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RESEARCH REPORT

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Cannabis dispensary exposure and smoked, vaped and edible cannabis use among young adults: Comparison of web-scraped and government-maintained registries

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Abstract

Background and aims: The impact of exposure to cannabis dispensaries on young adult cannabis use may depend on how exposures and outcomes are defined. We estimated associations of dispensary exposure with young adult cannabis use across: (a) a government-maintained licensed dispensaries registry versus a web-scraped list of licensed and unlicensed dispensaries; and (b) varying modes of cannabis modes (i.e. smoked, edible, vaped).

Methods: This study used three waves of data (2021–2023) from a prospective cohort of n = 2277 young adults (mean baseline age = 22 years) from California, USA. Generalized linear models estimated the contemporaneous association of number of dispensaries within 1 mile of participants' homes with repeated measures of past 6-month, past 30-day frequency and past 30-day daily/near-daily (≥ 20 days/month) smoked, edible and vaped cannabis use (separate models for each product type). We compared associations for dispensary exposure derived from a government-maintained registry versus a validated web-scraped dispensary list.

Results: For each additional dispensary located within 1 mile of home, young adults had 5–6% increased risk of past 6-month use of smoked, edible and vaped cannabis use using registry data and 3–4% increased risk using web-scraped dispensary data. Dispensary exposure was positively associated with past 30-day frequency of smoked [incidence rate ratio (IRR)(registry list) = 1.08, 95% confidence interval (CI) = 1.01–1.15; IRR (web-scraped) = 1.04, 95% CI = 1.00–1.08] and edible [IRR(registry list) = 1.07, 95% CI = 0.99–1.15; IRR(web-scraped) = 1.04, 95% CI = 0.99–1.08] cannabis use, but was not consistently associated with cannabis vaping frequency or daily/near-daily use of any product. Magnitude of associations was generally smaller when using dispensary data derived through web-scraping than the government-maintained registry of dispensary licenses, though conclusions were mostly similar between the two lists and confidence intervals consistently overlapped.

Conclusions: Living near a greater number of cannabis dispensaries within 1 mile of home appears to be associated with an increased risk of cannabis use. Web-scraped dispensary sources and United States government-maintained registry lists produce similar conclusions regarding the association of living near a greater number of dispensaries with young adult cannabis use.

KEYWORDS
cannabis, density exposure, dispensaries, epidemiology, mode of cannabis use, young adults

INTRODUCTION

The prevalence of cannabis use among young adults has increased over the last decade in the USA [1], with approximately one-third (32%) of young adults aged 23–24 years reporting current use in 2023 and 11.9% reporting daily/near-daily use (i.e. use on ≥20 days/month) [2]. Young adults are more likely than other age groups to engage in frequent cannabis use [1, 3], and daily/near-daily cannabis use is now more prevalent than daily/near-daily alcohol use [4, 5]. Frequent and/or heavy cannabis use is associated with adverse health outcomes such as cannabis use disorder [6], acute and negative psychiatric symptoms [7], cannabis hyperemesis [8, 9] and respiratory symptoms [10], many of which require emergency department visits [11, 12]. Identifying factors that may contribute to young adult cannabis use is critical for informing potential interventions and/or cannabis regulations to protect young adults.

Brick-and-mortar cannabis retailers (i.e. dispensaries) are proliferating across the USA, with >15 000 dispensaries recorded in 2023 [13]. The commercialization of cannabis has led to a diversified market of cannabis products available to consumers, including smoked, vaped and edible cannabis products, and individuals living in states with cannabis legalization are more likely to use alternative methods of cannabis administration (e.g. vapes, edibles) [14–19]. The growth in legal cannabis retailers and expanding commercialization could increase the risk of cannabis use among young adults by directly increasing access for those who can legally purchase cannabis (i.e. those aged 21 years and older), or through product diversion to young adults under the legal purchasing age [20–23]. Exposure to cannabis retailers could also influence cannabis use through increased exposure to outward-facing marketing displays [24, 25] and other shifts in cultural norms and harm perceptions [22, 26, 27]. A 2024 systematic review identified three studies examining the association of cannabis retail access near homes with frequent cannabis use among young adults in the USA [28], all of which found positive associations [22, 25, 29]. However, the studies mostly analyzed data collected prior to (or just after) adult-use legalization policies, before the maturation of commercialized cannabis markets. It is unknown whether exposure to dispensaries is differentially associated with the use of certain products that may be more accessible and have rapidly grown in popularity in a commercial market (e.g. edibles, vape products).

