Washington State Institute for Public Policy

September 2023

Technical Report—

The Relationship Between Initiative 502 and Reported Substance Use

This Technical Report details one of several outcome analyses related to WSIPP's long-term evaluation of non-medical cannabis (NMC) legalization in Washington. For a full description of findings from all analyses we conducted in 2023, please refer to Initiative 502 and Cannabis-Related Public Health and Safety Outcomes: *Third Required Report.*[1] For more background information about Initiative 502 and related cannabis policy, please refer to our previously published report, A 10-Year Review of Non-Medical Cannabis Policy, Revenues, and Expenditures.[2]

In November 2012, Washington State voters passed Initiative 502 (I-502), which legalized limited possession, private use, and retail sales of cannabis for adults.[3] The law also directed the Washington State Institute for Public Policy (WSIPP) to conduct a benefit-cost evaluation of the implementation of I-502 that should consider (among other things) *youth and adult rates of cannabis and other substance use.*

In this technical report, we provide a comprehensive description of our evaluation of the relationship between non-medical cannabis legalization in Washington and reported substance use. We also examine the relationship between the advent of the cannabis retail market and reported substance use. For this analysis, we use national survey data from 2004 to 2019 and a synthetic control method to compare changes in the rates of reported cannabis, alcohol, and other substance use in Washington relative to comparable states after the enactment of I-502 and the advent of a licensed retail market.

An abridged description of this analysis can be found in our main report.[4] This main report also summarizes key findings from related work focusing on substance use disorder, traffic collision outcomes, and criminal justice outcomes.

In Section I, we briefly summarize the existing literature related to cannabis legalization and substance use. In Section II, we describe our data and the research methodology. In Section III, we report our results. In Section IV, we detail the limitations of our analysis and discuss our findings.

> Suggested citation: Ingraham, B., & Rashid, A. (2023). Technical report—The relationship between Initiative 502 and reported substance use (Document Number 23-09-3204). Olympia: Washington State Institute for Public Policy.

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[1] Rashid, A. (2023). *Initiative 502 and cannabis-related public health and safety outcomes: Third required report* (Doc. No. 23-09-3201). Olympia: Washington State Institute for Public Policy.

[2] Ingraham, B., & Rashid, A. (2023). *A 10-year review of non-medical cannabis policy, revenues, and expenditures* (Doc. No. 23-06-3201). Olympia: Washington State Institute for Public Policy.

[3] Initiative Measure No. 502.

[4] Rashid (2023).

I. Related Literature on Cannabis Legalization

The body of literature examining the impacts of non-medical cannabis (NMC) laws is comparatively new, given that the adoptions of NMC laws are a relatively recent occurrence. Much of the research examines how legalization of the adult-use and commercial retail of cannabis relate to changes in the likelihood of adult cannabis use—in particular, heavy and chronic use. Researchers also explore the concern that non-medical cannabis laws such as I-502 may produce spillovers that lead to increases in underage young adult and youth use of cannabis, which may be associated with negative cognitive development outcomes.[5] Last, when considering other potential public health implications, researchers examine if laws that increase access to cannabis may inadvertently lead to an increase in other substance use, such as alcohol, cocaine, and heroin.

Medical Cannabis Legalization

Although laws legalizing non-medical cannabis use are relatively new, state legislation legalizing medical use dates back to 1996—as of February 2022, 37 states have legalized the medical use of cannabis.[6] Medical cannabis (MC) laws generally allow cannabis use, possession, and sale for *medical purposes*. Under most medical cannabis legislation, cannabis possession and purchase require registration and a doctor's recommendation. There is a vast literature exploring the relationship between MC laws and substance use.

For example, studies examining the impacts of MC laws generally find an association between these laws and increased adult cannabis use.[7] Furthermore, robust evidence shows this association is strongest in states with operational cannabis dispensaries.[8] However, studies generally find that MC legalization does not predict greater youth cannabis use.[9]

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[5] Hall, W., Leung, J., & Lynskey, M. (2020). The effects of cannabis use on the development of adolescents and young adults. *Annual Review of Developmental Psychology*, *2*, 461-483.

