Associations between recreational cannabis legalisation and disparities in use and co-use of tobacco and cannabis

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ABSTRACT

Background Recreational cannabis legalisation has been associated with increases in adult cannabis use. However, it is unclear whether legalisation is driving the rising levels of co-use of tobacco and cannabis.

Methods We linked 2016–2023 Behavioural Risk Factor Surveillance System data on 854 878 adults aged 18+ years from 38 states with data on state recreational cannabis legalisation and retail sales availability. Using multinomial logit regression models, we examined the associations between legalisation and the use and co-use of tobacco and cannabis overall and by demographic (age, sex, education, race and ethnicity) and higher-risk (mental health, alcohol use) strata, with demographic and policy controls and state and year fixed effects.

Results Recreational cannabis legalisation was associated with overall increases in cannabis-only use (adjusted relative risk ratio (aRRR) 1.88; 95% CI 1.78 to 1.99) and co-use of tobacco and cannabis (1.44; 1.34 to 1.54) compared with no use, and with decreases in tobacco-only use (0.87; 0.83 to 0.91). Similar patterns emerged in response to the start of cannabis retail sales. There was some evidence of increases in co-use of tobacco and cannabis post-legalisation and/or retail sales among adults aged 18–24 and 55+ years, with a high school degree or higher, and who identified as White or Black. No differential effects for co-use emerged across higher-risk strata.

Conclusion Recreational cannabis legalisation is increasing cannabis-only use and co-use of tobacco and cannabis, including rises in co-use among populations with lower levels of cannabis use. Increased surveillance of and screening for co-use of tobacco and cannabis can help inform public health responses to legalisation.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ States have been legalising cannabis for recreational use since 2012 and there is evidence that legalisation increases adult cannabis use.
⇒ Whether legalisation is associated with changes in the co-use of tobacco and cannabis separately from cannabis use alone remains understudied.

WHAT THIS STUDY ADDS

⇒ Recreational cannabis legalisation and the start of cannabis retail sales were associated with overall increases in cannabis-only use and co-use of tobacco and cannabis versus no use, alongside declines in tobacco-only use.
⇒ These shifts in use were similar across higher risk populations and groups with historically lower levels of cannabis use.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Policymakers and public health professionals must collaborate to increase awareness of rising levels of tobacco and cannabis co-use and develop broad outreach strategies.
⇒ Population-level surveillance is needed to monitor trends in co-use following legalisation, alongside implementing universal screening for co-use in clinical settings.
⇒ States that have legalised recreational cannabis and are considering legalisation should account for shifting patterns of tobacco and cannabis use in data-driven regulatory and public health planning.

INTRODUCTION

The steady decline in adult tobacco use has corresponded with a rise in cannabis use[1 2] and the co-use of tobacco and cannabis.[1] Co-use can occur sequentially (eg, one followed by another), simultaneously (eg, both substances in same product) or concurrently (eg, temporal use of both products).[1] Both substances were among the most widely used in the USA in 2023, with past-month cannabis use surpassing tobacco use among adults aged 18–25 (25.2% vs 15.7%), but not among those aged 26+ years (15.0% vs 19.7%).[3] National data from 2021 indicated that the prevalence of exclusive cannabis use among adults was 7.3% while co-use of tobacco and cannabis was 6.4%, which are the highest levels recorded over the last two decades.[1] Co-use is higher among adults who are male, identify as White or Black, have lower levels of education and income, report depressive symptoms and engage in more frequent or heavy alcohol use.[1 4–6]

Beyond the known health consequences of tobacco use[7] and growing evidence of cannabis-related harms,[8 9] co-use has been linked with an increased risk of developing dependence[10] and research is emerging that co-use has greater health consequences than use of either substance alone. Co-use of inhaled tobacco and cannabis increases exposure to toxicants and carcinogens compared with either substance, suggesting potential additive health effects.[11] A recent study showed an additive exposure to combustion by-products from co-use,

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Table 1 Characteristics of states and recreational cannabis legalisation, 2016–2023

