively associated with the initiation of use of these substances, heavier and more problematic use, and more difficulty quitting (Cantrell et al., 2016; Chen et al., 2009; Kuntsche et al., 2008; Pacula et al., 2014; Reitzel et al., 2011; Scribner et al., 2000). Similar relationships emerged in the early cannabis policy literature, although the results are mixed.

Mair and colleagues (2015) found positive associations between medical dispensary density and cannabis hospitalizations, as well as poorer health outcomes among disadvantaged communities. More medical cannabis dispensaries per square mile also predicted more frequent cannabis use (Freisthler & Gruenewald, 2014) and higher Cannabis Use Disorder (CUD)-related hospitalizations (Mair et al., 2015). Last, a greater number of medical dispensaries per capita predicted early onset cannabis use, vaping, and the use of edible products (Borodovsky et al., 2016; Borodovsky et al., 2017).

Figure 1. *Prevalence of Adolescent Cannabis Use in Illinois: 2012-2018*




Source (Illinois Youth Survey 2012-2018)

*Note.* 2018 prevalence differs from analytic sample due to missing ZIP code data.

Another study showed that intentions to use did not increase in areas with higher medical cannabis dispensary density, but results differed among racial/ethnic groups (Shih et al., 2021.) Specifically, only Whites and Asians had higher intentions to use if living in proximity to more medical dispensaries. A slightly different picture emerged for recreational outlets. That is, Pedersen and colleagues (2020) found recreational dispensary density in LA County to be positively associated with intentions to use, any use, and heavy use of cannabis. However, these studies are limited to the California context and focus on young adults rather than adolescents. Young adults and adolescents are distinct populations known to differ on motivation to change (Smith et al., 2010) and treatment outcomes (Smith, et al., 2011).

*Density versus Living in a ZIP Code with a Dispensary (ZCWD).* Studies on density are useful for capturing changes in adolescent use once extensive dispensary proliferation has occurred. In this study, however, we measure the effect of living in a ZIP code with a medical dispensary (ZCWD) prior to the existence of a large legal market. This allows for understanding the effects of early implementation of MML, after dispensaries were operational yet prior to an extensive network of dispensaries forming. By using ZIP codes we obtain more precise estimates of adolescent cannabis use at the local (vs. state) level. This is important because state-level estimates may not capture local differences in prevalence possibly attributable to living in a ZCWD.

*MMLs and Adolescent Cannabis Use*

Several statewide and national surveys have measured cannabis use among adolescents both pre- and post-passage of MMLs and RMLs. Additional research is needed due to variation in policies across the states (Cambron et al., 2017).

Although cannabis use is higher among adolescents in MML states, the risk for using does not appear to increase after the passage of MMLs (Hasin et al., 2015). Sarvet and colleagues (2018) conducted a meta-analysis to assess the effect of MMLs on past-month adolescent cannabis use, finding no significant changes compared to non-MML states. In fact, four of the 11 studies

included found higher rates of past-month use in MML states prior to passage. This is consistent with other studies (Wall et al., 2011; Lynne-Landsman et al., 2013; Martins et al., 2016). Also, Choo and colleagues (2014) paired MML states in the Northeastern US with neighboring non-MML states and found no increase in use. Finally, states with MMLs have more treatment admissions for youth cannabis use compared to medical cannabis states that do not legally protect dispensaries (Pacuel et al., 2015). To our knowledge, no existing study has focused exclusively on a Midwestern state in the United States that has implemented an MML.

### *Purpose of Study*

Because of the changing policy landscape, additional research should shed light on whether living in a ZCWD influences adolescent cannabis use. Much of the early research on cannabis outlet density is from California and other Western states. Thus, this study in a Midwestern state could yield insights into the associations between living in a ZCWD and adolescent cannabis use earlier on in the process of dispensary proliferation. Such data could increase the generalizability of the findings on whether living in a ZCWD influences adolescent cannabis use.

## METHODS

### *Survey Data and Sampling Procedure*

This study used data from the 2018 Illinois Youth Survey (IYS), a self-report biennial survey administered to adolescents in 8th, 10th, and 12th grades. Survey questions asked about a variety of health and social issues. While all schools can voluntarily participate, the survey contractor (the Center for Prevention Research and Development) generates a random sample for each administration. In 2018, all public schools with at least 16 students in 8th, 10th, and 12th grades were included in the sampling frame. The IYS uses a stratified two-stage cluster sampling design with selection based on probability proportional to grade level enrollment size (PPS). First, schools were stratified by four regions and three grade levels. Afterward, schools were selected within each region and grade using PPS to ensure an adequately represented student population within each stratum. Students were surveyed between January and June 2018. After receiving surveys back and validating data, 50 surveys were selected randomly from each participating school within each region and grade to finalize the cluster sampling design.