[6] NCSL. *State Medical Cannabis Laws*.

[7] Chu, Y.W.L. (2014). The effects of medical marijuana laws on illegal marijuana use. *Journal of Health Economics*, *38*, 43-61; Cerdá, M., Wall, M., Keyes, K.M., Galea, S., & Hasin, D. (2012). Medical marijuana laws in 50 states: investigating the relationship between state legalization of medical marijuana and marijuana use, abuse and dependence. *Drug and Alcohol Dependence*, *120*(1-3), 22-27; Hasin, D.S., Sarvet, A.L., Cerdá, M., Keyes, K.M., Stohl, M., Galea, S., & Wall, M.M. (2017). US adult illicit cannabis use, cannabis use disorder, and medical marijuana laws: 1991-1992 to 2012-2013. *JAMA Psychiatry*, *74*(6), 579-588; and Choi, A., Dave, D., & Sabia, J.J. (2019). Smoke gets in your eyes: medical marijuana laws and tobacco cigarette use. *American Journal of Health Economics*, *5*(3), 303-333.

[8] Pacula, R.L., Powell, D., Heaton, P., & Sevigny, E.L. (2015). Assessing the effects of medical marijuana laws on marijuana use: the devil is in the details. *Journal of Policy Analysis and Management*, *34*(1), 7-31 and Chu, Y.W.L. (2015). Do medical marijuana laws increase hard-drug use? *The Journal of Law and Economics*, *58*(2), 481-517.

[9] Hollingsworth, A., Wing, C., & Bradford, A.C. (2022). Comparative effects of recreational and medical marijuana laws on drug use among adults and adolescents. *The Journal of Law and Economics*, *65*(3), 515-554; Choo, E.K., Benz, M., Zaller, N., Warren, O., Rising, K.L., & McConnell, K.J. (2014). The impact of state medical marijuana legislation on adolescent marijuana use. *Journal of Adolescent Health*, *55*(2), 160-166; and Anderson, D.M., Hansen, B., & Rees, D.I. (2015). Medical marijuana laws and teen marijuana use. *American Law and Economics Review*, *17*(2), 495-528.

Various studies have explored the relationship between MC legalization and other substance use. Most evidence indicates that MC laws predict a reduction in adult alcohol consumption.[10] However, one study finds that MC laws relate to an increase in reported adult *binge drinking*.[11] There is robust evidence that MC laws relate to reductions in opioid prescriptions and opioid-related mortalities.[12] Evidence regarding the impact of MC laws on other drug use, such as heroin and cocaine, is less conclusive.[13]

Non-Medical Cannabis Legalization

The literature exploring the relationship between NMC laws and substance use is relatively small, with most studies looking at outcomes in the years immediately after NMC legalization. Most evidence indicates that NMC laws are associated with increases in adult cannabis use, with some evidence indicating that this association is strongest after the advent of a retail market.[14] However, these same studies generally do not find compelling evidence that NMC laws predict youth/adolescent cannabis use, with one notable exception that found that, on average, NMC laws in the U.S. predict increases in reported adolescent past-month use.[15] Only a few studies have examined the relationship between NMC laws and other substance use; study results were largely mixed and inconclusive.[16] Therefore, while studies have largely found a relationship between NMC legalization and adult cannabis use, few conclusions can be drawn regarding NMC laws and youth cannabis use or other substance use.

Current Study

In this study, we build upon this literature by examining a broad range of outcomes related to cannabis, alcohol, and other drug use in Washington State. Previous studies have found the largest impacts of NMC laws after retail sales are permitted in a state, and therefore, our analyses will primarily focus on the relationship between NMC legalization and reported substance use after retail sales began in 2014. However, in alternate analyses, we also separately examine the impact of I-502 right after enactment at the end of 2012.