State	N= 854 878	Years	% of sample*	Mean %* Tobacco-only use	Mean %* Cannabis-only use	Mean %* Tobacco and cannabis co-use	Effective date of recreational cannabis legalisation	Date of recreational cannabis retail first sales
Alaska	13 128	16–17, 20–21	0.4	15.4	8.7	9.5	2/24/2015	10/29/2016
California	30 100	16–19	32.8	9.2	9.5	4.3	11/9/2016	1/1/2018
Colorado	12 440	16	1.2	14.3	7.4	6.2	12/10/2012	1/1/2014
Connecticut	21 885	21–23	1.1	9.4	9.3	5.6	7/1/2021	1/10/2023
Delaware	12 608	20–23	0.4	13.0	6.8	5.8	4/27/2023	†
Florida	43 244	16, 18	4.8	15.7	4.2	4.5		
Georgia	4613	17	1.1	18.0	3.4	4.0		
Hawaii	20 614	20–22	0.6	12.5	6.8	4.6		
Idaho	27 555	16–21	1.3	16.5	3.9	4.3		
Illinois	17 141	19–23	6.0	10.9	8.0	5.1	1/1/2020	1/1/2020
Indiana	32 321	20–23	2.5	18.9	4.7	5.7		
Kansas	4624	22	0.4	19.3	4.6	4.5		
Kentucky	8008	20–21	1.1	24.1	4.1	5.9		
Maine	40 722	20–23	0.6	11.5	11.9	9.2	1/30/2017	10/9/2020
Maryland	64 419	18–23	6.6	10.8	5.9	3.7	7/1/2023	7/1/2023
Massachusetts	2910	22	0.9	7.9	12.9	6.4	12/15/2016	11/20/2018
Michigan	2644	22	1.2	13.2	10.4	9.3	12/6/2018	12/1/2019
Minnesota	83 571	16–21	4.3	14.9	4.5	4.3	8/1/2023	†
Mississippi	17 799	16, 20, 22–23	1.2	23.9	3.6	5.2		
Montana	23 007	18, 21–23	0.5	17.0	8.5	8.0	1/1/2021	1/1/2022
Nebraska	45 064	16, 20–23	1.5	17.8	3.2	3.8		
Nevada	6599	21–23	0.7	14.2	11.1	8.0	1/1/2017	7/1/2017
New Hampshire	25 642	17–21	0.9	12.2	6.7	5.9		
New Mexico	6580	22–23	0.3	15.7	10.6	6.5	6/29/2021	4/1/2022
New York	10 303	21	2.4	11.2	7.4	5.4	3/31/2021	12/29/2022
North Dakota	22 968	18–22	0.5	18.9	3.4	4.7		
Ohio	54 917	16, 18, 20–23	9.0	20.5	4.5	5.7	12/7/2023	†
Oklahoma	20 679	16–23	3.6	20.1	5.8	6.3		
Oregon	9739	22–23	0.6	10.8	13.7	8.5	7/1/2015	10/1/2015
Rhode Island	9141	20–21	0.3	9.9	9.3	6.8	5/25/2022	12/1/2022
South Carolina	28 822	17–20	2.6	17.7	4.3	3.9		
Tennessee	21 897	16–20	3.9	23.6	3.7	4.7		
Utah	29 242	19–21	1.6	9.5	5.0	3.3		
Vermont	12 426	21, 23	0.1	10.4	14.0	8.2	7/1/2018	10/1/2022
Virginia	13 032	22–23	1.0	12.7	7.1	6.2	7/1/2021	†
West Virginia	14 580	18–20	0.7	25.8	3.1	5.5		
Wisconsin	8629	22	0.7	14.7	6.4	5.9		
Wyoming	31 265	16–23	0.5	22.8	3.4	4.2		

*Weighted.
†Retail sales started after 2023.

including higher levels among users of e-cigarettes.[12] Most studies have focused on co-use via smoking (eg, blunts) and more research is needed on the health effects of newer methods, particularly vaping cannabis via electronic cigarettes as well as co-use of tobacco products with cannabis edibles.

Changing trends in cannabis use and co-use[1] have overlapped with the strengthening of state-level tobacco control policies[7 13] and the liberalisation of cannabis laws.[14] States began decriminalising cannabis use in the 1970s followed by medical legalisation in the 1990s, and recreational cannabis use in 2012.[9] As of July 2025, 24 states and DC had legalised recreational cannabis for adults aged 21+.[14] There is an accumulating body of evidence that recreational cannabis legalisation (RCL) increases adult cannabis use.[15 16] Whether RCL is also driving changes in adult co-use of tobacco and cannabis remains understudied.

Legalisation may serve as a signal that cannabis is safe, has benefits and is acceptable to use.[17] Indeed, public concern regarding the safety of cannabis use is declining,[18 19] with some endorsing the view that daily smoking of cannabis and associated smoke exposure is less harmful than tobacco.[19] Adults who use tobacco may initiate or substitute cannabis, while non-users may begin using cannabis. Using quasi-experimental methods, Weinberger and colleagues found that RCL was associated with increases in cannabis-only use and declines in cigarette-only use, but no changes in co-use overall, although some increases among adults aged 50+ years.[20] However, few states had legalised

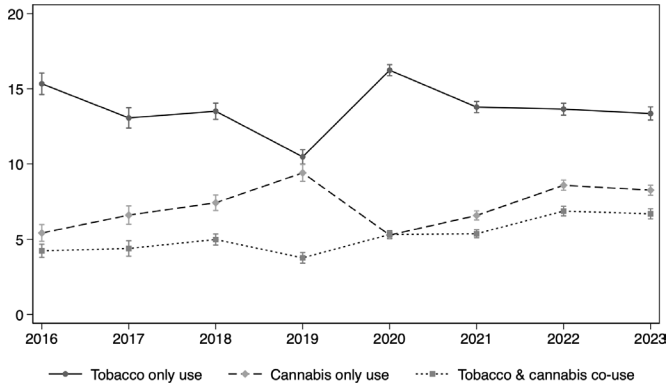

Figure 1 Prevalence (%) of past-month use of tobacco and cannabis, 2016-2023. Note: The Behaviour Risk Factor Surveillance System did not collect information on e-cigarette use in 2019.

recreational use prior to this analysis, the study did not include co-use with all tobacco products, nor control for decriminalisation or tobacco control policies. In a longitudinal cohort, Pravosud and colleagues found that RCL was associated with a significant increase in cannabis-only use from 2017 to 2021, but not with changes in the prevalence of tobacco-only use or co-use by state legalisation status.[21] They did not examine differential effects of RCL across groups.