The state sample is weighted to balance different probabilities of selection at each stage of sampling. Additionally, the weighted sample accounts for student absenteeism, which is associated with substance use (Gakh et al., 2020). Thus, adolescents reporting more absences received larger weights. Furthermore, a post-stratification weight was assigned to adjust for any racial, gender, and socioeconomic differences between the sample and the sampling frame. The final sample included 11,259 surveys from 162 schools statewide.

### *Measures*

*Cannabis dispensary data.* On August 1, 2013, Illinois passed the Compassionate Use of Medical Cannabis Act (PA 098-0122), legalizing the use of medical cannabis and allowing patients to apply for a Medical Cannabis Registry Card (Illinois Department of Public Health, 2021). Illinois began approving licenses for medical cannabis dispensaries in August 2015. There were 20 licenses approved in 2015, 29 in 2016, four in 2017, and two approved through July in 2018. We obtained a list of dispensaries with their exact locations and license dates from the Illinois Department of Public Health. Furthermore, we obtained sales data from the Illinois Department of Professional Regulation (IDFPR) to determine when sales began. Fifty-three of the approved dispensaries were operational in advance of the 2018 IYS survey administration. The minimum length of operation prior to IYS data collection was 6 months (range: 6 months to 3 years). At the time of this study, no ZIP code housed more than one dispensary.

*Participant ZIP codes.* Participants' self-reported ZIP codes served as a measure of living in a ZCWD. We matched ZIP codes reported on the survey to those known to have an operational cannabis dispensary before the time of the study. If a participant's ZIP code was the same as the ZIP code of a dispensary, they were coded as living in a "ZCWD." If there was not a match between the

participant's ZIP code and the dispensary ZIP codes, they were coded as "not living in a ZCWD."

*Cannabis use.* Two questions on the IYS measured cannabis use. One asked *"On how many occasions (if any) have you used marijuana during the past 30 days?"* The second was "*In the past year, on how many occasions (if any) have you used marijuana?*" Response choices ranged from "0 occasions" to "20 or more occasions." Data were highly skewed toward "0 occasions." Thus, responses were dichotomized as "never used" or "ever used."

### *Statistical Analysis*

Among 11,259 statewide surveys, 690 (6%) left their ZIP code blank. So, the analytic sample included 10,569 surveys containing 536 self-reported student ZIP codes. All analyses used the statistical software packages Stata version 15 and SPSS v28.

*Preliminary analyses.* To examine adolescents' characteristics across their ZCWD status, $\chi^2$ tests of independence and Univariate ANOVAs were used (Table 1). For continuous demographic variables, (i.e., age) we used adjusted Wald tests (Koch et al., 1975).

We considered whether ZIP code size may influence participants' awareness of dispensaries, and in turn, affect substance use. For example, students living in large ZIP codes may not be as aware of the presence of a dispensary. The average area within a ZIP code was approximately 32.54 square miles (SD =37.02). The average land area was smaller, albeit non-significantly, for ZCWD (M = 23.77, SD = 39.49) relative to ZIP codes with no dispensaries (M = 33.26, SD = 36.77, $p > .10$). Moreover, there was no significant correlation between ZIP code size and adolescent cannabis use in the past 30 days ($p = -0.08$) and past year ($p = -0.05$).

*Main analyses.* We used multivariate logistic regression to test if living in a ZCWD was associated with adolescent cannabis use. We completed one analysis collapsed across all grades and regions (Row 1 of Table 3) and then ran separate models for each grade level and geographic region. These models controlled for gender, race, free/reduced lunch status, and ZIP code size. The exponential function of the regression coefficient is the odds ratio reported in Table 3. Odds ratios with values above one indicated higher odds of cannabis use, and conversely those lower than one indicated lower odds of use.

## RESULTS

### *Respondent Characteristics*

Table 1 displays adolescents' characteristics in the final analytic sample by ZCWD status. Approximately one in eight of the participants (12.8%) lived in a ZCWD (Table 1). Overall, more than half of the adolescents were White (53.4%) followed by Latino/Latina (16.9%). The majority of adolescents were from suburban Chicago (46.8%), received free or reduced-price lunch (51.7%), and were female (51.4%). The average age of participants was 15.7. The sample had more 10th graders versus 8th or 12th graders.