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[10] Veligati, S., Howdeshell, S., Beeler-Stinn, S., Lingam, D., Allen, P.C., Chen, L.S., & Grucza, R.A. (2020). Changes in alcohol and cigarette consumption in response to medical and recreational cannabis legalization: Evidence from US state tax receipt data. *International Journal of Drug Policy*, *75*, 102585; Andreyeva, E., & Ukert, B. (2019). The impact of medical marijuana laws and dispensaries on self-reported health. In *Forum for Health Economics and Policy* (Vol. 22, No. 2). De Gruyter; and Anderson, D.M., Hansen, B., & Rees, D.I. (2013). Medical marijuana laws, traffic fatalities, and alcohol consumption. *The Journal of Law and Economics*, *56*(2), 333-369.

[11] Wen, H., Hockenberry, J.M., & Cummings, J.R. (2015). The effect of medical marijuana laws on adolescent and adult use of marijuana, alcohol, and other substances. *Journal of health economics*, *42*, 64-80. Binge drinking is defined as drinking five or more drinks in one setting.

[12] Powell, D., Pacula, R.L., & Jacobson, M. (2018). Do medical marijuana laws reduce addictions and deaths related to pain killers? *Journal of Health Economics*, *58*, 29-42 and Hayes, M.J., & Brown, M.S. (2014). Legalization of medical marijuana and incidence of opioid mortality. *JAMA Internal Medicine*, *174*(10), 1673-1674.

[13] Anderson, D.M., & Rees, D.I. (2023). The public health effects of legalizing marijuana. *Journal of Economic Literature*, *61*(1), 86-143.

[14] Smart, R., & Pacula, R. (2019). Early evidence of the impact of cannabis legalization on cannabis use, cannabis use disorder, and the use of other substances: Findings from the state policy evaluations. *The American Journal of Drug and Alcohol Abuse, 45*(6), 644-663; Darnell, A. (2020). *Review of scientific evidence on effects of medical and non-medical marijuana legalization on public health in the United States*. DDR Consulting; and Hollingsworth, A., Wing, C., & Bradford, A.C. (2022). Comparative effects of recreational and medical marijuana laws on drug use among adults and adolescents. *The Journal of Law and Economics*, *65*(3), 515-554.

[15] Hollingsworth et al. (2022).

[16] Smart & Pacula (2019) and Darnell (2020).

In this study, we address the following two questions:

Question 1: Is the enactment of I-502 or the advent of retail operations related to differences in rates of reported cannabis use in Washington compared to states that have not legalized NMC use and sales?

Question 2: Is the enactment of I-502 or the advent of retail operations related to differences in rates of reported alcohol and other drug use in Washington compared to states that have not legalized NMC use and sales?

We will answer these questions separately for the sample of individuals under the age of 21 and individuals ages 21 and older. Studies have generally examined the impact of I-502 (and other NMC laws) in the year or two following the advent of cannabis retail sales. In contrast, our analyses will examine outcomes over a five-year period after the advent of retail (from 2014 to 2019).

II. Data and Methodology

National Survey on Drug Use and Health (NSDUH)

We use data from the National Survey on Drug Use and Health (NSDUH). NSDUH is an annual national survey directed by the Substance Abuse and Mental Health Services Administration (SAMHSA) and conducted by RTI International. NSDUH is the most consistently conducted national drug use survey in the United States. It collects the most comprehensive information regarding the type, frequency, and mode of use for alcohol and other substances.[17]

NSDUH is designed to capture a representative sample of the civilian, noninstitutionalized population of individuals ages 12 years and older residing within the 50 states and the District of Columbia—roughly 70,000 individuals are surveyed annually.[18] NSDUH data are used to support prevention and treatment programs, monitor substance use trends, estimate treatment needs, and inform public health policy.[19]

Analysis Sample

For our analysis, we use NSDUH data from the years 2004-2019.[20] Exhibit 1 summarizes socio-demographic information from this sample of surveyed individuals. In the exhibit, we separately describe the sample of individuals in Washington, in other states that have legalized NMC,[21] and the remaining states that have not legalized NMC.

In our sample, a larger percentage of respondents in Washington report race as non-Hispanic White relative to other states. On average, 75% of survey respondents in WA are non-Hispanic White, while this group makes up 58% of other NMC-legalizing states and 68% of the remaining non-legalizing states. A lower percentage of respondents in Washington report race as non-Hispanic Black or report Hispanic ethnicity versus other states in the sample. On average, across all three columns of Exhibit 1, the average sample characteristics related to socio-economic and health descriptors are qualitatively similar.