Gaps remain in understanding the effects of RCL on disparities in the use and co-use of tobacco and cannabis during this time of expanding legalisation. Using state-representative data on adult substance use over an 8-year period across 38 states, we evaluated the associations between RCL and the use and co-use of tobacco and cannabis overall and across demographic and higher-risk strata.

METHODS

Study sample

Administered annually by the Centers for Disease Control and Prevention and state health departments, the Behaviour Risk Factor Surveillance System (BRFSS) is a state-representative health-related survey of over 400 000 adults in all 50 states and DC.[22] State-optional BRFSS cannabis modules were introduced in 2016 (states opt-in to optional modules of specific topics[22] and all respondents in those states receive the cannabis-related questions). We drew data from 874 084 respondents aged 18+ in the 38 states that included cannabis questions from 2016 through 2023. During this period, state-level median annual response rates ranged from 44.0% to 49.9%.[23 24] We excluded respondents with missing data on age, sex or education, resulting in a final analytical sample of 854 878.

Outcome measure

BRFSS respondents were asked, 'During the past 30 days, on how many days did you use marijuana or hashish?' Respondents were asked separately about current use of cigarettes; chewing tobacco, snuff or snus; and e-cigarettes or other electronic vaping products on 'every day, some days, or not at all'. We created a four-category indicator of past-month use of tobacco and cannabis: no use of tobacco or cannabis; tobacco-only use (defined as any use of cigarettes, smokeless tobacco products or e-cigarettes); cannabis-only use (defined as any marijuana or hashish use); tobacco and cannabis co-use (defined as use of both products). E-cigarette use was not included in the BRFSS questionnaire in 2019, so tobacco use for that year was based on affirmative responses to cigarette or smokeless tobacco product use only.

Policy variables

We identified effective dates of state RCL, indicating the month/year the policy became legally enforceable, using NexusUni, the Marijuana Policy Project,[14] Ballotpedia and government websites. We also tracked the date of the opening of the first licensed recreational cannabis retail store in each state using news outlets and state websites.

We also controlled for the broader substance use policy environment. We determined whether a state had legalised cannabis medically if they permitted cannabis use for medical conditions and did not limit to low-THC (tetrahydrocannabinol) cannabis.[14] For the decriminalisation of cannabis, we used the date when states decreased penalties to non-incarceration for first-time cannabis possession of small amounts.[14] We also included the inflation-adjusted tax rate per pack of 20 cigarettes and whether e-cigarette taxes were in effect (no tax vs any tax).[13] State laws and sales were coded as being in effect the month following their respective effective dates. We linked policies to BRFSS respondents using policy dates and the state and month/year of survey completion.

Covariates

We controlled for the following self-reported demographic characteristics: age (18–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65+ years), sex (male, female), educational attainment (less than high school, high school graduate, some college, college graduate), race and ethnicity (Asian, Black, Hispanic, other race and ethnicity, White), marital status (single, married), health insurance (not covered, covered) and children under age 18 in the household (no, yes).

Alcohol use and poor mental health have been identified as risk factors for cannabis use.[1 25 26] We created a three-level alcohol use variable indicating no use, low use (any non-binge/heavy use) and binge/heavy use (4+/5+ drinks per occasion for women/men or 7+/15+ drinks per week for women/men.[27] We also included a mental health indicator of poor ('not good' mental health for 14+ days)[28] versus good. Observations with missing values on covariates were coded to be retained in analyses.

Statistical analysis

We estimated difference-in-differences multinomial logit regression models to examine the associations between RCL and the use and co-use of tobacco and cannabis through the natural experiment created by legalisation of recreational cannabis across states.[29 30] We tested the parallel trends assumption using an event study framework by creating indicators for whether RCL was in effect currently or 1, 2 or 3+ years in the future versus not. Results from our adjusted models broadly supported the parallel trends assumption for our main outcomes of cannabis-only use and co-use (online supplemental table 1). Cannabis-only use did not vary across states that did and did not enact RCL in the 1–3 years prior to implementation in comparison to no use, although there was some evidence of higher co-use of tobacco and cannabis 2 years prior to implementation.