Among the 12.8% of participants living in a ZCWD, 49.7% were from Suburban Chicago, 31.8% were from Chicago, 15% were from other urban areas, and 3.5% resided in rural areas (Table 1). The majority self-identified as White (43%), followed by Latino/Latina (26%). There were more 8th graders (39.2%) and more females (50.5%) living in a ZCWD.

Table 1 also shows demographic characteristics between respondents living in a ZCWD and those not living in such ZIP codes. Significantly more Latinos (26%) and fewer Whites (43%) lived in a ZCWD versus a ZIP code without a dispensary. Also, significantly more 8th graders and less 10th and 12th graders were living in a ZCWD. Finally, a significantly larger number of youth from Chicago (31.8%) and a smaller number of youth from rural (3.5%) areas lived in a ZCWD.

Overall, 15.2% reported cannabis use in the past 30 days, which was lower for youth living in a ZCWD (12.0%) versus those outside of such ZIP codes (15.6%; See Table 2). Regarding past-year use, the overall prevalence was 21.9% in the total sample, and lower (18.3%) in ZCWD versus those with no dispensaries (22.4%). Table 2 also shows the typical age-related trend for cannabis use, where prevalence rates significantly increase as adolescents move from 8th grade to 12th grade ($p < .001$) independent of whether they live in a ZCWD. Finally, cannabis use prevalence was significantly higher in Chicago compared to other geographic areas ($p < .001$).

Table 1. *Respondent Characteristic in the Statewide Sample and Among the Proximity Status*

| Variable | Sample n (%) | Living in a ZCWD n (%) | Not living in a ZCWD n (%) | *p* |
|---|---|---|---|---|
| **All** | 10,569 | 1,348 (12.8%) | 9,221 (87.2%) | |
| Gender | | | | |
| Female | 5,426 (51.4%) | 680 (50.5%) | 4,746 (51.6%) | >.10 |
| Male | 4,941 (46.8%) | 635 (47.2%) | 4,306 (46.8%) | |
| Transgender | 61 (0.58%) | 11 (0.8%) | 50 (0.5%) | |
| Do not identify | 121 (1.2%) | 20 (1.5%) | 101 (1.1%) | |
| Race | | | | |
| White | 5,617 (53.4%) | 579 (43.0%) | 5,038 (54.6%) | <.001 |
| Black/African American | 1,271 (12.1%) | 177 (13.1%) | 1,094 (11.9%) | |
| Latino/Latina | 1,785 (16.9%) | 351 (26.0%) | 1,434 (15.6%) | |
| Asian American | 543 (5.2%) | 79 (5.9%) | 464 (5.0%) | |
| Any Other | 1,307 (12.4%) | 160 (11.9%) | 1,147 (12.4%) | |
| Age (n, mean) | 10,559 (15.7) | 1,348 (15.4) | 9,211 (15.7) | >.10 |
| Grade | | | | |
| 8th | 3,234 (30.6%) | 529 (39.2%) | 2,705 (29.3%) | <.001 |
| 10th | 3,884 (36.7%) | 439 (32.6%) | 3,445 (37.4%) | |
| 12th | 3,451 (32.6%) | 380 (28.2%) | 3,071 (33.3%) | |
| Free/reduced lunch | | | | |
| Free lunch | 4,707 (45%) | 648 (48.6%) | 4,059 (44.4%) | >.10 |
| Reduced price lunch | 704 (6.7%) | 77 (5.8%) | 627 (6.9%) | |
| Neither | 5,056 (48.3%) | 608 (45.6%) | 4,448 (48.7%) | |
| Region | | | | |
| Suburban Chicago | 4,944 (46.8%) | 670 (49.7%) | 4,274 (46.4%) | <.001 |
| Chicago | 1,532 (14.5%) | 429 (31.8%) | 1,103 (12.0%) | |
| Other Urban | 2,131 (20.2%) | 202 (15.0%) | 1,929 (20.9%) | |
| Rural | 1,962 (18.5%) | 47 (3.5%) | 1,915 (20.8%) | |

