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FULL TEXT ARTICLE

Local Cannabis Policy and Cannabis Use by California High School Students Before and After Statewide Retail Legalization

Source

Close
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THIS PEER REVIEWED STUDY REVEALED

Abstract

"ANY and frequent cannabis use among youth was markedly lower where all cannabis retail sales

Purpose

were banned both before and after state retail legalization ..." P.18

Although most US states with legalized recreational cannabis retail (RCR) allow some degree of local control, the impact of local policy on cannabis use has seldom been studied. Changes in self-reported cannabis use by California 11th graders pre- and post-RCR legalization (January 2018) were examined, overall and by local policy.

Methods

Adjusted interrupted time-series multilevel models assessed changes in past 30-day cannabis use post-RCR and tested whether such changes differed by local city and county allowance of storefront and delivery cannabis sales. Cross-sectional data from the 2015/2016 to 2019/2020 California Healthy Kids Surveys were analyzed (n = 377,205).

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Results

ny past 30-day cannabis use increased after legalization (odds ratio [OR] [Δ level]: 1.06, p =.013) among all jurisdictions except for those allowing medical delivery only—which decreased—and then slowly declined (OR [Δ slope]: 0.97, p =.001) among all jurisdictions except for those newly allowing storefronts and delivery retail, where elevated rates persisted. Pre-RCR legalization odds of frequent use decreased, whereas post-RCR, they increased through spring 2020 (OR [Δ level]: 1.30, p <.001; OR [Δ slope]: 1.13, p <.001) with no differential changes by local policy. Odds of recent cannabis use and frequent cannabis use were lower in retail-banning jurisdictions without pre-RCR medical sales compared to those allowing storefronts.

Discussion

Frequent cannabis use among California 11th graders increased post-RCR legalization. After an increase in any 30-day use, use in retail-banning jurisdictions declined, whereas rates in jurisdictions newly permitting storefronts and delivery remained raised. Lower cannabis use in retail-banning jurisdictions pre-RCR suggests pre-existing norms potentially spurred local policies.

Implications and Contribution

Studies evaluating the health impacts of cannabis legalization policy have been limited by often ignoring the policy variation within legalizing states. This study identified differential rates of recent and frequent youth use by local policy pre-statewide and post-statewide recreational cannabis retail legalization and highlighted increases in the frequent use post-legalization.

One of the greatest concerns of legalizing recreational cannabis retail (RCR) is the potential impact on youth use and subsequent harms. The human brain continues to mature until the mid-twenties [1], and individuals who initiate and use cannabis frequently in adolescence are uniquely susceptible to adverse health effects such as impairment of memory [2], risk of cannabis use disorder [3], and psychotic disorders [4]. Legal cannabis retail markets may increase the likelihood of youth using cannabis via greater visibility and accessibility of cannabis and exposure to youth-appealing advertising [5]. Research has found that state legalization is associated with an increased use among young adults nationally [6], but findings are mixed among adolescents [7,8].

Few studies account for local policies [9], which directly shape the environments in which people live and may have a more immediate impact on the availability and use of cannabis than state laws [10,11].

[illegible]ctions retain discretion to allow or prohibit cannabis retail sales. One study found that 1 year after recreational sales were legalized in January 2018, 263 (49%) of California's 539 local jurisdictions allowed medical and/or recreational cannabis sales within their borders [12], whether by storefronts or by delivery businesses within or outside their jurisdiction. By January 2024, it was estimated that 320 (59%) allowed sales, covering 67% of California residents [13].

A large cross-sectional study of California teens found lower rates of any cannabis use and problem use in jurisdictions that banned storefront and delivery retail compared to those that allowed them [14]. However, the study did not account for pre-state legalization trends in youth use. Those few studies that examined adolescent cannabis use pre-statewide and post-statewide policy, along with local regulation, have reported mixed findings [15,16,17]. In a repeated cross-sectional study of Oregon adolescents, Paschall and Grube reported downward trends in 30-day use pre-state legalization (2010–2014) that attenuated at the same rate 1 and 3 years post-state legalization (2016, 2018) regardless of whether the adolescent's county allowed or banned recreational cannabis sales [15]. Using the cross-sectional Healthy Kids Colorado Survey, Brooks-Russell et al. saw no effect of state retail legalization (January 1, 2014) on adolescent cannabis use, regardless of whether their local municipality allowed recreational sales [16]. Rusby et al. assessed cannabis use among eighth and ninth graders in Oregon pre- and post-state retail legalization. They found no association between state legalization and cannabis initiation. However, among current users, the frequency of use increased after state legalization, and the rate of increase was greater in jurisdictions that banned local sales than those in jurisdictions that legalized [17]. Studies may have been limited by absence of measures of pre-existing medical sales before state recreational legalization and using dichotomous measures of state and local policy (i.e., allowed/ban) [9,15,16,17] rather than characterizing the type of retail allowed (e.g., storefront vs. delivery). These variations in local policy may modify the impact of cannabis legalization on adolescent cannabis use.

In this study, we built on the current literature by using a nuanced characterization of local cannabis policy that accounted for whether medical cannabis sales were allowed pre-state RCR, types of retail allowed locally, and policy consistency over time. We examined changes in any recent and frequent cannabis use among California 11th graders before and after statewide RCR legalization and tested whether changes differed according to the local policy profile of their school's jurisdiction.

Methods

Data source

Data originated from the 2015/16 through 2021/22 waves of the California Healthy Kids Survey (CHKS) for secondary students, an annual cross-sectional survey of 7th, 9th, and 11th grade students by the California Department of Education [18]. Survey years were chosen to investigate changes in use before and after state legalization of RCR (January 1, 2018), which occurred 1 year after legalization of possession and personal cultivation in late 2016. Students' participation was voluntary, anonymous, and required parental consent. In the 2019/2020 school year, no surveys were administered after March 13, 2020, when most on-site education was suspended due to the COVID-19 pandemic, resulting in lower participation and a younger-than-average sample. The Public Health Institute Institutional Review Board qualified this research as exempt under category four per 45 CFR 46.104.