We estimated four sets of models. First, we conducted multinomial logit regression models to examine the associations between RCL and the four-category indicator of adult tobacco and cannabis use (no use, tobacco-only use, cannabis-only use, tobacco and cannabis co-use), reporting change as adjusted relative risk ratios (aRRR) with no use of either product as the referent

Table 2 Demographics of sample and past-month use of tobacco and cannabis (N=854 878)

	N= 854 878	% of sample*†	Mean %* No use of tobacco or cannabis (n=657 973)	Mean %* Tobacco-only use (n=119 681)	Mean %* Cannabis-only use (n=43 943)	Mean %* Tobacco and cannabis co-use (n=33 281)	P value testing differences in proportions
Age (years)							<0.001
18–24	46 643	12.0	67.1	10.8	13.2	8.8	
25–29	38 225	7.6	63.9	15.2	12.0	8.9	
30–34	45 300	9.3	66.2	16.1	10.0	7.7	
35–39	51 301	7.9	69.4	16.4	7.4	6.7	
40–44	53 313	8.4	71.7	16.2	6.6	5.6	
45–49	55 593	7.2	74.9	15.7	5.3	4.1	
50–54	67 584	8.6	74.9	16.1	4.7	4.3	
55–59	80 392	8.3	74.6	16.3	5.5	3.6	
60–64	93 614	8.8	76.0	14.9	5.8	3.3	
65+	322 913	21.9	86.9	9.0	3.1	1.0	
Sex							<0.001
Male	386 916	48.5	68.9	16.3	8.2	6.5	
Female	467 962	51.5	79.4	11.3	5.9	3.4	
Educational attainment							<0.001
No high school	52 827	13.0	70.6	19.4	3.8	6.2	
High school graduate	226 232	26.6	68.3	18.5	6.9	6.3	
Some college	240 932	31.7	71.4	14.4	8.7	5.5	
College graduate	334 887	28.7	84.9	6.1	6.7	2.4	
Race and ethnicity†							<0.001
White	669 602	59.9	72.6	15.4	6.7	5.3	
Black	57 825	10.0	72.3	13.1	8.8	5.8	
Hispanic	55 656	17.9	79.3	9.8	7.5	3.4	
Asian	21 159	7.3	84.9	8.2	4.8	2.1	
Other‡	34 833	3.3	62.5	18.8	9.1	9.5	
Marital status†							<0.001
Single	398 533	49.1	67.0	16.3	9.2	7.5	
Married	452 507	50.4	81.4	11.3	4.9	2.4	
Health insurance†							<0.001
Not covered	55 295	9.7	66.0	18.9	6.6	8.5	
Covered	786 902	88.9	75.2	13.2	7.1	4.5	
Children in household†							0.086
No	562 300	63.0	74.4	13.5	7.2	4.9	
Yes	288 993	36.5	74.2	14.3	6.7	4.9	
Current mental health†							<0.001
Good	740 886	85.8	77.2	12.7	6.3	3.9	
Poor	101 122	12.8	56.0	20.6	11.6	11.8	
Current alcohol use†							<0.001
No	413 129	47.3	80.3	13.1	3.6	2.9	
Low	309 828	35.0	77.2	11.0	7.9	3.9	
Binge/heavy drinking	123 511	16.8	51.8	21.0	14.8	12.5	
Year							<0.001
2016	113 106	20.3	75.0	15.3	5.4	4.2	
2017	59 037	11.1	76.0	13.1	6.6	4.4	
2018	106 698	16.6	74.1	13.5	7.4	5.0	
2019	86 958	14.6	76.4	10.5	9.4	3.8	
2020	132 804	11.6	73.2	16.2	5.3	5.3	
2021	150 161	12.7	74.3	13.8	6.6	5.4	
2022	109 736	12.4	70.9	13.7	8.6	6.9	
2023	96 378	0.8	71.7	13.4	8.3	6.7	

*Weighted.
†Covariates with missing data: Race and ethnicity 1.6% (n=15 803), marital status 0.5% (n=3838), health insurance 1.5% (n=12 681), children in household 0.5% (n=3585), mental health 1.3% (n=12 870) and alcohol use 1.0% (n=8410).
‡Other race and ethnicity included American Indians, Alaskan Natives and Multiracial.

Table 3 Relative risk ratios for the associations between recreational cannabis legalisation and past-month use of tobacco and cannabis for the full sample and interacted with demographic (age, sex, education, race and ethnicity) and higher-risk (mental health, alcohol use) strata