*Note.* ZCWD – ZIP code with a medical dispensary

Table 2. *Past 30-Day and Past Year Cannabis Use in the Sample and by ZIP Code Status*

| **Cannabis Use** | Sample n (%) | Living in a ZCWD n (%) | Not living in a ZCWD n (%) |
|---|---|---|---|
| **Past 30-day Use** | **1,561 (15.2%)** | **157 (12.0%)** | **1,404 (15.6%)** |
| **Grade Level** | | | |
| 8th grade | 186 (5.5%)* | 41 (6.6%) | 146 (5.2%) |
| 10th grade | 478 (13.4%)* | 42 (10.6%) | 436 (13.7%) |
| 12th grade | 849 (25.7%)* | 77 (20.1%) | 772 (26.4%) |
| **Geographic Level** | | | |
| Suburban Chicago | 766 (13.5%) | 68 (8.2%) | 698 (14.4%) |
| Chicago | 293 (20.9%)* | 69 (17.7%) | 225 (22.1%) |
| Other Urban Areas | 322 (15.2%) | 20 (12.4%) | 302 (15.5%) |
| Rural Areas | 132 (11.8%) | 3 (11.7%) | 129 (11.8%) |
| **Past Year Use** | **2,249 (21.9%)** | **239 (18.3%)** | **2,010 (22.4%)** |
| **Grade Level** | | | |
| 8th grade | 292 (8.6%)* | 58 (9.7%) | 233 (8.4%) |
| 10th grade | 716 (19.9%)* | 68 (16.9%) | 648 (20.3%) |
| 12th grade | 1,172 (35.5%)* | 119 (30.9%) | 1,052 (36.1%) |
| **Geographic Level** | | | |
| Suburban Chicago | 1097 (19.4) | 123 (15%) | 975 (20.1%) |
| Chicago | 402 (28.7%)* | 94 (24.2%) | 308 (30.3%) |
| Other Urban Areas | 458 (21.9%) | 25 (15.7%) | 433 (22.4%) |
| Rural Areas | 222 (19.9%) | 4 (16.1%) | 218 (20%) |

*Note.* ZCWD-ZIP code with a medical dispensary. *$p < .001$

*Association Between Living in a ZIP Code with a Dispensary (ZCWD) and Cannabis Use*

Table 3 summarizes the logistic regression models, including sample sizes (n), adjusted odds ratio (OR), 95% confidence interval (CI), and *p* values. Overall, adolescents living in a ZCWD had significantly lower odds of past-30-day cannabis use than those not living in one (OR = 0.69, 95% CI: 0.51 – 0.95, $p < .05$). However, there were no significant differences in past-year cannabis use (OR=0.79, 95% CI: 0.61 – 1.02, p > 0.10).

Because cannabis use increases with age and significantly varies between grade levels ($p < .001$), we ran additional models for each grade level (8th, 10th, and 12th). Living in a ZCWD was not associated with past-30-day cannabis use for 8th graders. However, 10th (OR = 0.62, 95% CI: 0.39 – 0.96) and 12th graders (OR = 0.59, 95% CI: 0.42 – 0.83, $p < .05$) living in a ZCWD had significantly lower odds of past-30-day cannabis use. For past-year use, living in a ZCWD was not associated with cannabis use for 8th and 10th graders. However, our analyses found significantly lower odds of past-year cannabis use among 12th graders living in a ZCWD (OR = 0.70, 95% CI: 0.51 – 0.98, $p < .05$).

When considering geographic areas, suburban adolescents living in a ZCWD had significantly lower cannabis use in the past month compared to those not living in proximity (OR = 0.54, 95% CI: 0.38 to 0.78, $p < .001$). In other geographic regions, there were no differences in cannabis use based on living in a ZCWD.

## DISCUSSION

As cannabis policies evolve, it remains important to track trends in adolescent cannabis use. This study on living in a ZCWD and adolescent cannabis use adds to the existing literature due to its careful timing within 3 years after medical cannabis dispensaries were operational. For example, prior national research on the association between cannabis use and MMLs through 2014 (Hasin et al., 2015) included Illinois but before any of Illinois' dispensaries were operational. This study also showed the association of adolescent cannabis use and the presence of a dispensary at the ZIP code level, which may be more precise than taking a state average for cannabis prevalence, as done in national studies.

Consistent with the literature, cannabis use increased with age. However, adjusted models, collapsed across grade level, revealed lower odds of past-30-day cannabis use among those living in a ZCWD. Additionally, 10th and 12th graders living in a ZCWD had significantly lower rates of past-30-day cannabis use. These findings suggest that in 2018, when 53 dispensaries were selling cannabis for medical purposes, there was a negative association between living in a ZIP code with medical dispensaries and adolescent cannabis use. Although we did not test moderators, it is possible that these findings reflect the already high level of access to cannabis use among 10th and 12th graders prior to the opening of medical dispensaries. As noted, one