Studies that examine dispensary density use two different potential sources for exposure data, including government-maintained registries of licensed dispensaries regulated by the state, and/or lists generated through web-scraping methods in which dispensaries are identified through listings on websites such as Yelp, Leafly and/or Weedmaps [23, 30–32]. Government-maintained registries are easily accessible online (depending on the state), but fail to capture unlicensed dispensaries, the presence of which vary by state. For example, in 2020 unlicensed dispensaries represented approximately 60% of total active brick-and-mortar dispensaries in California [32, 33] (though licensing procedures and the formal establishment of the Bureau of Cannabis Control have likely reduced the number of unlicensed dispensaries in the state) [34]. In contrast, dispensary address data sourced from web services can capture both licensed and unlicensed retailers and may be more suited to national analyses, as not all states use similar approaches to maintain (or make available) dispensary registry lists [30]. But web scraping and the required cleaning and deduplication processes involved are time and computationally intensive. Web scraping may also overestimate the total number of dispensaries, as closed businesses may still have a presence online and relocated businesses may not update their addresses online.

It is unknown whether associations of dispensary exposure with cannabis use outcomes differ depending on the source of dispensary data used. Efforts have been made to compare the accuracy and validity of registry versus web-scraped dispensary lists, and studies have found that web-scraped lists and government-maintained registries have similar operating status accuracy (i.e. percentage of identified dispensaries that are open and active), but web-scraped lists have lower location accuracy (i.e. precision of address coordinates) [30]. Understanding implications of the exposure data source on associations with cannabis use outcomes is critical, as even small levels of misclassification (i.e. under- or over-estimating levels of dispensary exposure) can substantially impact measures of association [35]. Additionally, the retail environment of unlicensed versus licensed dispensaries may differ, leading to heterogeneous effects on cannabis use for government-maintained registries and web-scraped lists. Unlicensed dispensaries may be more likely to sell products with child-appealing packaging and allow on-site consumption [36], which may exert greater influence on young adult behaviors. However, licensed dispensaries are allowed to clearly advertise their presence with marketing materials that may enhance the influence of dispensary exposure on cannabis use [24, 25]. Thus, it is not clear whether including unlicensed retailers in dispensary exposure variables would increase or attenuate associations with cannabis use.

In the current study, we examined whether Californian young adults who live near a greater number of dispensaries are at greater risk of cannabis use and cannabis use frequency over three longitudinal waves of semi-annual data collection. Cannabis use behaviors were differentiated by smoked, vaped and edible cannabis use. We compared two sources of cannabis dispensary exposure data—addresses of licensed dispensaries obtained from the California Department of Cannabis Control list and addresses of licensed and unlicensed dispensaries obtained via validated web-scraping methods—to determine whether associations were sensitive to the exposure data source.

METHODS

Participant data source

Data were from three waves of the Happiness and Health Study (H&H), a prospective cohort study of young adults from the Los Angeles metropolitan area [37]. Participants were recruited from 10 Los Angeles high schools during 9th grade in 2013 and were surveyed in-class semi-annually throughout high school (eight high school waves; *n* = 3396). After high school, participants reconsented as young adults (*n* = 2601; 76.6% of the original sample), and were emailed a link to complete surveys online approximately annually between 2018 and 2023 (six young adult waves; giving 14 waves of data collection in total). The current study used data from the three most recent young adult survey waves: wave 12 (November 2021–April 2022; median = 28 November 2021), wave 13 (July 2022–February 2023; median = 22 August 2022) and wave 14 (July 2023–December 2023; median = 21 July 2023). All included survey waves occurred after California initiated legal sales of cannabis to adults in January 2018 (the law legalizing adult use passed in November 2016).

Participants provided home address data at each wave, representing their address at the time of data collection. If address data were missing at a given wave, data were imputed based on the most recent previously reported address. Addresses from waves 1–14 were geocoded to obtain the latitude and longitude coordinates of the home location. Geocodes were assigned a quality value based on the precision of coordinates, with precise geocodes defined as addresses representing a sub-address, point address or street address [38]. Participants were eligible for the current study if they participated in waves 12, 13 and/or 14 of H&H, resided in California and met the definition of a precise geocode. Out of *n* = 2601 participants who had reconsented as adults in H&H, *n* = 2277 were eligible and included in the analytic sample. Compared with excluded participants, those included in the analytic sample were more likely to be female and enrolled in a degree program, but did not differ meaningfully in financial status, race or area-level social vulnerabilities (Table S1).

Dispensary data sources

We obtained dispensary data from two separate sources. The first was the official state government-maintained registry list of licensed cannabis dispensaries in California. Data on licensed cannabis dispensaries are from the California Department of Cannabis Control. This report includes all licensed dispensaries in California, with type of license [adult use (recreational) and/or medical], retailer name and address, and license issue and expiration date. The list is updated on a rolling basis, and for the current study we used three lists downloaded on 1 March 2022, 3 August 2022 and 4 October 2023 to capture changes in licensed dispensaries over the follow-up period [39].