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[17] These surveys are conducted with a laptop using the audio computer-assisted self-interviewing (ACASI), or computer-assisted personal interviewing (CAPI) methods and can be conducted in English or Spanish.

[18] Center for Behavioral Health Statistics and Quality. *2019 National Survey on Drug Use and Health (NSDUH) methodological resource book: Section 2: Sample design report*. Rockville, MD: Substance Abuse and Mental Health Services Administration.

[19] NSDUH. *What is NSUDH?*
NSDUH. *Who uses NSDUH data?*

[20] We chose to end our study sample before the advent of the COVID-19 pandemic in 2020 because, at this time, we are not confident we can disentangle the differential effects of COVID-19 from the effect of I-502 in Washington versus other states.

[21] Between the years 2004-2019 nine other states legalized limited adult possession and use of cannabis and the purchase of cannabis products from a state-licensed cannabis retailer. This includes Alaska, California, Colorado, Maine, Massachusetts, Michigan, Nevada, Oregon, and Vermont. Although these states are omitted from the synthetic control analyses, they are included in Exhibit 1 for reference. Note that during this period the District of Columbia also legalized non-medical cannabis use and possession, but it did not legalize NMC retail and is therefore entirely omitted from consideration.

Exhibit 1
NSDUH Survey Weighted Sample Description, 2004-2019

Characteristics	Washington Percent (SE)	Other NMC legalizing states* Percent (SE)	Non-legalizing states Percent (SE)
Age (years):			
Ages 12 to 20	14.47 (0.32)	14.93 (0.11)	14.67 (0.05)
Ages 21 and older	85.53 (0.32)	85.07 (0.11)	85.33 (0.05)
Race/ethnicity:			
Non-Hispanic, White	74.59 (0.80)	57.66 (0.32)	67.71 (0.15)
Non-Hispanic, Black/African American	3.45 (0.31)	6.88 (0.14)	13.63 (0.12)
Non-Hispanic, Native American/Alaskan Native	0.80 (0.14)	0.38 (0.02)	0.57 (0.02)
Non-Hispanic, Native Hawaiian/other Pacific Islander	0.95 (0.12)	0.61 (0.04)	0.25 (0.01)
Non-Hispanic, Asian	7.76 (0.53)	9.07 (0.21)	3.57 (0.05)
Non-Hispanic, more than one race	2.82 (0.20)	1.89 (0.05)	1.33 (0.02)
Hispanic	9.63 (0.44)	23.50 (0.28)	12.93 (0.10)
Education:			
Less than high school (18 years and older)	10.87 (0.45)	14.14 (0.20)	14.66 (0.09)
Completed college (18 years and older)	31.83 (0.85)	32.54 (0.30)	28.44 (0.14)
Unemployed (18 years and older)	4.00 (0.25)	5.04 (0.09)	4.45 (0.04)
Married (18 years and older)	56.09 (0.81)	52.53 (0.26)	53.44 (0.14)
Physical health:			
Excellent	23.73 (0.48)	24.48 (0.18)	23.09 (0.09)
Very good	37.26 (0.63)	36.70 (0.20)	36.62 (0.09)
Good	27.12 (0.62)	27.03 (0.18)	27.47 (0.09)
Fair or poor	11.88 (0.51)	11.79 (0.15)	12.82 (0.08)
Household with at least one child (ages 18 and older)	37.15 (0.79)	39.73 (0.28)	37.90 (0.12)
Households with father present (ages 12 to 17)	76.35 (0.92)	75.73 (0.28)	73.30 (0.15)
Health insurance coverage:			
Medicaid	11.30 (0.49)	15.39 (0.18)	12.22 (0.08)
Medicare	18.15 (0.74)	16.61 (0.22)	18.83 (0.11)
Private insurance	69.81 (0.80)	66.15 (0.27)	66.86 (0.13)
No insurance	10.91 (0.42)	12.18 (0.15)	13.09 (0.07)
Living in poverty (excludes ages 18 to 22)	10.44 (0.48)	14.07 (0.19)	14.16 (0.09)
Receiving government assistance	17.61 (0.69)	17.34 (0.20)	18.05 (0.10)
Weighted N	**5,723,565**	**57,825,345**	**258,514,032**