Table 3. *Associations Between Living in a ZIP Code with a Medical Dispensary (ZCWD) and Adolescent Cannabis Use*

| Variable | Past 30-day Cannabis Use[a] | | Past year Cannabis Use[a] | |
|---|---|---|---|---|
| | n | AOR (95% CI) | n | AOR (95% CI) |
| **Living in a ZCWD** | 9,920 | 0.69 (0.51 - 0.95)* | 9,900 | 0.79 (0.61 - 1.02) |
| **Grade Level** | | | | |
| 8th graders in a ZCWD | 3,043 | 1.11 (0.40 - 3.05) | 3,021 | 1.05 (0.52 - 2.12) |
| 10th graders in a ZCWD | 3,631 | 0.62 (0.39 - 0.96)* | 3,633 | 0.73 (0.52 - 1.04) |
| 12th graders in a ZCWD | 3,254 | 0.59 (0.42 - 0.83)* | 3,253 | 0.70 (0.51 - 0.98)* |
| **Geographic Region** | | | | |
| In a ZCWD /Suburban Chicago | 4,655 | 0.54 (0.38 - 0.78)** | 4,659 | 0.76 (0.56 - 1.04) |
| In a ZCWD /Chicago | 1,418 | 0.81 (0.46 - 1.41) | 1,415 | 0.85 (0.52 - 1.38) |
| In a ZCWD /Other Urban | 1,985 | 0.75 (0.46 - 1.23) | 1,970 | 0.67 (0.39 - 1.14) |
| In a ZCWD /Rural | 1,870 | 0.71 (.24 – 2.09) | 1,863 | 0.62 (0.14 – 2.65) |

*Note.* [a]Adjusted Odds Ratio. Analyses controlled gender, race, free/reduced lunch, grade, region, and ZIP code size; ZCWD: ZIP code with a medical dispensary. *$p < .05$, **$p \leq .001$.

robust annual trend is that 80-90% of 12th grade students in the Monitoring the Future study report that obtaining cannabis is fairly or very easy (Johnston et al., 2010). Thus, their already high access to cannabis may not have increased when medical dispensaries started operating in Illinois. Yet, we caution readers that this access could change once more dispensaries open, as this study's findings apply specifically to the time when just over 50 medical dispensaries existed.

These findings are similar to those reported in Hasin et al. (2015). However, in our study we found significantly less use among 12th graders living in a ZCWD. Further, Hasin and colleagues found that 8th graders in MML states had significantly lower use, and we found no significant differences in use between 8th graders who did or did not live in a ZCWD. Because early onset of cannabis use is associated with negative outcomes (Lynskey et al., 2003), additional attention to trends in 8th grade cannabis use is recommended.

It is likely that the number of dispensaries will continue to grow over time. Illinois legalized the recreational use of cannabis in January 2020. Thus, the associations reported in this study are from just a snapshot in time when there were 53 operational medical dispensaries and two that were approved but not operational. By contrast, there were approximately 900 dispensaries in Los Angeles County alone at the time of Pedersen et al.'s (2020) study. This was due to the longer legacy of medical cannabis in California. Future research in Illinois may consider using sales data or density of dispensaries within ZIP codes as more dispensaries become operational.

Notwithstanding the challenges, tracking longitudinal trends in cannabis use and the proliferation of dispensaries is also important. Regrettably, one research challenge with Illinois data will be that the implementation of recreational use in Illinois (January 2020) corresponded closely with the onset of the global COVID-19 pandemic (March 2020). The pandemic likely affected both surveillance methodology and substance use trends. Nationally, past-year cannabis use decreased among adolescents ages 12-17 from 13% in 2019 to 10% in 2020 (Substance Abuse and Mental Health Services Administration, 2021). However, the authors cautioned readers that 2020 estimates may be inaccurate due to pandemic year survey changes. Similarly, our Illinois Youth Survey (IYS) was shortened in 2020, ceasing all surveying in March 2020. Thus, the 2020 IYS sample, although very large, was not representative of the youth in Illinois. Nevertheless, additional research should continue tracking trends over time after recreational policies have been implemented for several years. Many states with recreational use implemented their policies within the past five years (Marijuana Policy Project, 2021). So, findings from this and other studies on the associations between policy changes and adolescent cannabis use should be considered preliminary.

This study's findings should be interpreted in light of its strengths and weaknesses. Regarding strengths, our study used a sample from a Midwestern state, used local data with respondents' ZIP codes, and confirmed policy implementation timing through license approval dates and sales data. However, the study was limited by its cross-sectional design, and it is unclear whether ZIP codes are adequate measures of actual proximity to dispensaries. For example, some youth may technically live outside dispensary ZIP codes, but may be in very close proximity to a dispensary, depending on their exact location. Also, the analysis did not account for the nested structure of the data. In addition, few youth in rural areas in the IYS lived in dispensary ZIP codes, affecting power for some analyses. Finally, youth self-reported their cannabis use.