The second data source was a list of dispensaries obtained through validated web-scraping methods [30]. In January 2022, June 2022 and June 2023, the name, location and geocoordinates of cannabis retailers were obtained from web services that advertised cannabis retailer information (i.e. CANORML, Kushguide, Leafly, Weedmaps, Yelp) across 26 states and DC (resulting in three separate retailer lists to capture changes in dispensaries over the course of the follow-up). Details on web-scraping procedures and post-collection deduplication and cleaning processes were reported previously [30]. For the current study, we restricted the data set to dispensaries within California, and to entries where the meta-data that accompanied the original web-scraped postings contained a positive indication of a storefront to reduce the probability of false-positive dispensaries and the influence of misclassification on associations. We searched the combined metadata from each deduplicated observation for keywords (e.g. 'storefront', 'dispensary', 'retail') and flagged observations as a storefront if a keyword was present.

Measures

Dispensary exposure

Our primary exposure variables were count of dispensaries within 1-mile circular buffers surrounding participants' homes, which we calculate using the registry and web-scraped dispensary lists separately. We linked participant addresses at each wave with dispensary addresses collected across the three time points to produce time-varying exposure measures of dispensary counts. Using the ArcGIS Pro Buffer Tool, we defined a 1-mile radius around home addresses (i.e. an egocentric circular buffer) and counted the number of dispensaries completely contained within each buffer. Dispensary exposure variables were analyzed as raw continuous variables and were also categorized into 0, 1, 2 or 3+ dispensaries within 1 mile of home. A cut-off of three or more dispensaries was used as an upper cut-off for the categorical exposure because—for both retail sources—it represented the 75th percentile of dispensary counts among participants exposed to one or more dispensary. The 1-mile radius was chosen to focus on the influences of one's proximal neighborhood environment, based on dispensaries within walking distances (or very short driving distances) of participants' homes. In secondary analyses, we examined 0.5-mile buffers to capture dispensaries closer to home as well as 2- and 4-mile buffers, which capture dispensaries within biking and driving distance and were the distances used in prior studies [25, 29].

Cannabis outcomes

At each wave, participants reported whether they had used smoked, edible and/or vaped cannabis in the past 6 months (yes/no, separately by product type). Participants also reported the number of days in the past 30 days that they used each product type (response options: 0, 1–2, 3–5, 6–9, 10–19, 20–29, 30 days), which we recoded as a quantitative count variable by taking the mean integer within each response range (e.g. 0, 2, 4, 8, 15, 25, 30), as in previous work [40]. We also created a binary outcome for daily/near-daily use of each product, defined as use on ≥20 versus 0–19 days in the past 30 days, separately by product type.

Covariates

At wave 12 (baseline), participants self-reported sex (male, female), race and ethnicity [Hispanic, non-Hispanic: White, Asian American or Pacific Islander, Black or African American, multiracial, another race (American Indian or Alaska Native, another race not listed)], subjective financial situation growing up since birth [41] (well-off, average, struggling or in poverty, or varied financial status) and whether they were enrolled in a degree program (yes, no or do not know). We linked the participant home census tract with its corresponding 2022 social vulnerability index (SVI) to control for area-level socio-economic status (SES) and racial/ethnic minority status [42]; SVI scores range from 0 to 1, with higher levels indicating greater social vulnerability.

Analysis

Data were restructured in long form as three observations per person corresponding to waves 12–14 to examine the association of time-varying dispensary exposure with repeated measures of past 6-month frequency, past 30-day frequency and daily/near-daily cannabis use outcomes in waves 12–14. We fitted repeated-measures generalized linear models (GLMs) separately for each outcome and each dispensary exposure, adjusting for time interval and all covariates. For binary outcomes of past 6-month use and daily/near-daily use, we estimated risk ratios (RRs) with 95% confidence intervals (95% CIs) using GLMs with a Poisson distribution and log-link function (i.e. modified Poisson models) [43]. For the count outcome of past 30-day frequency we estimated incidence rate ratios (IRRs) with 95% CIs by fitting GLMs with negative binomial distributions and log-link functions. Models used generalized estimating equations with an independence correlation structure to produce standard errors robust to repeated outcome measures. Sensitivity analyses examined whether estimates were robust to alternative modeling approaches that accounted for geographic clustering (i.e. mixed-effects models with a random intercept for census tract).

To quantify differences in the magnitude of associations when using exposure derived via government-maintained registry versus web-scraped dispensary data sources, we calculated the relative difference in RRs as [RR(registry) – RR(web scraped)]/RR(web scraped) for each outcome.

Missing data ranged from 10.6% (cannabis outcomes) to 12.4% (perceived financial status). We used multiple imputation with the fully conditional specification method and 10 imputed data sets to address missing covariate and outcome data, and results were pooled across imputations to obtain correct variance estimates in imputed values. Given that null hypothesis testing has contributed to a reproducibility crisis in science [44], and following guidance issued by the American Statistical Association [45], we interpret each estimate based on the magnitude of the point estimate (i.e. RR or IRR) and the precision of the 95% CI, rather than based on the statistical significance of the *P*-value. The analysis was not pre-registered and results should be considered exploratory.