Measures

Cannabis use

Students were asked how many days in the past 30 days they used "marijuana (pot, weed, grass, hash, or bud)" in 2015/16–2016/17 and "marijuana (smoke, vape, eat, or drink)" for years 2017/18–2021/22. Options were 0, 1, 2, 3–9, 10–19, and 20–30. Any recent cannabis use was operationalized as at least 1 day and frequent use as 20–30 days [16,19].

Local policy profiles

Local cannabis retail policies and their effective dates were collected annually (2018–2022) for all 539 California jurisdictions—482 incorporated cities and 57 county unincorporated areas—using Fyllo's CannaRegs Regulatory Database (discontinued in 2023) [20], municipal codes, and direct outreach to jurisdiction staff (last updated September 4, 2024) [12,21]. California Department of Tax and Fee Administration sales data (2014–2017) were used to identify jurisdictions with active medical retailers before 2018 [22].

Jurisdictions were categorized into policy profiles based on pre-2018 medical cannabis sales and, for each year post-state legalization, whether storefront and/or delivery retail was allowed for recreational and/or medical use. To focus on jurisdictions with stable policy environments, we excluded those that changed legal retail status after January 2018 (n = 123) or altered the allowed use type after January 2018 (n = 58). We also excluded policy profiles containing solely one

jurisdiction or lacking data for at least one survey term (n = 12). The 6 resulting profiles (Table 1) were (always) restrictive, newly restrictive, always permissive, newly permissive, (newly) delivery-only, and (newly) medical delivery-only. Notably, from January 2019 to November 2020, state ed—permitted cannabis delivery statewide regardless of local law [23], meaning even restrictive locations potentially had legal access during that period.

Table 1

Local policy profiles descriptions

Local policy profile (included in analysis)	Medical cannabis sales 2014–2017	Recreational (R) and medical (M) cannabis policies 2018–2022 [a]		Number of jurisdictions in California (n = 539)
		Storefronts policy	Delivery policy	
Always restrictive	No	R and M banned	R and M banned	218
Newly restrictive	Yes	R and M banned	R and M banned	11
Always permissive	Yes	R and M allowed	R and M allowed	24
Newly permissive	No	R and M allowed	R and M allowed	27
Newly delivery-only	No	R and M banned	R and M allowed	47
Newly medical delivery-only	No	R and M banned	M allowed only	19

We merged local policy data with the CHKS dataset based on school addresses obtained from the California Department of Education [24].

Sociodemographics

Individual-level gender, sexual orientation, race and ethnicity, and parental education were obtained from CHKS. School socioeconomic environment was measured using the percentage of students qualifying for free or reduced-price meals (FRPM) [25]. Jurisdiction population density (people per kilometers squared) was derived from the 2020 census [26] (See Supplemental Text 1).

Survey administration term

The term (0 = fall, 1 = spring) served as a proxy for age—students were older in the spring term—and to control for non-linear use trends. Time was coded based on year and survey administration term, centered at fall 2015 (0 = fall 2015,..., 9 = spring 2020).

Period of study and final analytic sample

…n effects was restricted to data collected before pandemic school … 2020). (Justification for exclusion of 2020/21 and 2021/22 survey waves is provided in Supplementary Text 2 and Supplementary Figure 1). The sample of 11th graders who participated in CHKS between 2015/16 and 2019/20 was 661,360. After excluding students in jurisdictions not classified into a defined local policy profile (n = 226,793), missing term data (n = 8,513), from schools reporting only 1 year of data (n = 23,271), or missing use information (n = 21,618) or FRPM data (n = 616), the final analytic sample included 377,205 students, 553 schools, and 233 jurisdictions (57.0% of 11th graders in the CHKS sample).

Statistical analysis

Descriptive statistics were calculated overall and by local policy profile. Significant differences across policy profiles were assessed using omnibus chi-squared tests for categorical variables and analysis of variance for population density. In addition, we investigated significant pairwise differences between the restrictive policy sample and each policy profile separately. For categorical variables, we used the "comparing cells" method [27] with Bonferroni adjustment for multiple comparisons. For population density, we used the Tukey multiple comparison test.

We examined the effect of the State of California's 2018 legalization of RCR on any recent cannabis use and frequent use among 11th graders using an interrupted time-series (ITS) framework [28] and multilevel generalized linear models, accounting for nonindependence between students in the same schools (model 1). We adjusted for policy profile, survey administration term, and all other individual-, school-, and jurisdiction-level characteristics.

Model 1 can be represented as follows, where i = student and j = school:

$$\ln\left(E\left[y_{ij}\right]\right) = \beta_0 + \beta_1 \text{Time} + \beta_2 \text{Post - RCR} + \beta_3 \text{Post - RCRSlope} + \beta_4 \text{NewlyRestrictive}_j + \beta_5 \text{AlwaysPerm}$$

Time accounts for secular trend, post-RCR is a dummy variable indicating whether the survey term was before or after the state RCR legalization (0 = fall 2015-fall 2017, 1 = spring 2018-spring 2020), and post-RCR slope indicates the number of school terms after state legalization (0 = fall 2015-spring 2018, 1 = fall 2018, …, 4 = spring 2020). Local policy profiles are dummy variables (reference = always restrictive). Z_{ij} represents the covariates, b_{0j} the random intercept, and ε_{ij} the random error. Significance of coefficients was determined using Z-tests (Supplemental Text 3).