	No use of tobacco or cannabis	Tobacco-only use	Cannabis-only use	Tobacco and cannabis co-use
	aRRR* (95% CI)	aRRR* (95% CI)	aRRR* (95% CI)	aRRR* (95% CI)
Recreational cannabis legalisation	Referent	0.87 (0.83 to 0.91)	1.88 (1.78 to 1.99)	1.44 (1.34 to 1.54)
Interactions with recreational cannabis legalisation	Average marginal effect (95% CI)	Average marginal effect (95% CI)	Average marginal effect (95% CI)	Average marginal effect (95% CI)
By age (years)	Wald test:	p=0.583	p=0.016	p=0.571
18–24	−0.045 (−0.066 to −0.024)		0.063 (0.046 to 0.080)	
25–29	−0.044 (−0.069 to −0.019)		0.049 (0.031 to 0.067)	
30–34	−0.035 (−0.058 to −0.012)		0.054 (0.038 to 0.070)	
35–39	−0.016 (−0.038 to 0.006)		0.027 (0.013 to 0.041)	
40–44	−0.028 (−0.050 to −0.007)		0.037 (0.023 to 0.051)	
45–49	−0.012 (−0.032 to 0.009)		0.043 (0.031 to 0.055)	
50–54	−0.013 (−0.032 to 0.007)		0.025 (0.014 to 0.035)	
55–59	−0.027 (−0.047 to −0.007)		0.032 (0.020 to 0.043)	
60–64	−0.038 (−0.060 to −0.017)		0.041 (0.029 to 0.054)	
65+	−0.016 (−0.025 to −0.007)		0.025 (0.021 to 0.030)	
By sex	Wald test:	p<0.001	p=0.128	p=0.287
Male	−0.033 (−0.042 to −0.024)	−0.022 (−0.029 to −0.015)		
Female	−0.020 (−0.028 to −0.012)	−0.029 (−0.035 to −0.023)		
By educational attainment	Wald test:	p=0.010	p<0.001	p<0.001
No high school	0.029 (0.011 to 0.048)	−0.038 (−0.055 to −0.020)	0.006 (−0.003 to 0.015)	0.002 (−0.008 to 0.013)
High school graduate	−0.013 (−0.025 to −0.001)	−0.043 (−0.053 to −0.033)	0.036 (0.028 to 0.044)	0.019 (0.012 to 0.026)
Some college	−0.043 (−0.055 to −0.031)	−0.022 (−0.031 to −0.014)	0.047 (0.039 to 0.055)	0.019 (0.012 to 0.025)
College graduate	−0.042 (−0.050 to −0.034)	−0.009 (−0.014 to −0.003)	0.044 (0.038 to 0.049)	0.007 (0.003 to 0.011)
By race and ethnicity	Wald test:	p<0.001	p=0.003	p=0.033
White	−0.024 (−0.031 to −0.017)	−0.038 (−0.044 to −0.033)	0.045 (0.040 to 0.049)	0.018 (0.013 to 0.022)
Black	−0.043 (−0.065 to −0.022)	−0.007 (−0.024 to 0.010)	0.036 (0.021 to 0.051)	0.015 (0.003 to 0.027)
Hispanic	−0.024 (−0.040 to −0.008)	−0.002 (−0.013 to 0.009)	0.027 (0.016 to 0.037)	−0.001 (−0.008 to 0.007)
Asian	−0.026 (−0.052 to 0.001)	0.009 (−0.013 to 0.031)	0.011 (−0.006 to 0.028)	0.006 (−0.003 to 0.015)
Other†	0.004 (−0.024 to 0.031)	−0.058 (−0.080 to −0.035)	0.037 (0.019 to 0.055)	0.017 (−0.001 to 0.035)
By mental health	Wald test:	p=0.037	p=0.022	p=0.418
Good	−0.023 (−0.030 to −0.017)	−0.024 (−0.029 to −0.019)	0.038 (0.034 to 0.042)	
Poor	−0.018 (−0.037 to 0.000)	−0.062 (−0.077 to −0.048)	0.045 (0.032 to 0.059)	
By alcohol use	Wald test:	p=0.038	p=0.157	p=0.418
No	−0.004 (−0.012 to 0.005)	−0.028 (−0.035 to −0.021)		
Low	−0.037 (−0.047 to −0.028)	−0.025 (−0.032 to −0.018)		
Binge/heavy drinking	−0.052 (−0.069 to −0.036)	−0.037 (−0.051 to −0.024)		

*Models include adjustment for age, sex, educational attainment, race and ethnicity, marital status, health insurance, children in household, mental health, alcohol use, medical cannabis legalisation, cannabis decriminalisation, cigarette taxes, e-cigarette taxes, year and state fixed effects.
†Other race and ethnicity included American Indians, Alaskan Natives and Multiracial.
aRRR, adjusted relative risk ratio.

group. Second, we re-estimated the main models changing the referent group to tobacco-only use and cannabis-only use, respectively, to test differences between groups. Third, we tested interactions between demographic (age, sex, education, race and ethnicity) and higher-risk (mental health, alcohol use) strata and RCL using adjusted Wald tests. We present interactions that were jointly significant at $p<0.1$, but only interpret stratum-specific average marginal effects based on the predicted probabilities of each category of use that were significant at $p\leq0.05$. Fourth, we conducted sensitivity analyses to test whether co-use of tobacco and cannabis varied based on when retail stores opened rather than RCL enactment. All models adjusted for respondents' age, sex, educational attainment, race and ethnicity, marital status, health insurance, children in household, mental health, alcohol use, medical cannabis legalisation, cannabis decriminalisation, cigarette taxes, e-cigarette taxes, year and state fixed effects. We re-estimated main models without adjustment for alcohol use and depressive symptoms and the results were consistent (results not shown).

We conducted analyses using Stata statistical software V.18.5 (StataCorp, College Station, Texas, USA) using svy commands to account for the BRFSS complex sampling design, subpop commands for participants with cannabis-related data and survey weights.[22]

RESULTS

Among the 38 states that collected information on cannabis use, 3 states had legalised recreational cannabis prior to 2016 and 17 additional states implemented RCL through 2023 (table 1).