RESULTS

The sample of 2277 young adults contributed 6710 observations and were on average 22.6 years of age at wave 12 and were predominately female (58.9%) and Hispanic (48.5%) (Table 1). Overall, 36.9% reported their financial status as living comfortably, and 42.7% were enrolled in a degree program. The mean SVI score was 0.48 for the area-level SES index and 0.65 for the area-level racial/ethnic minority index. Participants with zero dispensaries near their homes were more likely than those with three or more dispensaries (for both data sources) to have higher area-level SES and higher percentage of racial/ethnicity minority residents.

The web-scraped dispensary list captured a greater number of dispensaries within the 1-mile home buffers than the registry list (Tables 1 and S2). When using the registry dispensary list, 85.8% of participants had zero dispensaries and 4.7% had three or more dispensaries within 1 mile of their home (range = 0–22 dispensaries). For the web-scraped list, 66.4% of participants had zero dispensaries and 9.8% had three or more dispensaries within 1 mile of their home (range = 0–32 dispensaries). Among participants with one or more dispensary within their 1-mile home buffers, the median number of dispensaries was 2.0 (IQR = 1–3) for the registry list and 1.0 (IQR = 1–3) for the web-scraped list. The two dispensary exposures were positively correlated among participants, with the correlation increasing with larger buffer sizes (Pearson's *R*: 0.5 mile = 0.682; 1 mile = 0.828; 2 mile = 0.899, 4 mile = 0.894) (Table S3).

Associations with past 6-month cannabis use

A greater number of dispensaries within 1 mile of participants' homes was associated with a greater risk of past 6-month use of smoked, edible and vaped cannabis for exposures derived using both the government-maintained registry and the web-scraped dispensary list (Table 2). When using the government-maintained registry, the adjusted RRs for continuous exposure (i.e. number of dispensaries) were 1.06 (95% CI = 1.03–1.09), 1.05 (95% CI = 1.02–1.08) and 1.05 (95% CI = 1.02–1.08) for past 6-month use of smoked, edible and vaped cannabis, respectively. When using the web-scraped list, the RRs were 1.04 (95% CI = 1.02–1.05), 1.03 (95% CI = 1.01–1.05) and 1.03 (95% CI = 1.01–1.05) for past 6-month use of smoked, edible

TABLE 1 Characteristics of young adult participants overall and by cannabis dispensary exposure (n = 6710 observations).

		Number of dispensaries within 1 mile of home							
		Government-maintained registry list				Web-scraped dispensary list			
	Overall sample[a]	0	1	2	≥3	0	1	2	≥3
Total, *n* (%)	6710 (100)	5758 (85.8)	462 (6.9)	175 (2.6)	315 (4.7)	4453 (66.4)	1161 (17.3)	440 (6.6)	656 (9.8)
Age, years, M (SD)	22.6 (0.40)	22.6 (0.40)	22.6 (0.38)	22.7 (0.35)	22.7 (0.44)	22.6 (0.40)	22.7 (0.42)	22.6 (0.37)	22.7 (0.42)
Sex, %									
Male	41.1	41.8	34.0	36.0	41.0	42.3	38.2	38.6	39.0
Female	58.9	58.2	66.0	64.0	59.1	57.7	61.8	61.4	61.0
Race, %									
Hispanic	48.5	48.1	59.5	42.3	42.9	45.0	62.9	52.7	44.2
Asian	18.2	19.0	11.3	10.3	19.4	22.0	9.1	7.5	16.2
Black	4.6	4.5	2.6	7.4	8.9	4.4	3.4	7.3	6.9
White	14.2	14.2	14.3	20.6	11.4	14.4	13.1	14.1	15.1
Another	14.4	14.3	12.3	19.4	17.5	14.3	11.5	18.4	17.7
Financial status, %									
Live comfortably	36.9	38.1	27.7	26.3	33.7	39.7	33.8	26.8	30.0
Meet needs with little left	34.1	33.2	45.2	36.6	32.4	33.4	33.8	41.8	33.7
Just meet basic expenses	22.7	22.5	20.1	28.0	26.7	20.6	25.6	28.2	27.9
Do not meet basic expenses	6.4	6.2	6.9	9.1	7.3	6.2	6.9	3.2	8.4
Enrolled in degree program, %									
No	54.4	54.0	58.0	50.3	58.1	53.9	56.4	50.9	56.1
Yes	42.7	42.9	39.2	49.7	40.0	43.2	40.0	46.8	41.2
Do not know	3.0	3.1	2.8	0	1.9	2.9	3.6	2.3	2.7
SVI score, M (SD)									
SES index	0.48 (0.23)	0.45 (0.23)	0.66 (0.21)	0.55 (0.23)	0.60 (0.27)	0.44 (0.22)	0.55 (0.24)	0.54 (0.23)	0.57 (0.26)
Race/ethnicity index	0.65 (0.22)	0.65 (0.21)	0.69 (0.26)	0.50 (0.23)	0.56 (0.25)	0.66 (0.21)	0.70 (0.21)	0.55 (0.25)	0.56 (0.25)

Abbreviations: M = mean; SD = standard deviation; SES = socio-economic status; SVI = social vulnerability index.
[a]Represents 6710 observations over three waves of follow-up for 2277 unique individual participants.