### *Future Research Recommendations*

We have three recommendations for future study. First, future studies should use longitudinal designs. Second, whenever possible, it would be more accurate to use a proximity measure by using distance in miles or buffers rather than ZIP codes. Finally, research could also track perceived harmfulness and types of cannabis consumption in Illinois. This study only focused on cannabis use in general. However, it is reasonable to hypothesize that some forms of use, such as concentrates or edibles, would be more prevalent among youth in closer proximity to dispensaries.

### *Conclusion*

Despite its limitations, this study found no evidence for increased cannabis use among youth living in ZIP codes with active medical cannabis dispensaries. In fact, 12th graders living in ZIP

codes with dispensaries had lower past-year and past-30-day cannabis use. Additional research should monitor how evolving cannabis policies influence adolescent cannabis use.

## REFERENCES


Anderson, D. M., Hansen, B., Rees, D. I., & Sabia, J. J. (2019). Association of cannabis laws with teen cannabis use: New estimates from the Youth Risk Behavior surveys. *JAMA Pediatrics*, E1-E2. https://doi.org/10.1001/jamapediatrics.2019.1720

Anderson, D. M., & Rees, D. (2014). The legalization of recreational cannabis: How likely is the worst-case scenario? *Journal of Policy Analysis and Management, 33*(1), 221-232. https://doi.org/10.1002/pam.21727

Center for Prevention Research and Development (2018). *Illinois Youth Survey 2018 frequency report: State of Illinois*.

Borodovsky, J. T., Crosier, B. S., Lee, D. C., Sargent, J. D., & Budney, A. J. (2016). Smoking, vaping, eating: Is legalization impacting the way people use cannabis? *International Journal of Drug Policy, 36*, 141–147. https://doi.org/10.1016/j.drugpo.2016.02.022

Borodovsky, J. T., Lee, D. C., Crosier, B. S., Gabrielli, J. L., Sargent, J. D., & Budney, A. J. (2017). U.S. cannabis legalization and use of vaping and edible products among youth. *Drug and Alcohol Dependence, 177*, 299-306. https://doi.org/10.1016/j.drugalcdep.2017.02.017a

Cambron, C., Guttmannova, K., & Fleming, C. B. (2017). State and national contexts in evaluating cannabis laws: A case study of Washington State. *Journal of Drug Issues*, *47*(1), 74-90. https://doi.org/10.1177/0022042616678607

Cantrell, J., Pearson, J. L., Anesetti-Rothermel, A., Xiao, H., Kirchner, T. R., & Vallone, D. (2016). Tobacco retail outlet density and young adult tobacco initiation. *Nicotine & Tobacco Research, 18*(2), 130–137. https://doi.org/10.1093/ntr/ntv036

Cerdá, M., Wall., M., Feng, T., Keyes, K. M., Sarvet, A., Schulenberg, J., O'Malley, P. M., Pacula, R. L., Galea, S., & Hasin, D. S. (2017). Association of state recreational marijuana laws with adolescent marijuana use. *JAMA Pediatrics, 171*(2), 142-149. https://doi.org/10.1001/jamapediatrics.2016.3624

Chen, M. J., Gruenewald, P. J., & Remer, L. G. (2009). Does alcohol outlet density affect youth access to alcohol? *Journal of Adolescent Health, 44*(6), 582-589. https://doi.org/10.1016/j.jadohealth.2008.10.136

Choo, E. K., Benz, M., Zaller, N., Warren, O., Rising, K. L., & McConnell, J. (2014). The impact of state medical cannabis legislation on adolescent cannabis use. *Journal of Adolescent Health, 55*(2), 160-166. https://doi.org/10.1016/j.jadohealth.2014.02.018

Freisthler, B., & Gruenewald, P. J. (2014). Examining the relationship between the physical availability of medical cannabis and cannabis use across fifty California cities. *Drug and Alcohol Dependence, 143*, 244–250. https://doi.org/10.1016/j.drugalcdep.2014.07.036

Gakh, M., Coughenour, C., Assoumou, B. O., & Venderstelt, M. (2020). The relationship between school absenteeism and substance use: An integrative literature review. *Substance Use and Misuse, 55*(3), 491-502. https://doi.org/10.1080/10826084.2019.1686021

Hasin, D. S., Wall, M., Keyes, K. M., Cerdá, M., Schulenberg, J., O'Malley, P. M., Galea, S., Pacula, R., & Feng, T. (2015). Medical cannabis laws and adolescent cannabis use in the USA from 1991 to 2014: Results from annual, repeated cross-sectional surveys. *Lancet Psychiatry, 2*, 601-608. http://doi.org/10.1016/ S2215-0366(15)00217-5