We assumed level and slope changes in cannabis use [28], hypothesizing that RCR, starting January 1, 2018, could elicit an immediate, significant increase in use due to the market's novelty and advertising and that this could be followed by either a gradual increase in use, as popularity and retail infrastructure grew, or a gradual decrease, as novelty waned and other cannabis policies,

such as advertising restrictions and local tax adoption, were implemented. Sensitivity analyses checked for diversions from the hypothesized slope change—occurring after state regulations allowed delivery statewide in January 2019, for example—by relaxing the assumption that changes as term-specific dummy variables similar to a difference-in-difference (DID) approach (Supplemental Text 4).

ear trend after RCR using a model that operationalizes post-RCR

To assess whether changes in cannabis use among 11th graders post-state RCR differed based on the local policy profile of the jurisdiction of the student's school, we added interactions between policy profiles and post-RCR and post-RCR slope variables (model 2, Supplemental Text 3). For the DID sensitivity model, interactions between policy profiles and post-RCR term dummy variables were added (Supplemental Text 4) . The linear combination of main and interaction coefficients and Z-tests were calculated to determine the extent to which significant interactions amplified, attenuated, or reversed the main effect's direction.

To aid interpretation, we predicted individual-level probabilities of any and frequent use using model 2, taking both fixed and random effects into consideration, and averaged probabilities by policy profile. Preliminary analyses found that participant demographics varied over time; to balance representation for the entire period, probabilities were predicted for all participants at each time point, irrespective of survey administration term, and then averaged by policy profile.

All statistical analyses were conducted using Stata/SE 19.5 (Stata Corp, College Station, TX).

Results

Table 2 presents sample characteristics. Of 377,205 students, about half (52.8%) attended schools in restrictive policy jurisdictions, 12.8% in newly restrictive, 19.1% in permissive, 5.1% in newly permissive, 6.0% in delivery-only, and 4.2% in medical delivery-only. All individual-, school-, and jurisdiction-level characteristics differed significantly across policy profiles. Restrictive jurisdictions had a significantly higher percentage of White and Asian students but lower percentage of Latinx students compared to all other policy profiles except for delivery-only jurisdictions, which had a lower percentage of Asian students but a higher percentage of White students than restrictive jurisdictions. Restrictive jurisdictions had a lower percentage of Black students than permissive and newly permissive jurisdictions. Students in restrictive jurisdictions were more likely to have parents who graduated from college compared to students in all other jurisdictions except for those in delivery-only jurisdictions, where rates were higher. On average, those in restrictive jurisdictions were more likely to have a low school FRPM percentage compared to those in newly restrictive, permissive, and newly permissive jurisdictions and less likely compared to delivery-only jurisdictions. Students in always restrictive and always permissive jurisdictions were more likely to attend school in a more densely populated jurisdiction than those in all other policy profiles.

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Sample characteristics by local policy profile (fall 2015-spring 2020 school terms)

	Total [a]		Always restrictive		Newly restrictive		Always permissive		Newly permissive		Newly delivery-on	
	Count	Pct.	Count	Pct.	Count	Pct.	Count	Pct.	Count	Pct.	Count	Pc
Local jurisdictions	233	100	145	62.2	9	3.9	20	8.6	22	5.6	25	1(
Schools	553	100	245	44.3	50	9.0	176	31.8	31	9.4	31	5.
Students	377,205	100	199,328	52.8	48,202	12.8	72,189	19.1	19,056	5.1	22,720	6.
Gender												
Male	184,167	48.8	97,385	48.9	23,694	49.2	34,876	48.3	9,256	48.6	11,202	4(
Female	189,035	50.1	99,909	50.1	24,113	50.0	36,414	50.4	9,563	50.2	11,282	4(
Missing/other	4,003	1.1	2,034	1.0	395	0.8	899	1.2	237	1.2	236	1.
Sexual orientation												
Heterosexual/straight	296,303	78.6	155,381	78.0	38,898	80.7 [b]	56,170	77.8	15,034	78.9	17,892	7(
Gay, lesbian, bisexual	29,418	7.8	14,847	7.4	3,838	8.0	6,200	8.6 [b]	1,700	8.9 [b]	1,742	7.
Not sure/other	17,396	4.6	9,000	4.5	2,133	4.4	3,597	5.0	894	4.7	1,126	5.
Declined/not answered	34,088	9.0	20,100	10.1	3,333	6.9 [b]	6,222	8.6 [b]	1,428	7.5 [b]	1,960	8. [b]
Race and ethnicity												
Non-Hispanic/Latinx												
White	90,172	23.9	55,056	27.6	9,276	19.2 [b]	11,000	15.2 [b]	3,200	16.8 [b]	7,850	3([b]
American Indian/Alaska Native	2,200	0.6	1,244	0.6	285	0.6	365	0.5	143	0.8	101	0.
Asian	53,041	14.1	31,411	15.8	5,607	11.6 [b]	8,825	12.2 [b]	2,255	11.8 [b]	2,886	1([b]
Black	13,127	3.5	5,852	2.9	1,733	3.6	3,734	5.2 [b]	1,057	5.5 [b]	390	1. [b]

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	Total [a]		Always restrictive		Newly restrictive		Always permissive		Newly permissive		Newly delivery-on	
	ıt	Pct.	Count	Pct.	Count	Pct.	Count	Pct.	Count	Pct.	Count	Pc
Native Hawaiian/Pacific Islander	5,715	1.5	3,271	1.6	457	0.9 b	1,028	1.4	473	2.5	250	1.
Multiracial	28,198	7.5	16,111	8.1	3,164	6.6 b	4,447	6.2 b	1,514	7.9	1,828	8.
Hispanic/Latinx	182,746	48.4	85,346	42.8	27,420	56.9 b	42,387	58.7 b	10,297	54.0 b	9,300	4(
Missing	2,006	0.5	1,037	0.5	260	0.5	403	0.6	117	0.6	115	0.
Parents' education												
Graduated from college	159,707	42.3	95,574	47.9	17,999	37.3 b	21,275	29.5 b	6,054	31.8 b	12,201	5: b
Attended college	54,380	14.4	29,898	15.0	6,990	14.5	9,355	13.0 b	3,217	16.9 b	2,697	1] b
Graduated from high school	63,200	16.8	31,186	15.6	9,120	18.9 b	13,518	18.7 b	3,821	20.1 b	2,859	1: b
Did not finish high school	60,508	16.0	24,898	12.5	8,801	18.3 b	17,560	24.3 b	3,591	18.8 b	3,004	1:
Don't know/missing	39,410	10.4	17,772	8.9	5,292	11.0 b	10,481	14.5 b	2,373	12.5 b	1,959	8.
Percentage school qualifying for free/reduced price meals												
0%–25%	89,702	23.8	57,495	28.8	11,160	23.2 b	6,479	9.0 b	760	4.0 b	9,510	4] b
26%–50%	103,762	27.5	64,239	32.2	6,624	13.7 b	16,090	22.3 b	5,358	28.1 b	6,610	2! b
51%–75%	89,152	23.6	46,522	23.3	11,837	24.6	15,603	21.6 b	8,924	46.8 b	2,497	1] b
76%–100%	94,589	25.1	31,072	15.6	18,581	38.5 b	34,017	47.1 b	4,014	21.1 b	4,103	1{ b
Jurisdiction population density (people per kilometers squared)												