TABLE 2 Association of dispensaries within 1 mile of participants homes with past 6-month cannabis use.

	Government-maintained registry list			Web-scraped dispensary list			
	Past 6-month use (%)	RR[a]	95% CI	Past 6-month use (%)	RRa	95%CI	Relative difference in RRs[b]
Smoked cannabis							
0 dispensaries	33.3	Ref.	Ref.	32.2	Ref.	Ref.	–
1 dispensary	34.4	1.02	0.86–1.20	36.0	1.08	0.96–1.22	−5.6%
2 dispensaries	43.1	1.24	0.97–1.58	37.3	1.09	0.92–1.29	13.8%
≥3 dispensaries	47.6	1.42	1.19–1.70	43.8	1.31	1.14–1.50	8.4%
Continuous	–	1.06	1.03–1.09	–	1.04	1.02–1.05	1.9%
Edible cannabis							
0 dispensaries	27.3	Ref.	Ref.	26.5	Ref.	Ref.	
1 dispensary	30.9	1.18	0.98–1.41	28.7	1.10	0.96–1.25	7.3%
2 dispensaries	34.7	1.23	0.93–1.62	32.6	1.20	0.99–1.45	2.5%
≥3 dispensaries	36.9	1.35	1.10–1.66	35.3	1.30	1.11–1.52	3.9%
Continuous	–	1.05	1.02–1.08	–	1.03	1.01–1.05	1.9%
Vaped cannabis							
0 dispensaries	30.1	Ref.	Ref.	29.8	Ref.	Ref.	
1 dispensary	33.4	1.11	0.93–1.32	31.2	1.03	0.91–1.17	7.8%
2 dispensaries	39.5	1.29	1.00–1.67	33.1	1.06	0.88–1.27	21.7%
≥3 dispensaries	38.9	1.34	1.10–1.63	37.2	1.23	1.06–1.43	8.9%
Continuous	–	1.05	1.02–1.08	–	1.03	1.01–1.05	1.9%

[a]Models adjusted for survey wave, sex assigned at birth, race/ethnicity, perceived financial status, enrollment in degree program and area-level socio-economic status and area-level racial/ethnic minority status.
[b]Relative difference in risk ratios (RRs) calculated as [RR(registry) – RR(web scraped)]/RR(web scraped).

and vaped cannabis, respectively. Having three or more dispensaries within 1 mile of home was associated with an approximately 30%–40% increased risk of past 6-month cannabis use when using the government-maintained registry, and was associated with an approximately 20%–30% increased risk when using the web-scraped list.

Associations with daily/near-daily cannabis use

An increasing number of dispensaries within 1 mile of participants' homes was associated with a greater risk of daily/near-daily smoked cannabis for the government-maintained registry (RR = 1.06, 95% CI = 1.00–1.12), while RRs for continuous exposure were comparatively attenuated for the web-scraped list (RR = 1.02, 95% CI = 0.99–1.06) (Table 3). Risk of daily/near-daily smoked and edible cannabis use was elevated among participants with three or more (vs zero) dispensaries near home for exposure derived from the government-maintained registry (RR smoked cannabis = 1.27, 95% CI = 0.90–2.78; RR edible cannabis = 1.32, 95% CI = 0.74–2.35) and from the web-scraped list (RR smoked cannabis = 1.26, 95% CI = 0.97–1.64; RR edible cannabis = 1.21, 95% CI = 0.74–1.99); however, the confidence intervals were wide and indicated a range of associations, including none. There was no consistent evidence that a greater number of dispensaries was associated with an increased risk of daily/near-daily cannabis vaping for either exposure data source.

Associations with past 30-day cannabis use frequency

The count of dispensaries within 1 mile of participants' homes was positively associated with past 30-day frequency of smoked cannabis use and edible cannabis use for registry-derived exposures (IRR smoked cannabis = 1.08, 95% CI = 1.01–1.15; IRR edible cannabis = 1.07, 95% CI = 0.99–1.15) and web-scraped exposures (IRR smoked cannabis = 1.04, 95% CI = 1.00–1.08; IRR edible cannabis = 1.04, 95% CI = 0.99–1.08) (Table 4). Having three or more (vs zero) dispensaries was associated with an approximately 50%–60% increased rate of smoked and edible cannabis use days for registry-derived exposures and an approximately 40% increased rate of smoked and edible cannabis use days for web-scraped exposures. For both exposure data sources, living near a greater number of dispensaries was not consistently associated with past 30-day cannabis vaping frequency.