Illinois Department of Financial and Professional Regulation (2019). *IDFPR-licensed medical cannabis dispensaries*. https://www.idfpr.com/Forms/MC/ListofLicensedDispensaries.pdf

Illinois Department of Public Health (2021). *Medical Cannabis Patient Registry Program*. https://dph.illinois.gov/topics-services/prevention-wellness/medical-cannabis

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2010). *Monitoring the Future national results on adolescent drug use: Overview of key findings, 2009* (NIH Publication No. 10-7583). National Institute on Drug Abuse.

Kelleghan, A. R., Sofis, M. J., Budney, A., Ceasar, R., & Leventhal, A. M. (2022). Associations of cannabis product source and subsequent cannabis use among adolescents. *Drug and Alcohol Dependence, 233*, 109374. https://doi.org/10.1016/j.drugalcdep.2022.109374

Keyes, K. M., Wall, M., Cerdá, M., Schulenberg, J., O'Malley, P. M., Galea, S., Feng, T., & Hasin, D.S. (2016). How does state cannabis policy affect US

youth? Medical cannabis laws, cannabis use and perceived harmfulness: 1991-2014. *Addiction, 111*(12), 2187-2195. https://doi.org/10.1111/add.13523

King, K. A., Merianos, A. L., & Vidourek, R. A. (2016). Characteristics of marijuana acquisition among a national sample of adolescent users. *American Journal of Health Education, 47*(3), 126-135. http://dx.doi.org/10.1080/19325037.2016.1157535

Kuntsche, E., Kuendig, H., & Gmel, G. (2008). Alcohol outlet density, perceived availability and adolescent alcohol use: A multilevel structural equation model. *Journal of Epidemiology and Community Health, 62*, 811-816. http://dx.doi.org/10.1136/jech.2007.065367

Lynne-Landsman, S. D., Livingston, M. D., & Wagenaar, A. C. (2013). Effects of state medical cannabis laws on adolescent cannabis use. *American Journal of Public Health, 103*(8), 1500-1506. https://doi.org/10.2105/AJPH.2012.301117

Lynskey, M. T., Heath, A. C., Bucholz, K. K., Slutske, W. S., Madden, P. A., Nelson, E. C., Statham, D. J., & Martin, N. G. (2003). Escalation of drug use in early-onset cannabis users vs co-twin controls. *JAMA*, *289*(4), 427-433. https://doi.org/10.1001/jama.289.4.427

Mair, C., Freisthler, B., Ponicki, W. R., & Gaidus, A. (2015). The impacts of cannabis dispensary density and neighborhood ecology on cannabis abuse and dependence. *Drug and Alcohol Dependence, 154*(1), 111-116. https://doi.org/10.1016/j.drugalcdep.2015.06.019

Martins, S. S., Mauro, C. M., Santaella-Tenorio, J., Kim, J. H., Cerdá, M., Keyes, K. M., Hasin, D. S., Galea, S., & Wall, M. (2016). State-level medical marijuana laws, marijuana use and perceived availability of marijuana among the general U.S. population. *Drug and Alcohol Dependence, 169*, 26-32. http://dx.doi.org/10.1016/j.drugalcdep.2016.10.004

Moss, S. L., Santaella-Tenorio, J., Mauro, P. M., Keyes, K. M., & Martins, S. S. (2018). Changes over time in cannabis use, deviant behavior and preference for risky behavior among US adolescents from 2002 to 2014: Testing the moderating effect of gender and age. *Addiction, 114*, 674-686. https://doi.org/10.1111/add.14506

Pacula, R. L., Kilmer, B., Wagenaar, A. C., Chaloupka, F. J., Caulkins, J. P. (2014). Developing public health regulations for cannabis: Lessons from alcohol and tobacco. *American Journal of Public Health, 104*(6), 1021–1028. https://doi.org/10.2105/AJPH.2013.301766

Pacula, R. L., Powell, D., Heaton, P., & Sevigny, E. L. (2015). Assessing the effects of medical marijuana laws on marijuana use: The devil is in the details. *Journal of Policy Analysis and Management, 34*(1), 7-31. https://doi.org/10.1002/pam.21804