	Total [a]		Always restrictive		Newly restrictive		Always permissive		Newly permissive		Newly delivery-on	
	ıt	Pct.	Count	Pct.	Count	Pct.	Count	Pct.	Count	Pct.	Count	Pc
Mean (SE)	4,944.2 (0.0)		4,752.7 (6.9)		4,643.5 (20.6) [c]		6,932.5 (13.6) [c]		4,047.3 (16.7) [c]		4,056.8 (19.4) [c]	
School term												
Fall	155,840	41.3	94,276	47.3	17,272	35.8 [b]	16,270	22.5 [b]	6,612	34.7 [b]	12,781	5€ [b]
Spring	221,365	58.7	105,052	52.7	30,930	64.2 [b]	55,919	77.5 [b]	12,444	65.3 [b]	9,939	4: [b]

California Healthy Kids Survey, 2015/16–2019/2020. Local policy profiles: always restrictive had no medical sales pre-2018 and banned all cannabis retail sales (recreational and medical, storefronts, and delivery) each year post-state recreational retail legalization (RCR; 2018–2022); newly restrictive had medical sales pre-2018 but banned all cannabis retail sales each year post-RCR; always permissive had pre-2018 medical cannabis sales and allowed all retail each year post-RCR; newly permissive had no pre-2018 medical sales but allowed all retail each year post-RCR; newly delivery-only had no medical sales pre-2018 and allowed only sales by delivery of cannabis (recreational and medical) each year post-RCR; and newly medical delivery-only had no medical sales pre-2018 and allowed only sales by delivery of medical cannabis each year post-RCR.

Any recent use

Before state RCR in January 2018, overall odds of any recent cannabis use were stable over time (2015–2017; odds ratio [OR] [time] = 0.99, 95% confidence interval [CI]: 0.98, 1.00; Table 3 , model 1). There was a significant increase in the odds of any use in the term immediately after state RCR (OR [post-RCR] = 1.05, 95% CI: 1.01, 1.10), but odds of use began a statistically significant, albeit slow, decline between spring 2018 and spring 2020 (OR [post-RCR slope] = 0.97, 95% CI: 0.96, 0.99). On average, the odds of any use among students in the permissive (OR = 1.17, 95% CI: 1.07, 1.28), newly permissive (OR = 1.23, 95% CI: 1.05, 1.45), and delivery-only (OR = 1.38, 95% CI: 1.18, 1.61) jurisdictions were significantly greater than those in the restrictive jurisdictions over the entire study period.

Table 3

Change in any and frequent past 30-day use by 11th graders pre- and post-state recreational cannabis retail legalization (fall 2015-spring 2020)

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	Any recent use		Frequent use	
	Model 1	Model 2	Model 1	Model 2
	OR (95% CI)	OR (95%CI)	OR (95% CI)	OR (95% CI)
Time	0.99 (0.98,1.00)	0.99 (0.98,1.00)	**0.94*** (0.92,0.96)**	**0.94*** (0.92,0.96)**
Post-RCR	**1.05* (1.01,1.10)**	**1.06* (1.01,1.12)**	**1.30*** (1.20,1.41)**	**1.34*** (1.21,1.48)**
Post-RCR slope	**0.97*** (0.96,0.99)**	**0.97*** (0.95,0.99)**	**1.13*** (1.10,1.16)**	**1.12*** (1.08,1.15)**
Local policy profile				
Always restrictive				
Newly restrictive	0.91 (0.80,1.03)	0.88 † (0.77,1.00)	0.93 (0.80,1.09)	0.88 (0.74,1.04)
Always permissive	**1.17*** (1.07,1.28)**	**1.20*** (1.10,1.32)**	**1.19** (1.07,1.34)**	**1.24*** (1.09,1.41)**
Newly permissive	**1.23* (1.05,1.45)**	**1.20* (1.01,1.41)**	**1.30** (1.07,1.59)**	**1.26* (1.01,1.56)**
Newly delivery-only	**1.38*** (1.18,1.61)**	**1.33*** (1.13,1.56)**	1.14 (0.94,1.38)	1.15 (0.93,1.41)
Newly medical delivery-only	1.01 (0.83,1.23)	1.10 (0.90,1.35)	0.92 (0.72,1.18)	1.00 (0.77,1.29)
Local policy profile interactions				
Post-RCR × newly restrictive		1.06 (0.98,1.15)		1.08 (0.92,1.27)
Post-RCR × always permissive		0.97 (0.90,1.04)		0.92 (0.80,1.06)
Post-RCR × newly permissive		0.97 (0.87,1.08)		0.97 (0.80,1.19)
Post-RCR × newly delivery-only		1.02 (0.92,1.13)		0.87 (0.71,1.07)
Post-RCR × newly medical delivery-only		**0.84** (0.74,0.96)**		0.88 (0.68,1.14)
Post-RCR slope × newly restrictive		1.01 (0.97,1.04)		1.02 (0.96,1.09)
Post-RCR slope × permissive		0.99 (0.96,1.01)		1.01 (0.96,1.06)
Post-RCR slope × newly permissive		**1.06** (1.02,1.10)**		1.06 (0.99,1.13)
Post-RCR slope × newly delivery-only		1.04 † (1.00,1.08)		1.07 † (0.99,1.15)