Differences in associations by dispensary exposure data source

The magnitude of differences in point estimates for the registry versus web-scraped exposures ranged from 56.1% lower (two vs zero dispensaries for daily/near-daily edible use) to 62.8% higher (two vs zero dispensaries for daily/near-daily vaped cannabis) and 69.4% of

TABLE 3 Association of dispensaries within 1 mile of participants homes with past 30-day daily/near-daily cannabis use.

	Government-maintained registry list			Web-scraped dispensary list			
	Daily/near-daily use (%)	RR[a]	95% CI	Daily/near-daily use (%)	RR[a]	95% CI	Relative difference in RRs[b]
Smoked cannabis							
0 dispensaries	9.0	Ref.	Ref.	8.7	Ref.	Ref.	–
1 dispensary	11.1	1.13	0.83–1.53	10.3	1.08	0.86–1.36	4.6%
2 dispensaries	12.6	1.23	0.77–1.98	9.2	0.93	0.65–1.34	32.3%
≥3 dispensaries	12.9	1.27	0.90–1.78	12.9	1.26	0.97–1.64	0.8%
Continuous	–	1.06	1.00–1.12	–	1.02	0.99–1.06	3.9%
Edible cannabis							
0 dispensaries	3.1	Ref.	Ref.	3.0	Ref.	Ref.	
1 dispensary	2.7	0.80	0.41–1.56	2.9	0.88	0.53–1.47	−9.1%
2 dispensaries	2.3	0.58	0.13–2.50	4.2	1.32	0.71–2.43	−56.1%
≥3 dispensaries	5.0	1.32	0.74–2.35	4.2	1.21	0.74–1.99	9.1%
Continuous	–	1.02	0.91–1.14	–	1.00	0.94–1.07	2.0%
Vaped cannabis							
0 dispensaries	7.8	Ref.	Ref.	7.8	Ref.	Ref.	
1 dispensary	7.0	0.90	0.61–1.32	8.2	1.00	0.77–1.29	−10.0%
2 dispensaries	10.3	1.27	0.75–2.16	6.3	0.78	0.50–1.22	62.8%
≥3 dispensaries	5.9	0.76	0.47–1.25	7.6	0.93	0.67–1.29	−18.3%
Continuous	–	0.95	0.87–1.04	–	0.96	0.91–1.01	−1.0%

[a]Models adjusted for survey wave, sex assigned at birth, race/ethnicity, perceived financial status, enrollment in degree program, and area-level socio-economic status and area-level racial/ethnic minority status. Daily/near-daily cannabis use defined as ≥20 versus 0–19 days in the past 30 days.
[b]Relative difference in risk ratios (RRs) calculated as RR(registry) − RR(web scraped)/RR(web scraped).

TABLE 4 Association of dispensaries within 1 mile of participants' homes with past 30-day frequency of cannabis use.

	Government-maintained registry list			Web-scraped dispensary list			
	Mean frequency	IRR[a]	95% CI	Mean frequency	IRR[a]	95% CI	Relative difference in RRs[b]
Smoked cannabis							
0 dispensaries	3.68	Ref.	Ref.	3.58	Ref.	Ref.	
1 dispensary	4.25	1.10	0.81–1.49	4.04	1.05	0.85–1.31	4.8%
2 dispensaries	5.19	1.29	0.77–2.14	3.80	0.97	0.69–1.37	33.0%
≥3 dispensaries	5.62	1.54	1.06–2.24	5.33	1.38	1.04–1.83	11.6%
Continuous	–	1.08	1.01–1.15	–	1.04	1.00–1.08	3.9%
Edible cannabis							
0 dispensaries	1.73	Ref.	Ref.	1.68	Ref.	Ref.	
1 dispensary	1.84	1.10	0.76–1.58	1.72	1.04	0.79–1.36	5.8%
2 dispensaries	1.82	0.97	0.51–1.86	2.27	1.35	0.91–2.00	−28.3%
≥3 dispensaries	2.88	1.58	1.03–2.41	2.45	1.37	0.98–1.91	15.3%
Continuous	–	1.07	0.99–1.15	–	1.04	0.99–1.08	2.9%
Vaped cannabis							
0 dispensaries	3.36	Ref.	Ref.	3.33	Ref.	Ref.	
1 dispensary	3.26	1.00	0.71–1.41	3.52	1.01	0.80–1.28	−1.0%
2 dispensaries	4.15	1.16	0.67–2.02	3.20	0.96	0.67–1.39	20.8%
≥3 dispensaries	3.45	1.04	0.69–1.57	3.67	1.08	0.79–1.46	−3.7%
Continuous	–	1.02	0.96–1.09	–	1.01	0.97–1.05	1.0%

[a]Models adjusted for survey wave, sex assigned at birth, race/ethnicity, perceived financial status, enrollment in degree program, and area-level socio-economic status and area-level racial/ethnic minority status.
[b]Relative difference in incidence rate ratios (IRRs) calculated as [IRR(registry) − IRR(web scraped)]/IRR(web scraped).