There was wide variation across states in tobacco-only use (7.9% in Massachusetts to 25.8% in West Virginia), cannabis-only use (3.1% in West Virginia to 14.0% in Vermont) and co-use of tobacco and cannabis (3.3% in Utah to 9.5% in Alaska). From 2016 through 2023, the prevalence of tobacco-only use remained relatively stable at 13.8% (p=0.857 for test of linear change), and similarly, cannabis-only use at 7.0% (p=0.692), while co-use increased from 4.2% to 5.4% (p=0.007) (figure 1).

Tobacco and cannabis use and co-use varied across demographic and higher-risk strata (p<0.001), except for the presence of children in the household (table 2). Overall patterns indicated greater use of either substance or co-use among adults who were younger, male, single, had lower educational attainment, were without health insurance and reported poor mental health and binge/heavy drinking. Tobacco and cannabis use also was more prevalent among adults who identified as other race and ethnicity, followed by White and Black adults, with lower levels among Hispanic and Asian adults.

Model results

We found that overall use varied in response to RCL (table 3). Compared with no use of tobacco or cannabis, the likelihood of cannabis-only use (aRRR 1.88; 95% CI 1.78 to 1.99) and co-use of tobacco and cannabis (1.44; 1.34 to 1.54) increased post-legalisation, while tobacco-only use decreased (0.87; 0.83 to 0.91). Changing the referent group indicated that cannabis-only use (2.17; 2.03 to 2.32) and co-use of tobacco and cannabis (1.65; 1.53 to 1.79) increased more compared with tobacco-only use following RCL (online supplemental table 2). However, co-use of tobacco and cannabis (0.76; 0.70 to 0.83) increased less than cannabis-only use post-legalisation.

Interactions revealed that RCL was associated with higher cannabis-only use and co-use of tobacco and cannabis across certain groups, and lower tobacco-only use across others. A significant interaction with age (p=0.016) revealed that cannabis-only use increased across all age groups in response to RCL with larger increases among adults who were younger, ranging from a 6.3% increase among 18–24 year-olds (average marginal effect 0.063; 95% CI 0.046 to 0.080) to a 2.5% increase among 65+-year-olds (0.025; 0.021 to 0.030). An interaction with sex (p<0.001) showed that females (−0.029; −0.035 to −0.023) had larger declines in tobacco-only than males (−0.022; −0.029 to −0.015) post-legalisation. Interactions with educational attainment (all p≤0.01) found that adults with a high school degree or higher increased cannabis-only use (3.6% to 4.7%) and co-use of tobacco and cannabis (0.7% to 1.9%) in response to RCL, while tobacco-only use had smaller declines across increasing levels of education, ranging from 3.8% among adults with no high school degree (−0.038; −0.055 to −0.020) to 0.9% among college graduates (−0.009; −0.014 to −0.003). Interactions with race and ethnicity (all p≤0.05) revealed that adults who identified as White, Black, Hispanic and other increased cannabis-only use (2.7% to 4.5%) and White and Black adults increased co-use of tobacco and cannabis (1.8% and 1.5%, respectively) post-RCL. Adults who identified as White and other race and ethnicity decreased tobacco-only use by 3.8% and 5.8%, respectively, in response to legalisation. Cannabis-only and tobacco-only use also varied by mental health status (both p≤0.05). Adults who reported poor mental health had larger increases in cannabis-only use (0.045; 0.032 to 0.059) than those with good mental health (0.038; 0.034 to 0.042) post-legalisation, while tobacco-only use decreased more among adults who reported poor versus good mental health (6.2% vs 2.4%, respectively). An interaction with alcohol use (p=0.038) showed that adults across all levels of use decreased tobacco-only use by 2.5% to 3.7% post-legalisation, with larger declines among those who reported binge/heavy drinking.

Sensitivity analyses

We re-estimated models with cannabis retail sales and found consistent patterns in the strength and direction of associations compared with RCL, with increases in cannabis-only use and co-use of tobacco and cannabis compared with no use and with tobacco-only use after the opening of retail locations (table 4; online supplemental table 2). Compared with cannabis-only use, co-use of tobacco and cannabis increased less post-retail store openings.

Interactions across demographic and higher-risk strata were also similar with a few exceptions. We found a significant interaction with age (p=0.071), which showed an increase in co-use of tobacco and cannabis among adults aged 18–24 years (2.0%) and 50–65+ years (0.5% to 2.2%) after retail sales started. An interaction with sex (p=0.053) found larger increases in cannabis-only use among females (3.2%) than males (3.0%) post-retail store openings. In contrast, there were no significant interactions between retail sales and race and ethnicity (p=0.691) for co-use of tobacco and cannabis or with mental health status (p=0.172) for tobacco-only use.