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	Any recent use		Frequent use	
	Model 1	Model 2	Model 1	Model 2
	OR (95% CI)	OR (95%CI)	OR (95% CI)	OR (95% CI)
Post-RCR slope × newly medical delivery-only		1.00 (0.95,1.05)		0.99 (0.89,1.09)

Bold font indicates significance. N = 377,205. Interrupted time-series multilevel model results estimating change in any (1+ days) and frequent cannabis use (20+ days) in past 30 days by California 11th graders pre- and post-state recreational cannabis retail legalization, overall and by local policy profile (fall 2015-spring 2020). All models adjusted for gender, sexual orientation, race and ethnicity, parent's education, percentage school qualifying for free/reduced price meals, jurisdiction population density, and school term (fall/spring). Odds Ratios for control variables can be found in Supplementary Table 2. Time indicates school term since fall 2015. Post-RCR is a dummy variable indicating whether the survey term was pre- or post-state recreational cannabis retail legalization (RCR; January 1, 2018) and post-RCR slope indicates the number of school terms post-retail legalization. Local policy profiles: always restrictive had no medical sales pre-2018 and banned all cannabis retail sales (recreational and medical, storefronts and delivery) each year post-state recreational retail legalization (RCR; 2018–2022); newly restrictive had medical sales pre-2018 but banned all cannabis retail sales each year post-RCR; always permissive had pre-2018 medical cannabis sales and allowed all retail each year post-RCR; newly permissive had no pre-2018 medical sales but allowed all retail each year post-RCR; newly delivery-only had no medical sales pre-2018 and allowed only sales by delivery of cannabis (recreational and medical) each year post-RCR; and newly medical delivery-only had no medical sales pre-2018 and allowed only sales by delivery of medical cannabis each year post-RCR.

† <0.10, *<0.05, **<0.01, ***<0.001.

In the interaction model (model 2), the increase in odds of any use in the term immediately after state RCR was significant (OR [post-RCR] = 1.06, 95% CI: 1.01, 1.12; Table 3 , model 2; Figure 1) for all but the medical delivery-only jurisdictions. The significant interaction between post-RCR and the medical delivery-only policy profile (OR = 0.84, 95% CI: 0.74, 0.96) attenuated the effect of post-RCR to the null (p =.089), meaning that immediately after retail legalization, there was no change in any use for those in the medical delivery-only jurisdictions. In the subsequent terms, there was a slight decrease in use (OR [post-RCR slope] = 0.97, 95% CI: 0.95, 0.99), but the post-RCR interactions results suggest that the decrease occurred in all policy profiles except for newly permissive. Specifically, there was a significant interaction between post-RCR slope and the newly permissive policy profile (OR = 1.06, 95% CI: 1.02, 1.10,) which attenuated the post-RCR slope effect to the null (p value =.121), meaning that after the initial increase in spring 2018, the odds of any recent use among students in newly permissive jurisdictions remained elevated between fall 2018 and spring 2020. There was also an attenuating, although only marginally significant, interaction between post-RCR slope and the delivery-only policy profile (OR = 1.04, 95% CI: 1.00, 1.08, p =.070) (Supplemental Table 1 for output including covariates).