Notes:
Percentages and corresponding standard errors were estimated using the NSDUH sampling weights, design variables, and methodology recommended by NSDUH documentation.
Restricted state identifiers were required for this analysis because the analyses required restricted-use data. The data were accessed through the Research Data Center.
*This includes Colorado, Alaska, Oregon, California, Massachusetts, Nevada, Maine, Vermont, and Michigan. Washington, D.C. did not legalize NMC retail and is therefore omitted from the sample.

Outcomes

Our outcome measures are constructed from an array of survey questions regarding the frequency of substance use. Responses to the following survey question were used to construct the primary measures of reported cannabis use:

> "During the past 30 days, on how many days did you use marijuana or hashish?"[22]

The first measure is an indicator for reporting any days of cannabis use in the last 30 days (i.e., past-month use).[23] The second is an indicator for *reporting 20 or more days of cannabis use in the last 30*, we refer to this as "heavy past-month use."[24]

We similarly analyze measures of past-month alcohol use and heavy past-month alcohol use.[25] Last, we define measures of use over the past 30 days separately for cigarettes, cocaine, and heroin.[26]

Exhibit 2 summarizes what percentage of our sample reports select measures of substance use in Washington between 2004-2019. We separately summarize this information for the sample of individuals ages 21 and older and the sample of individuals ages 12 to 20. Roughly 14% of individuals ages 12 to 20 reported cannabis use in the past 30 days, whereas 11% of individuals ages 21 and older reported past-month cannabis use. The prevalence of any alcohol consumption over the past 30 days is much higher among both groups, with 25% of individuals ages 12 to 20 reporting past-month use and over half of adults ages 21 and older reporting past-month use (61%). For both cannabis and alcohol, reported heavy use was less common. Past-month cigarette consumption is reported by 13% of underaged respondents and 21% of legal-age respondents in Washington. Cocaine and heroin are reported by less than 1% of each group.[27]

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[22] The subject of cannabis is introduced in the survey in the following way: "The next questions are about marijuana and hashish. Marijuana is also called pot or grass. Marijuana is usually smoked, either in cigarette, called joints, or in a pipe. It is sometimes cooked in food. Hashish is a form of marijuana that is also called 'hash.' It is usually smoked in a pipe. Another form of hashish is hash oil."

[23] This measure takes on a value of one if the individual reports any number between 1-30, and it takes on a value of zero if the individual had previously reported no use in the past 30 days. When available we used the SAMHSA-imputed or recoded versions of these variables that correct for misinterpretations or misconceptions about types of substance use. Using responses to other cannabis-related questions we also construct the following indicators of cannabis use: ever used, past-year use, and abuse or dependence. Substance Abuse and Dependence are based on Diagnostic and Statistical Manual of Mental Disorders IV (DSM-IV) criteria.

[24] Our definition of "heavy past-month cannabis use" is adopted from Johnson, J., Hodgkin, D., & Harris, S.K. (2017). The design of medical marijuana laws and adolescent use and heavy use of marijuana: Analysis of 45 states from 1991 to 2011. *Drug and Alcohol Dependence*, *170*, 1-8.

[25] Alcohol is introduced as "These questions are about alcoholic beverages. Throughout these questions, by a 'drink' we mean a can or bottle of beer, a glass of wine or a wine cooler, a shot of liquor, or mixed drink with liquor in it. We are not asking about times when you only had a sip or two from a drink."

[26] Tobacco, specifically cigarettes are introduced as "These questions are about your use of tobacco products. This includes cigarettes, chewing tobacco, snuff, cigars, and pipe tobacco. The first questions are about cigarettes only." Cocaine is introduced as "These questions are about cocaine, including all the different forms of cocaine, such as powder, 'crack,' free base, and coca paste." Heroin is introduced as "These next questions are about heroin."