DISCUSSION

We found that RCL and the start of cannabis retail sales were associated with overall increases in cannabis-only use and co-use of tobacco and cannabis, and with decreases in tobacco-only use in comparison to no use of either substance. While adults who were younger, had lower levels of education and who identified as White and Black had higher levels of cannabis-only use and co-use, policy effects also emerged for those that had lower levels of use across these demographic groups. We found evidence that RCL and/or the opening of cannabis retail stores were associated with increases in co-use of tobacco and cannabis among 18–24 year-olds, individuals aged 55+ years and those with a high school degree or higher. RCL and retail stores were associated with increases in cannabis-only use among adults who identify as Hispanic and other, but with increases in cannabis-only use and co-use among White and Black adults post-RCL only. Adults with poor mental health and binge/heavy drinking had a higher prevalence of cannabis-only use and co-use, but there were increases in cannabis-only use post-legalisation among adults with poor mental health only. Larger increases in cannabis-only use post-RCL and/or retail sales also emerged across younger age groups, females, adults with higher levels of education and adults with poor mental health. The consequences of RCL increasing co-use among groups historically less likely to use cannabis[31 32] suggest that policymakers need to collaborate with public health professionals to increase awareness about co-use and employ broad screening and outreach.

There have been increasing rates of cannabis use over the past two decades,[1 2] and research has focused on the health consequences[8 9] of and RCL effects[15 16] on cannabis use. Most studies have not separately examined cannabis-only use versus co-use of tobacco and cannabis. Our analysis contributes to this nascent body of evidence that co-use may be distinct,[10–12] and may run contrary to decreasing trends in tobacco use.[2] Two prior studies that examined the effects of RCL found increased cannabis-only use but no effects on co-use.[20 21] Only one also documented a decline in cigarette-only use post-legalisation.[21] However, those

Table 4 Relative risk ratios for the associations between recreational cannabis retail sales and past-month use of tobacco and cannabis for the full sample and interacted with demographic (age, sex, education, race and ethnicity) and higher-risk (mental health, alcohol use) strata

	No use of tobacco or cannabis	Tobacco only use	Cannabis only use	Tobacco and cannabis co-use
	aRRR* (95% CI)	aRRR* (95% CI)	aRRR* (95% CI)	aRRR* (95% CI)
Recreational cannabis retail sales	Referent	0.93 (0.88 to 0.99)	1.65 (1.54 to 1.76)	1.36 (1.25 to 1.47)
Interactions with recreational cannabis retail sales				
	Average marginal effect (95% CI)	Average marginal effect (95% CI)	Average marginal effect (95% CI)	Average marginal effect (95% CI)
By age (years)	Wald test:	p=0.856	p=0.004	p=0.071
18–24	−0.038 (−0.063 to −0.014)		0.041 (0.021 to 0.061)	0.020 (0.005 to 0.035)
25–29	−0.006 (−0.035 to 0.023)		0.022 (0.003 to 0.042)	0.008 (−0.011 to 0.027)
30–34	−0.039 (−0.065 to −0.013)		0.049 (0.030 to 0.067)	0.017 (−0.001 to 0.035)
35–39	−0.013 (−0.038 to 0.012)		0.025 (0.008 to 0.041)	0.015 (0.000 to 0.029)
40–44	−0.018 (−0.042 to 0.005)		0.026 (0.011 to 0.040)	0.000 (−0.014 to 0.013)
45–49	−0.023 (−0.047 to 0.001)		0.038 (0.023 to 0.052)	0.007 (−0.005 to 0.019)
50–54	−0.020 (−0.043 to 0.002)		0.028 (0.015 to 0.041)	0.014 (0.001 to 0.027)
55–59	−0.041 (−0.064 to −0.018)		0.031 (0.017 to 0.045)	0.022 (0.010 to 0.034)
60–64	−0.041 (−0.068 to −0.013)		0.035 (0.020 to 0.050)	0.011 (0.002 to 0.020)
65+	−0.022 (−0.032 to −0.011)		0.022 (0.017 to 0.028)	0.005 (0.002 to 0.008)
By sex	Wald test:	p=0.017	p=0.053	p=0.838
Male	−0.031 (−0.042 to −0.020)	−0.012 (−0.021 to −0.003)	0.030 (0.023 to 0.037)	
Female	−0.021 (−0.030 to −0.012)	−0.020 (−0.026 to −0.013)	0.032 (0.026 to 0.038)	
By education	Wald test:	p=0.037	p=0.007	p=0.001
No high school	0.011 (−0.010 to 0.032)	−0.016 (−0.036 to 0.004)	0.007 (−0.002 to 0.017)	−0.002 (−0.014 to 0.009)
High school graduate	−0.008 (−0.023 to 0.007)	−0.033 (−0.045 to −0.021)	0.027 (0.017 to 0.036)	0.014 (0.006 to 0.022)
Some college	−0.046 (−0.061 to −0.032)	−0.009 (−0.020 to 0.002)	0.038 (0.029 to 0.048)	0.017 (0.009 to 0.024)
College graduate	−0.035 (−0.043 to −0.026)	−0.009 (−0.015 to −0.003)	0.036 (0.030 to 0.043)	0.007 (0.003 to 0.012)
By race and ethnicity	Wald test:	p=0.023	p=0.005	p=0.691
White	−0.024 (−0.033 to −0.016)	−0.027 (−0.034 to -0.020)	0.038 (0.033 to 0.044)	
Black	−0.031 (−0.057 to −0.005)	−0.008 (−0.027 to 0.012)	0.021 (0.004 to 0.038)	
Hispanic	−0.027 (−0.043 to −0.011)	0.004 (−0.007 to 0.016)	0.020 (0.009 to 0.031)	
Asian	−0.020 (−0.049 to 0.010)	0.001 (−0.023 to 0.025)	0.014 (−0.005 to 0.032)	
Other†	−0.009 (−0.042 to 0.025)	−0.037 (−0.064 to -0.009)	0.025 (0.005 to 0.046)	
By mental health	Wald test:	p=0.172	p=0.089	p=0.248
Good	−0.024 (−0.032 to −0.017)		0.030 (0.026 to 0.035)	
Poor	−0.014 (−0.035 to 0.008)		0.037 (0.021 to 0.053)	
By alcohol use	Wald test:	p=0.020	p=0.104	p=0.377
No	−0.009 (−0.019 to 0.001)	−0.018 (−0.027 to −0.010)		
Low	−0.031 (−0.042 to −0.019)	−0.020 (−0.028 to −0.012)		
Binge/heavy drinking	−0.052 (−0.072 to −0.033)	−0.016 (−0.032 to 0.000)		