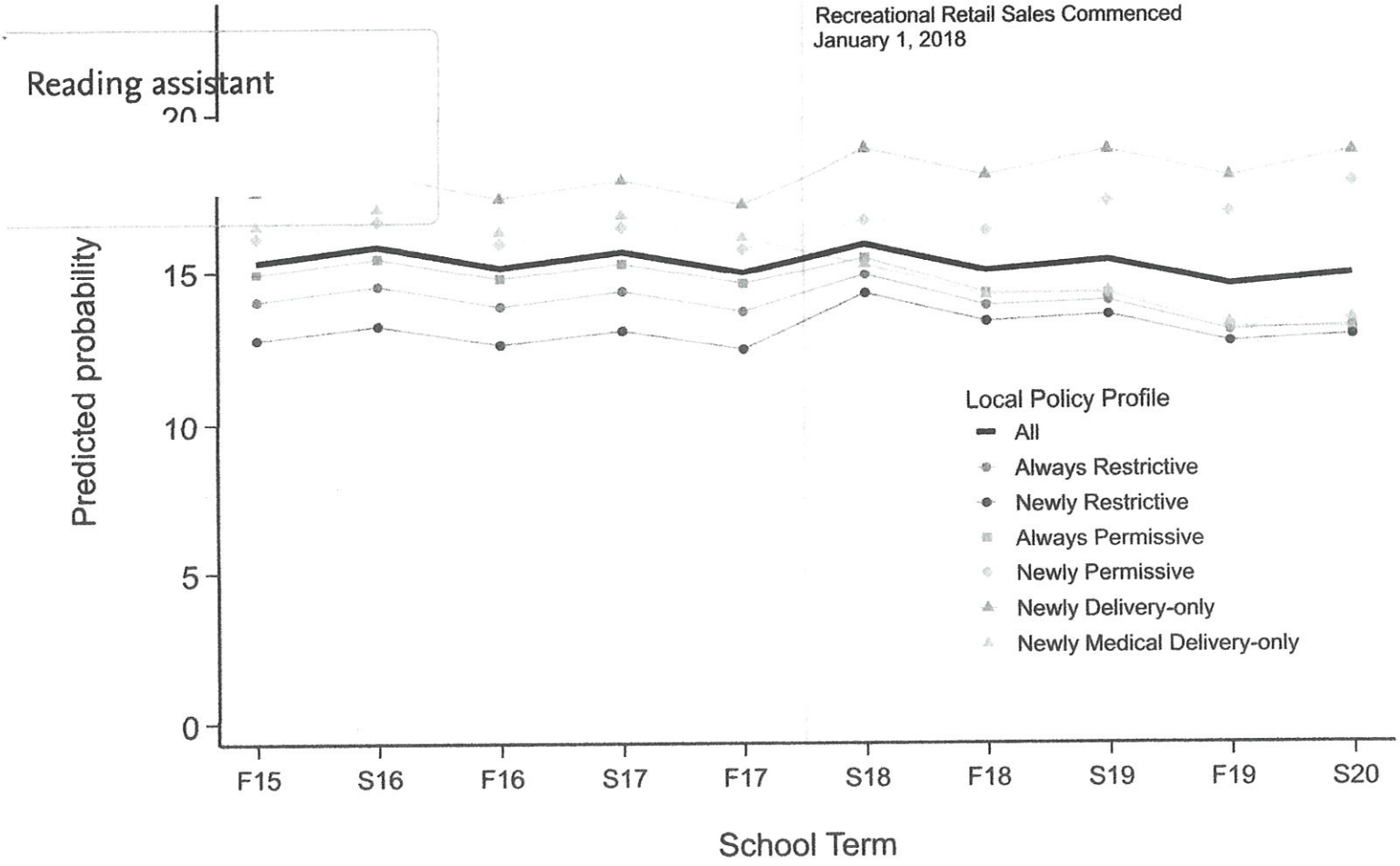

FIGURE 1

Predicted probability of any past 30-day cannabis use by California 11th graders pre- and post-state recreational cannabis retail legalization, by local policy profile (fall 2015–spring 2020). Probabilities were predicted from multilevel model 2, which was adjusted for gender, sexual orientation, race and ethnicity, parents' education, percentage of school qualifying for free or reduced meals, jurisdiction population density, and school term. Table 3 presents statistical significance of changes pre-RCR and post-RCR and differences in these changes across local policy profiles. F = fall school term, S = spring school term. Local policy profiles: always restrictive had no medical sales pre-2018 and banned all cannabis retail sales (recreational and medical, storefronts and delivery) each year post-state recreational retail legalization (RCR; 2018–2022); newly restrictive had medical sales pre-2018 but banned all cannabis retail sales each year post-RCR; always permissive had pre-2018 medical cannabis sales and allowed all retail each year post-RCR; newly permissive had no pre-2018 medical sales but allowed all retail each year post-RCR; newly delivery-only had no medical sales pre-2018 and allowed only sales by delivery of cannabis (recreational and medical) each year post-RCR; and newly medical delivery-only had no medical sales pre-2018 and allowed only sales by delivery of medical cannabis each year post-RCR.

Frequent use

odds of frequent use decreased over time (OR [time] = 0.94, 95% CI: 0.92, 0.96; Table 3, model 1). This was followed by a significant increase in odds of frequent use in the term immediately after state RCR began (OR [post-RCR] = 1.30, 95% CI: 1.20, 1.41), and the odds of frequent use continued to significantly increase between spring 2018 and spring 2020 (OR [post-RCR slope] = 1.13, 95% CI: 1.10, 1.16). Pre-RCR and post-RCR the odds of frequent use among students in the permissive (OR = 1.19, 95% CI: 1.07, 1.34) and the newly permissive jurisdictions (OR = 1.30, 95% CI: 1.07, 1.59) were greater compared to those in the restrictive jurisdictions. Nonsignificant interactions between each policy profile and post-RCR and post-RCR slope (model 2, Figure 2) indicated that changes in frequent use after state RCR legalization did not differ by local policy profile.