RRs differed by <10% (Tables 2–4). Greater relative differences were observed for the categorical exposure comparisons than for the continuous exposure measure; for categorical comparisons, 40.7% of estimates differed by >10%, while none of the continuous exposure RRs differed by >10%. Across nearly all outcomes, the estimates for registry-derived dispensary exposure were larger in magnitude than exposure derived from web scraping for the continuous exposure measures and comparing three or more vs zero dispensaries.

Sensitivity analyses

In secondary analyses, we examined the exposure to dispensaries within 0.5, 2 and 4 miles of participants' homes to capture exposures within the immediate vicinity as well as within biking and driving distances (Tables S4–S6). Associations with dispensaries within smaller and wider buffers mostly followed a similar pattern as the main analysis, though the RRs and IRRs for continuous exposure became increasingly attenuated as the home buffers increased in size. For example, each additional dispensary was associated with a 7%–14% increased risk of past 6-month cannabis use for 0.5-mile buffers, a 1%–2% increased risk of past 6-month cannabis use for 2-mile buffers and a 0.3%–0.7% increased risk of past 6-month use for 4-mile buffers. Associations derived from 0.5-mile buffers were also more imprecise (i.e. had wider confidence intervals) owing to lower exposure prevalence. Accounting for geographic clustering in multi-level models did not meaningfully change the estimates (Table S7).

DISCUSSION

In this prospective cohort study of young adults from California, living near a greater number of cannabis dispensaries within 1 mile of home was associated with an increased risk of smoked, edible and vaped cannabis use, with some differences observed in associations based on frequency of use, product type and dispensary data source. Although the web-scraped list included a greater number of dispensaries, the magnitude of associations of dispensary exposure with cannabis use outcomes was generally smaller when using web-scraped dispensary data than when using data from a government-maintained registry of dispensary licenses—though the conclusions were similar between the two lists and the confidence intervals consistently overlapped. Measures of association attenuated when expanding the geographic radius to 2 and 4 miles and became stronger when reducing the radius to 0.5 miles.

The findings of this study are consistent with earlier research demonstrating positive associations of exposure to cannabis dispensaries with cannabis use frequency in young adults [22, 25, 29]. The study provides evidence that such associations persisted for dispensaries within 1 mile of participants' homes, with the unique contribution of this study demonstrating such associations for past 6-month use of smoked, vaped and edible cannabis use. Associations with cannabis use became markedly weaker for dispensaries within 2 and 4 miles of participants' homes, which may be attributed to the growing scale of the cannabis market in California. For example, in 2018 there were 448 total licensed dispensaries in California [33]. In contrast, there were 900 licensed dispensaries in March 2022 and over 1200 in October 2024 [46]; the majority (68%) of young adults in this study lived within 4 miles of at least one licensed dispensary. The growing availability of dispensaries within driving distance in California may reduce the novelty of dispensary access and thus have a more limited influence on behavior compared with more proximal access directly near homes. In this study, associations for exposure to three or more (vs zero) dispensaries within 1 mile of participants' homes were relatively large (e.g. a 50% increased risk for some outcomes), suggesting that living in communities with a high saturation of cannabis dispensaries close to home may drive a substantial portion of the attributed risk for cannabis use. Future studies should confirm the plausibility of the magnitude of such associations.

While dispensary exposure was consistently associated with past 6-month use of smoked, edible and vaped cannabis, the associations with past 30-day use frequency appeared most consistently across primary and sensitivity analyses for smoked cannabis, followed by edible cannabis, with less consistent associations observed for vaped cannabis. Although cannabis dispensaries may have contributed to an increased availability of alternative cannabis product types, dried cannabis flower represents the largest portion of market share for products sold in dispensaries [47]. Smoking cannabis is also the most common mode of cannabis use among adults in the USA [48] and was the most prevalent mode reported in the current study. Further, an individual who is smoking cannabis frequently may diminish their dried cannabis flower faster than other modes of use, requiring more trips to dispensaries. Vaping, in particular, is an efficient form of tetrahydrocannabinol (THC) delivery, with cannabis concentrates often containing potencies of >90% THC, and thus a smaller amount may be needed to obtain the same psychoactive effect as smoking dried cannabis flower (e.g. titration), resulting in fewer trips to dispensaries [49]. Flower also tends to be less expensive than concentrates, and younger populations may be more sensitive to pricing [50]. Finally, there is a growing availability of vaped and edible hemp-derived cannabis products available online and in tobacco retailers, such as smoke and vape shops, which may diminish the effects of dispensary access on the use of vapes and edibles [51].

In general, associations of dispensary exposure with cannabis use outcomes were slightly stronger in magnitude when using lists of dispensaries derived from the government-maintained registry than those obtained through web scraping, though the 95% CIs overlapped in all cases. One possible explanation is that there are heterogeneous effects of licensed versus unlicensed dispensaries on cannabis use, whereby licensed dispensaries have a stronger impact on young adult use behaviors. To avoid detection, unlicensed dispensaries often have no exterior signage indicating the clear presence of a cannabis retailer [46], while licensed dispensaries are allowed to clearly advertise their presence, products and promotions. Store signage indicating cannabis retail is one of the main hypothesized mechanisms through which dispensary exposure influences cannabis use behaviors (i.e. through marketing effects and normalization), and thus by only including licensed dispensaries in the government-maintain registry, we may be selecting for exposure that has a greater impact [24, 25].