[27] In additional analyses we examine other measures of substance use and consider outcomes related to substance use and mental health treatment. Treatment for substance use is introduced as "These next questions deal with treatment for alcohol and drug problems, **not including cigarettes**. Please report treatment or counseling designed to help you reduce or stop your alcohol or drug use. Please include detoxification and any other treatment for medical problems associated with your alcohol or drug use." Treatment for mental health is introduced as "These next questions are about treatment and counseling for problems with emotions, nerves or mental health. Please do not include treatment for alcohol or drug use." Treatment can include overnight inpatient stays, outpatient visits, seeing a mental health clinician, or day treatment program.

Exhibit 2
Percentage of Reported Substance Use in Washington, NSDUH 2004-2019

Outcomes	Legal use adults (ages 21 and older) Percent (SE)	Youth & young adults (ages 12 to 20) Percent (SE)
Past-month cannabis use	11.37 (0.51)	13.88 (0.19)
Heavy past-month cannabis use (i.e., at least 20 days of past-month use)	4.35 (0.26)	3.89 (0.10)
Past-month alcohol use	61.17 (0.88)	24.87 (0.26)
Heavy past-month alcohol use	8.15 (0.45)	0.61 (0.04)
Past-month cigarettes use	21.47 (0.69)	12.51 (0.18)
Past-month cocaine use	0.73 (0.13)	0.79 (0.04)
Past-month heroin use	0.19 (0.06)	0.08 (0.01)
Weighted N	**4,895,642**	**827,924**

Notes:
Percentages and corresponding standard errors were estimated using the NSDUH sampling weights, design variables, and methodology recommended by NSDUH documentation.
Restricted state identifiers were required for this analysis. Because the analyses required restricted-use data, the data were accessed through the Research Data Center.

Estimation Strategy

In order to assess how I-502 impacted substance use in Washington, we examine if outcomes changed in Washington in the years after I-502 differently from how outcomes changed in other states. To accomplish these analyses, we use a synthetic control (SC) approach.[28] When contrasted against other techniques designed to compare Washington to other states, the synthetic control methodology allows us to selectively compare Washington to only a set of states that are similar (as opposed to all states).

The synthetic control method enables us to define and create a control group to best resemble a valid counterfactual for Washington's reported substance use outcomes (i.e., to represent what would have happened in Washington in the absence of I-502). This counterfactual is referred to as the synthetic control unit. It is composed of a weighted combination of other states that have not legalized NMC between 2004-2019 and resemble Washington in terms of outcomes in the years prior to legalization.[29] This approach allows for an observational comparison of rates of reported substance use trends in Washington and its synthetic counterpart.[30] The synthetic control approach has been used to evaluate various policy changes and health interventions.

For our primary analyses, the treatment year is 2014, the year cannabis retail sales commenced. However, limited adult cannabis use and possession were legal in Washington the year before the first retailer opened, and it is possible that changes in cannabis use (and related substance use) occurred as early as 2013; therefore, in supplemental analyses, we alternatively define the treatment year as 2013.

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[28] We follow the approach described by Abadie, A., Diamond, A., & Hainmueller, J. (2010). Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program. *Journal of the American Statistical Association*, *105*(490), 493-505.
[29] The weights applied to different states are chosen to minimize the difference in the pre-intervention period predictors between Washington (i.e., the treated unit) and the potential synthetic control unit. The predictors used to create the synthetic control include the lagged values of the dependent variables from 2009-2013 and the pre-treatment period average of the following: unemployment rate, percentage population high school graduate, percentage population non-Hispanic White, and average beer sales tax.
[30] For our analyses, we determine statistical significance using a placebo-based inference approach (Abadie 2010).

III. Results

In this section, we provide the results of our synthetic control analyses. First, we summarize findings from our analyses of the relationship between the advent of retail sales in Washington and measures of reported cannabis use. Second, we summarize the results from similar analyses which examine changes in other reported substance use, including alcohol, cigarettes, cocaine, and heroin. All analyses separately evaluate outcomes for the sample of individuals ages 12 to 20 and individuals ages 21 and older.