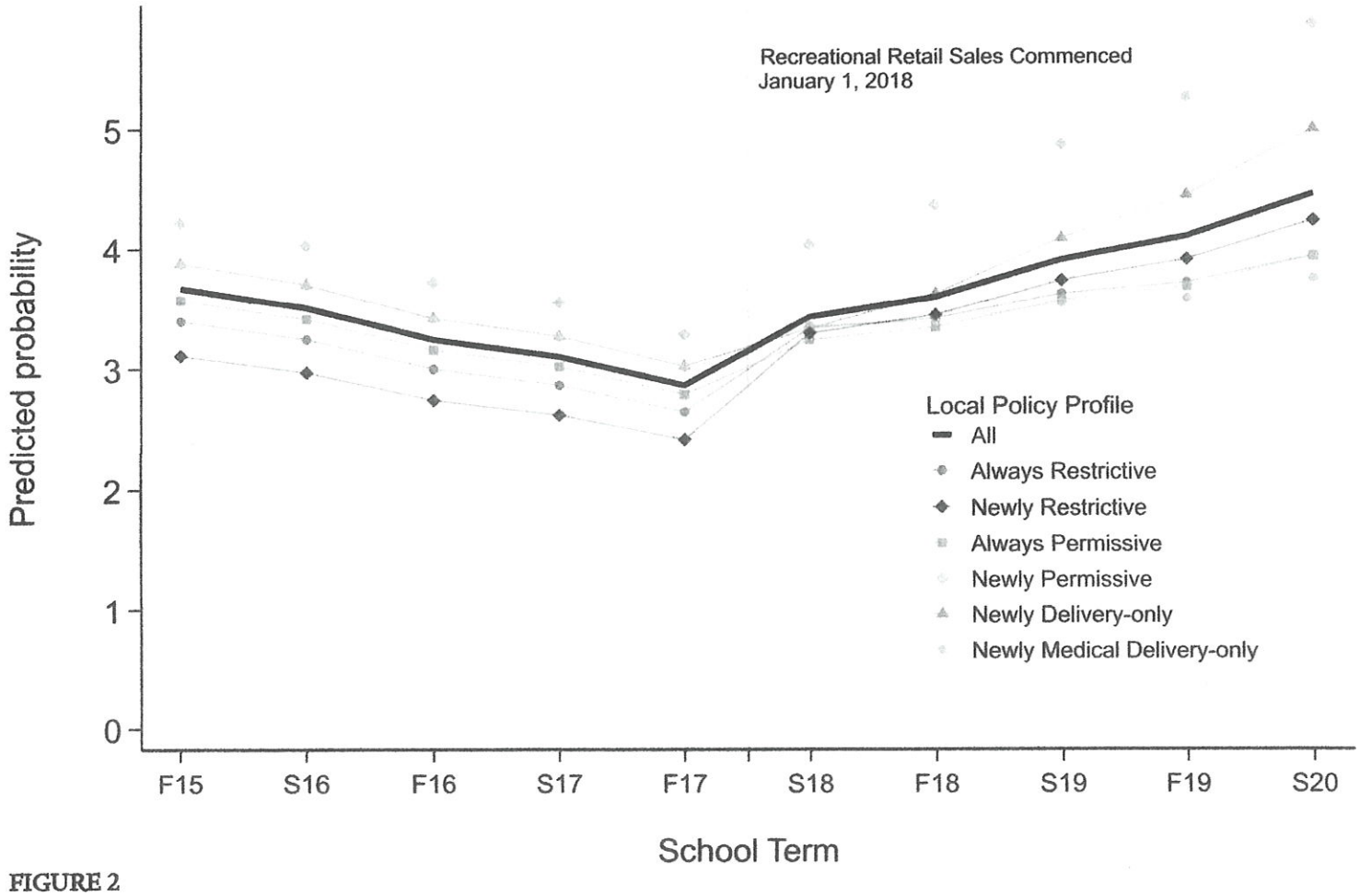

FIGURE 2

Predicted probability of frequent cannabis use (20+ days) in past 30 days by California 11th graders pre- and post-state recreational cannabis retail legalization, by local policy profile (fall 2015–spring 2020). Probabilities predicted from multilevel model 2, which was adjusted for gender, sexual orientation, race and ethnicity, parents' education, percentage of school qualifying for free or reduced meals, jurisdiction population density, and school term. Table 3 presents statistical significance of changes pre-RCR and post-RCR and differences in these changes across local policy profiles. F = fall school term, S = spring school term. Local policy profiles: always

restrictive had no medical sales pre-2018 and banned all cannabis retail sales (recreational and medical, storefronts and delivery each year poststate RCR (2018–2022); newly restrictive had medical sales pre-2018 but banned all cannabis retail sales each year post-RCR; always permissive nabis sales and allowed all retail each year post-RCR; newly permissive had no pre-2018 medical sales but allowed all retail each year post-RCR; newly delivery-only had no medical sales pre-2018 and allowed only sales by delivery of cannabis (recreational and medical) each year post-RCR; and newly medical delivery-only had no medical sales pre-2018 and allowed only sales by delivery of medical cannabis each year post-RCR.

Sensitivity analyses

The DID models, which relaxed the assumption that post-RCR changes followed a linear pattern, yielded consistent results to the main models with respect to frequent use (Supplemental Table 2) but supported slightly alternative trajectories of any recent use after state retail legalization. Findings from the DID interaction model suggested a more gradual increase in odds of any use than the ITS model. In the first term post-RCR, there was a nonsignificant increase in odds of any use post-RCR among restrictive, permissive, newly permissive, and delivery-only jurisdictions (OR [post-RCR 1] = 1.02, 95% CI: 0.96,1.08) and a significant increase in odds in newly restrictive jurisdictions, as evidenced by the significant interaction between post-RCR term 1 and the newly restrictive policy profile (OR = 1.11, 95% CI: 1.01,1.21). In the second term post-RCR (fall 2018), however, there was a significant increase in odds of any use (OR [post-RCR term 2] = 1.08, 95% CI: 1.01, 1.16) for all policy profiles except newly restrictive jurisdictions. Like in the ITS model, the interaction between the medical delivery-only policy profile and one term post-RCR had an attenuating effect on odds of any use (OR [post-RCR term 1 × medical delivery-only] = 0.79, 95% CI: 0.67, 0.93), but it yielded a significant decrease in odds of use among students in medical delivery-only jurisdictions rather than a null effect. Similar to the ITS model results, the increase in odds of any use was followed by a significant decrease in odds among students in restrictive, newly restrictive, and permissive jurisdictions in spring 2020 (OR [post-RCR term 5] = 0.87, 95% CI: 0.79, 0.96) and from spring 2019 to spring 2020 among students in medical delivery-only jurisdictions. In contrast, in spring 2020, the odds of any recent use for students in newly permissive jurisdictions were significantly higher (OR [post-RCR term 5 x newly permissive] = 1.35, 95% CI: 1.16, 1.57) and not significantly different than pre-RCR odds for students in delivery-only jurisdictions (OR [post-RCR term 5 × delivery-only] = 1.22, 95% CI: 1.01, 1.47). Both the newly restrictive and delivery-only jurisdictions had higher odds of any use in spring 2019—3 terms post-RCR and one term after statewide regulations that allowed delivery in every jurisdiction—than pre-RCR trends (OR [post-RCR term 3 × newly restrictive] = 1.22, 95% CI: 1.10, 1.35; OR [post-RCR term 3 × delivery-only] = 1.24, 95% CI: 1.03, 1.49).

Reading Discussion

Discussion

among 11th graders increased shortly following the opening of the RCR market in the State of California in all but medical delivery-only jurisdictions. This was followed by a slight downward trend for all but newly permissive and newly delivery-only jurisdictions. In contrast, previously declining patterns of frequent use reversed following RCR legalization, regardless of local allowance of storefronts or delivery. Odds of frequent use began rising immediately after state legal retail sales began and continued on an upward trajectory until spring 2020. The opposing trajectories of any and frequent use are consistent with a recent national study, which found a significantly lower likelihood of use overall but increased frequency of cannabis use among current adolescent users after RCR legalization [8].

Increases in adolescent frequent users are of deep concern since young frequent users are more likely to develop significant adverse health effects [29,30], including cannabis dependence [3], which may continue into adulthood. The growing diversification of cannabis products since states began legalizing recreational retail sales and notably the proliferation of high potency cannabis products [31] including vapes, dabs, and pre-rolls infused with tetrahydrocannabinol concentrates [31,32] and flavored products with appeal to youth [33], may be contributing to the increases in frequent use.