*Models include adjustment for age, sex, educational attainment, race and ethnicity, marital status, health insurance, children in household, mental health, alcohol use, medical cannabis legalisation, cannabis decriminalisation, cigarette taxes, e-cigarette taxes, year and state fixed effects.
†Other race and ethnicity included American Indians, Alaskan Natives and Multiracial.
aRRR, adjusted relative risk ratio.

studies included a short policy window or a timeframe with minimal variation in RCL across states and did not control for the broader substance use policy environment.

Weinberger and colleagues examined disparities in co-use in response to RCL and found that co-use increased among older adults,[20] which is consistent with our results, but there were no differences by income, education or race and ethnicity. Evidence of increasing trends in cannabis use among older adults during a period of legalisation,[33] combined with our findings, suggests that clinicians should assess this population for cannabis use and co-use of tobacco and cannabis. While prior research has identified increasing trends in cannabis use across demographic groups historically less likely to use cannabis, including women and adults with higher levels of education or income,[31 32] few studies have tested whether RCL differentially increased cannabis use among these groups post-legalisation,[34 35] or assessed co-use of tobacco and cannabis. More studies are needed to examine changing patterns in co-use in response to RCL and differential effects across demographic and higher-risk strata.

Our findings add to growing evidence that adults are shifting product use in response to cannabis legalisation. Agrawal and colleagues reviewed potential mechanisms for how the co-use of tobacco and cannabis could result from the gateway hypothesis (tobacco use leading to cannabis use), the reverse gateway hypothesis (cannabis use leading to tobacco use), shared genetic predisposition of substance use, peer influences on uptake,

increased availability of products and shared routes of administration (such as smoking or vaping).[10] A review by Yimer and colleagues found further evidence that the associations between tobacco and cannabis use are bi-directional, meaning that cannabis use increases future risk of tobacco use while tobacco use also increases later cannabis use.[36] Together, these findings suggest that altering the policy environment through legalisation, increasing access to cannabis products through retail stores[37] and increases in public perceptions of cannabis safety[18 19] could lead to increases in co-use of tobacco and cannabis through multiple pathways even with downward pressure on tobacco use from increased policy restrictions.

There are limitations to address. First, we defined co-use as any prior month use of both substances due to the limited BRFSS questions. Co-use can occur sequentially, simultaneously or concurrently,[1] and the BRFSS does not collect information on the timing, frequency or mode of using both products together. It is important for future research to assess the associations between RCL and co-use based on these alternative definitions as they may identify different higher-risk groups as a result of policy changes. Second, the BRFSS relies on self-report of tobacco and cannabis use, which is subject to social desirability bias and may also vary over time and in response to legalisation.[17] Third, the survey also excludes adults who are homeless or residing in institutions,[22] which may underestimate the prevalence of substance use. Fourth, the BRFSS does not collect information on cigar use, which may also underestimate the prevalence of co-use of tobacco and cannabis as a blunt is typically made by emptying a cigar and refilling the tobacco leaf wrapper with cannabis. The BRFSS also did not assess e-cigarette use in 2019, which may underestimate tobacco use in that year. Any underestimation of substance use would underestimate the true association between RCL and the use and co-use of tobacco and cannabis. Fifth, only 38 states that participated in the BRFSS collected information on cannabis use, so our findings may not be generalisable to all states.

CONCLUSION

We have shown that RCL and the expansion of cannabis retail sales are associated with increases in cannabis-only use and the co-use of tobacco and cannabis, including increases in co-use among those with historically lower levels of cannabis use, such as adults who are older and with higher levels of education. These shifting patterns may be narrowing disparities in use due to rising levels among populations less likely to use cannabis rather than declining use among higher-risk groups. These findings underscore the need for continued population-level surveillance to monitor long-term trends in use following RCL and research into the mechanisms for how RCL influences the uptake of tobacco and cannabis products, both of which can inform public health interventions. Healthcare providers should be aware of the potential for increased co-use of tobacco and cannabis post-legalisation and emphasise universal screening,[38] particularly in populations with rising levels of substance use.[32 33] States must consider how legalisation is changing patterns of tobacco and cannabis use, using data to guide regulatory practices and public health planning.

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