Another possible explanation could be differences in misclassification between the government registry and web-scraped list. Prior work demonstrates that location accuracy is lower in web-scraped data than in government-maintained registries [30], which may have resulted in more misclassification of dispensary exposure within the relatively small geographic area of 1-mile buffers. Additionally, web-scraped lists may be more likely than government registries to include false-positive dispensaries; retailers that no longer exist might continue to be listed online, addresses may not have been updated online or retailers may have been falsely flagged as a dispensary storefront when it was a delivery service or non-cannabis business. In general, non-differential misclassification of exposure most often results in the attenuation of true associations (i.e. bias towards the null), with some exceptions (e.g. when measurement error is related to the true value of the exposure) [52]. Differences in estimates between data sources were greater when continuous dispensary variables were categorized based on the upper quartile of exposure. However, the majority of associations differed by <10% between data sources and though the magnitude of risk ratios differed, the overall conclusions for each outcome were mostly similar for both exposure data sources. Thus, findings from this study provide evidence that both sources of data may be appropriate for analyses examining the effects of dispensary exposure on cannabis use, particularly when continuous exposure specifications are used.

Limitations

This study has limitations, including the potential for outcome misclassification owing to self-reported cannabis use. The dispensary dates also did not always align with the beginning of each cohort wave; although reverse causation is unlikely, as individual behaviors are unlikely to affect exogenous dispensary exposure, young adults who use cannabis may move to neighborhoods with more cannabis access. Additionally, dispensary list dates did not perfectly align with one another, which could contribute to differences in observed associations across the two lists. We also did not have data on exposure to exterior advertisements and storefront signage, which may be an important mechanism for associations [24, 25]. Our study also only focused on the dispensary density of brick-and-mortar outlets, which does not fully capture the complex market behaviors of legal cannabis (e.g. online, home delivery, visiting stores outside of one's home neighborhood, etc.). Further, we were unable to clearly identify which dispensaries in the web-scraped list were licensed versus unlicensed. While the web-scraped dispensary list captured a larger number of potential dispensaries, it is not clear whether the differences in exposure levels reflect unlicensed dispensaries versus false positives in web-scraped data and overestimation of exposure, particularly as California has recently barred unlicensed dispensaries from advertising on certain cannabis websites, such as Weedmaps and Yelp [53, 54]. Although there may be several mechanisms underlying the differences in observed associations between the web-scraped and government lists (e.g. licensing status, location accuracy, under/over-counting existing dispensaries, etc.), the study still provides a valuable comparison of two commonly used data sources for dispensary density and suggests that both provide similar conclusions regarding the influence on young adult cannabis use. This information is particularly valuable given that web-scraped lists are likely more accessible for national examinations of dispensary density, given the heterogeneity across states in licensing and tracking systems.

CONCLUSION

Commercialized cannabis markets continue to expand in California and across the USA as young adults report increasingly frequent use of a range of cannabis products. This study reinforces that access to cannabis dispensaries may be associated with young adult cannabis use, including smoked, vaped and edible cannabis use. This study also provides important methodological considerations for future research that aims to examine the influence of local access to dispensaries on cannabis use behaviors. Regardless of the source of dispensary data, there was a consistent positive association of living near a greater number of dispensaries with cannabis use behaviors among young adults, suggesting that both web-scraped dispensary sources and government-maintained registry lists may produce similar conclusions.

AUTHOR CONTRIBUTIONS

Alyssa F. Harlow: Conceptualization (equal); formal analysis (equal); funding acquisition (equal); methodology (equal); writing—original draft (equal); writing—review and editing (equal). **Michael P. Williams:** Data curation (equal); writing—review and editing (equal). **Rosalie Liccardo Pacula:** Methodology (equal); writing—review and editing (equal). **Adam Leventhal:** Investigation (equal); supervision (supporting); writing—review and editing (equal). **Eric R. Pedersen:** Methodology (equal); writing—review and editing (equal). **Myles G. Cockburn:** Methodology (equal); supervision (supporting); writing—review and editing (equal). **Laura K. Thompson:** Data curation (equal); writing—review and editing (equal). **Junhan Cho:** Methodology (equal); writing—review and editing (equal). **Jessica L. Barrington-Trimis:** Investigation (equal); supervision (equal); writing—review and editing (equal). **Danielle F. Haley:** Data curation (equal); investigation (equal); methodology (equal); supervision (equal); writing—review and editing (equal).

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DECLARATION OF INTERESTS

None to declare.

DATA AVAILABILITY STATEMENT

Data may be made available upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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