Although the increase in recent use among jurisdictions following state RCR legalization may be due to the novelty of new state legalization, the increase was subsequently mitigated among always restrictive, newly restrictive, and always permissive policy profiles. However, our findings suggest that the higher odds of use persisted among jurisdictions newly allowing recreational and medical storefronts and, to a lesser extent, among jurisdictions newly allowing recreational and medical delivery only. Before RCR, use rates among students in newly permissive and newly delivery-only jurisdictions were roughly as high as among students in always permissive jurisdictions. Thus, the difference in use trajectory post-RCR may have been driven by the relative increase in cannabis access and marketing compared to what youth were exposed to before local legalization, as opposed to a novelty effect. It may also be possible that newly permissive and newly delivery-only jurisdictions had less mature local regulatory systems than jurisdictions that had medical sales before state RCR. We have previously shown that there is a relative lack of regulations in delivery-only jurisdictions compared to those that allowed storefronts, such as requiring local licensing of delivery businesses and collecting licensing fees to fund compliance checks, restricting marketing to avoid youth seeing ads and encouraging youth to use, and passing a local tax [13,21], which can increase prices and decrease access among youth, who are especially price sensitive [34]. Home delivery risks increasing youth access due to unsupervised and less stringent age verification requirements versus a storefront retailer [35,36]. Research is needed to investigate how the variation in these other policies impacts differences in use trajectories.

Unlike in the other jurisdictions, any use by 11th graders in jurisdictions that newly permitted only medical cannabis delivery sales, did not increase immediately after statewide retail legalization and decreased in the terms following. This is consistent with previous studies that cannabis retail markets have lower impact on youth use compared to RCR ones [38]. Medical-only cannabis delivery markets may cultivate different retail, marketing, and normative environments. For example, limiting points of sale and the number of adults who can buy locally could decrease exposure to cannabis use among youth, and marketing with health claims is not appealing to youth [38].

Main analyses showed that both before and after state RCR implementation, the odds of any recent use of cannabis were lower in jurisdictions that banned all forms of retail compared to those that continuously allowed after 2018—with the exception of jurisdictions newly allowing medical delivery only—which is consistent with previous findings [15,16,17]. Our findings suggest that the differential rates of youth use across California were largely established before state recreational sales began, at least by fall 2015. Both behaviors and local policies may reflect predating local social norms. The phenomenon of low use rates preceding the passage of restrictive policies has been seen with tobacco control, such as the finding that local flavored e-cigarette bans were more common where e-cigarette use rates were already low [39]. Our findings underscore that cross-sectional studies of policy impacts on use rates cannot be interpreted in isolation from the pre-existing community behavioral norms, which may themselves spur local policy change.

We identified significant differences in sociodemographics across policy profiles, and we have previously described how adoption of local cannabis policies in California varied by sociodemographics, such as neighborhood deprivation and race and ethnicity [40]. Research should further explore patterns in local policy adoption, the role local policies may play in cannabis disparities, and the intersecting sociopolitical, historical, and economic contexts that may have given rise to both norms and local cannabis policies.

This study has several strengths. It is the first study to investigate the potential differential impact of state and local cannabis retail legalization on youth cannabis use using a nuanced multicategory measure of local policy; it also includes a large sample of both students and schools, a pre-legalization and post-legalization timeframe, and detailed information on respondents.

Several limitations do apply. Local policy variation goes beyond the profiles examined. It can regulate, for example, retailer density, taxation, products, and marketing, all of which may influence youth use of cannabis yet were not studied here [14,41]. This study assessed only the policy environment of schools and not homes. Furthermore, exposure across profiles from neighboring jurisdictions may have influenced behavior. In a large study of California teens in 2021, although half lived where cannabis storefronts were prohibited, the median drive time from home to the nearest storefront was still only 10 minutes [14]. Similarly, a short-lived (January 2019-November 2020) statewide policy that allowed licensed cannabis delivery to every jurisdiction [23]

may have influenced youth use behavior. Findings from the sensitivity analyses showed that odds of any use increased in the term directly after this policy was instituted in both newly restrictive and newly delivery-only jurisdictions, a portion of which had allowed delivery only from their jurisdiction before the policy, but no changes were seen in always restrictive jurisdictions or other policy profiles.

The survey cannabis question changed after 2016/2017, possibly influencing the increase in use in spring 2018. However, if question change was the main driver of reported use, we would expect a level increase and not a slope change in subsequent terms, which was not the case.

Determining which jurisdictions allowed medical sales pre-2018 based on tax data due to absence of state licensing may underestimate exposure, leading to overclassification of newly permissive jurisdictions and underclassification of always restrictive jurisdictions. Findings cannot be generalized to jurisdictions with local policy profiles outside the 6 we examined, such as those that newly banned or allowed retail sales or transitioned between types of retail allowed during 2018–2022. In addition, the study did not consider actual retail infrastructure, which may further differentiate use trajectories after RCR by local policy profile. The impact of pandemic school closures limited evaluation to only 5 terms post-RCR legalization, and broad policy and market changes may take more time before full effects on behavior are evident. The limited number of time points in the analysis reduces power [28]. The repeated cross-sectional design limits causal inference.

Conclusion

Given the extensive use of local control in state cannabis policy, the examination of how variation in these policies impact youth use is valuable. Among 11th graders, there was an increase in any recent cannabis use following California's 2018 legalization of recreational retail sales with the exception of newly medical delivery-only jurisdictions where rates declined. Elevated rates continued among newly permissive and, to a lesser extent, newly delivery-only jurisdictions. Frequent use of cannabis, which had been declining pre-RCR, increased immediately and continued to increase following state legalization. Any and frequent cannabis use among youth was markedly lower where all cannabis retail sales were banned both before and after state retail legalization, compared to where storefront sales were allowed. Increases in cannabis frequent use in adolescents post-legalization represents a concerning population health trend.

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Supplementary Data

Supplementary Material (/ui/service/content/url?section=static%2fimage&eid=1-s2.0-S1054139X25004173&path=1054139X%2FS1054139X25X00148%2FS1054139X25004173%2Fmmc1.docx)

Conflicts of interest: The authors have no conflicts of interest to disclose.

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