Pedersen, E. R., Firth, C. L., Rodriguez, A., Shih, R. A., Seelam, R., Kraus, L., Dunbar, M. S., Tucker, J. S., Kilmer, B., & D'Amico, E. J. (2021). Examining associations between licensed and unlicensed outlet density and cannabis outcomes from preopening to postopening of recreational cannabis outlets. *American Journal on Addictions*, *30*(2), 122-130. https://doi.org/10.1111/ajad.13132

ProCon.org. (2019, May 24). *Legal medical marijuana states and DC*. https://medicalmarijuana.procon.org/legal-medical-marijuana-states-and-dc/

Reed, M., Kioumarsi, A., Ataiants, J., Fedorova, E. V., Iverson, E., Wong, C. F., & Lankenau, S. E. (2020). Marijuana sources in a medical marijuana environment: Dynamics in access and use among a cohort of young adults in Los Angeles, California. *Drugs: Education, Prevention and Policy, 27*(1), 69-78. https://doi.org/10.1080/09687637.2018.1557595

Reitzel, L. R., Cromley, E. K., Li, Y., Cao, Y., Dela Mater, R., Mazas, C. A., Cofta-Woerpel, L., Cinciripini, P. M., &Wetter, D. W. (2011). The effect of tobacco outlet density and proximity on smoking cessation. *American Journal of Public Health, 101*(2), 315-320. https://doi.org/10.2105/AJPH.2010.191676

Sarvet, A. L., Wall, M. M., Fink, D. S., Greene, E., Le, A., Boustead, A. E., Pacula, R. L., Keyes, K. M., Cerdá, M., Galea, S., & Hasin, D. S. (2018). Medical cannabis laws and adolescent cannabis use in the United States: A systematic review and meta-analysis. *Addiction, 113*, 1003-1016. https://doi.org/10.1111/add.14136

Scribner, R. A., Cohen, D. A., & Fisher, W. (2000). Evidence of a structural effect for alcohol outlet density: A multilevel analysis. *Alcoholism: Clinical and Experimental Research, 24*(2), 188-195. https://doi.org/10.1111/j.1530-0277.2000.tb04590.x

Shih, R., Rodriguez, A., Parast, L., Pedersen, E. R., Tucker, J. S., Troxel, W., Kraus, L., Davis, J., & D'Amico, E. (2019). Associations between young

adult cannabis outcomes and availability of medical cannabis dispensaries and storefront signage. *Addiction, 114*(12), 2162-2170. https://doi.org/10.1111/add.14711

Shih, R. A., Tucker, J. S., Pedersen, E. R., Seelam, R., Dunbar, M. S., Kofner, A., Firth, C., & D'Amico, E. J. (2021). Density of medical and recreational cannabis outlets: Racial/ethnic differences in the associations with young adult intentions to use cannabis, e-cigarettes, and cannabis mixed with tobacco/nicotine. *Journal of Cannabis Research*, *3*(1), 28. https://doi.org/10.1186/s42238-021-00084-y

Smith, D. C., Cleeland, L. , & Dennis, M. L. (2010) Reasons for Quitting among Emerging Adults and Adolescents in Substance Use Disorder Treatment. *Journal of Studies on Alcohol and Drugs, 71, 3,* 400-409.

Smith, D. C., Godley, S. H., Godley, M. D., & Dennis, M. L. (2011) Adolescent Community Reinforcement Approach (A-CRA) Outcomes Differ among Emerging Adults and Adolescents. *Journal of Substance Abuse Treatment*, 41, 422-430.

Substance Abuse and Mental Health Services Administration. (2021). *Key substance use and mental health indicators in the United States: Results from the 2020 National Survey on Drug Use and Health* (HHS Publication No. PEP21-07-01-003, NSDUH Series H-56). Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration. https://www.samhsa.gov/data/

Volkow, N. D., Baler, R. D., Compton, W. M., & Weiss, S. R. B. (2014). Adverse health effects of cannabis use. *The New England Journal of Medicine, 370*(23), 2219-2227. https://doi.org/10.1056/NEJMra1402309

Wall, M. M., Poh, E., Cerdá, M., Keyes, K. M., Galea, S., & Hasin, D. S. (2011). Adolescent cannabis use from 2002 to 2008: Higher in states with medical cannabis laws, cause still unclear. *Annals of Epidemiology, 21*(9), 714-716. https://doi.org/10.1016/j.annepidem.2011.06.001

**Funding and Acknowledgements:** A prior version of this manuscript was presented at the 2019 conference of the Research Society of Marijuana (Vancouver, WA). This study was funded by Illinois Department of Human Services' Division of Substance Use Prevention and Recovery (Contract # 43CXZ03292). However, the views expressed in this article are those of the authors, and do not reflect official positions of the State of Illinois.