Reported Cannabis Use

We focus on results related to two primary measures of reported cannabis use: 1) the proportion of survey respondents who reported past-month cannabis use, and 2) the proportion of survey respondents who reported heavy past-month cannabis use (i.e., at least 20 of the last 30 days).

Adults ages 21 and older
Panel A of Exhibit 3 depicts the average trends in the proportion of adults ages 21 and older who reported past-month cannabis use in Washington (dark blue line) and its synthetic counterpart (light blue line) from 2004 to 2019. In the years before the advent of legal cannabis sales in Washington (2004 to 2013), the levels and trends of reported past-month cannabis use were very similar between Washington and its synthetic counterpart. This similarity in outcomes prior to I-502 between the two groups indicates that our synthetic control group is an appropriate comparison for Washington. When we examine trends after cannabis sales started in 2014, we do not see a large deviation in Washington's rate of reported past-month use. Although we see bigger gaps between outcomes in some of the years following retail allowance (e.g., 2017 and 2019), on average, the level and trend in reported past-month cannabis use for the synthetic unit still track relatively closely with Washington after 2014. This suggests that most, if not all, of the upward trend in reported past month use in Washington would have likely persisted over this period even in the absence of legalized retail sales (given that trends were similarly increasing in comparable non-legalizing states).

Exhibit 4 summarizes the average difference in outcomes in Washington compared to its synthetic counterpart in the years after the advent of retail sales. The first column (summarizing the analyses depicted in Exhibit 3, Panel A) indicates that the magnitude of the average difference in the rate of reported adult past-month cannabis use between WA and the synthetic control group is 2.3 percentage points. However, this difference is not statistically significant.

Panel B of Exhibit 3 similarly illustrates that we find no significant changes in the proportion of adults ages 21 and older who reported heavy past-month cannabis use in Washington relative to its synthetic counterpart. As summarized in the second column of Exhibit 4, the magnitude of the average difference in the proportion of adults reporting heavy past-month cannabis use is 1.3 percentage points, and it is not statistically significant.
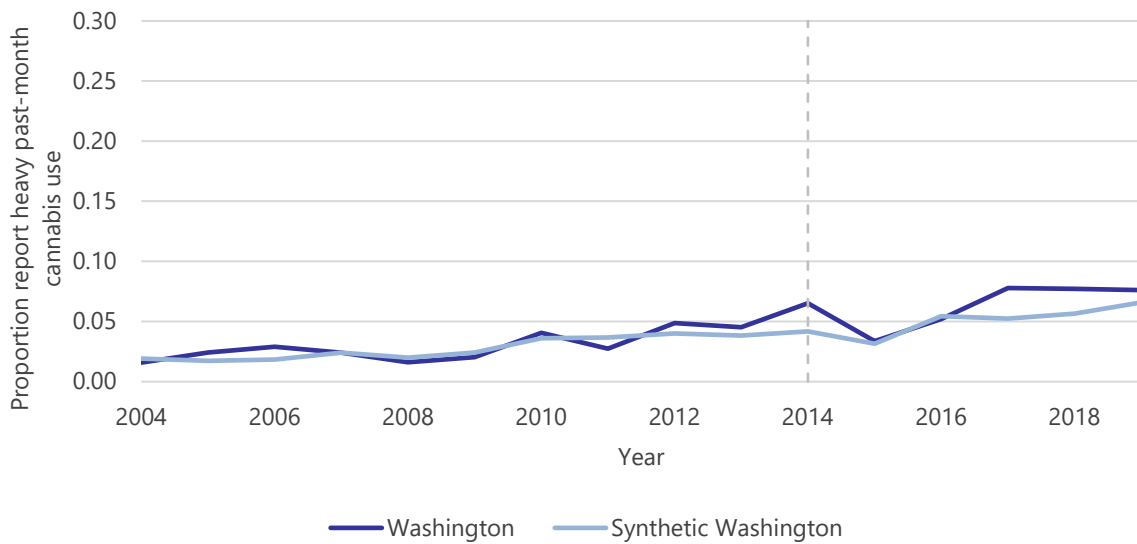
Exhibit 3
NSDUH Rates of Cannabis Use for Washington and the Synthetic Control Unit,
Adults Ages 21 and older
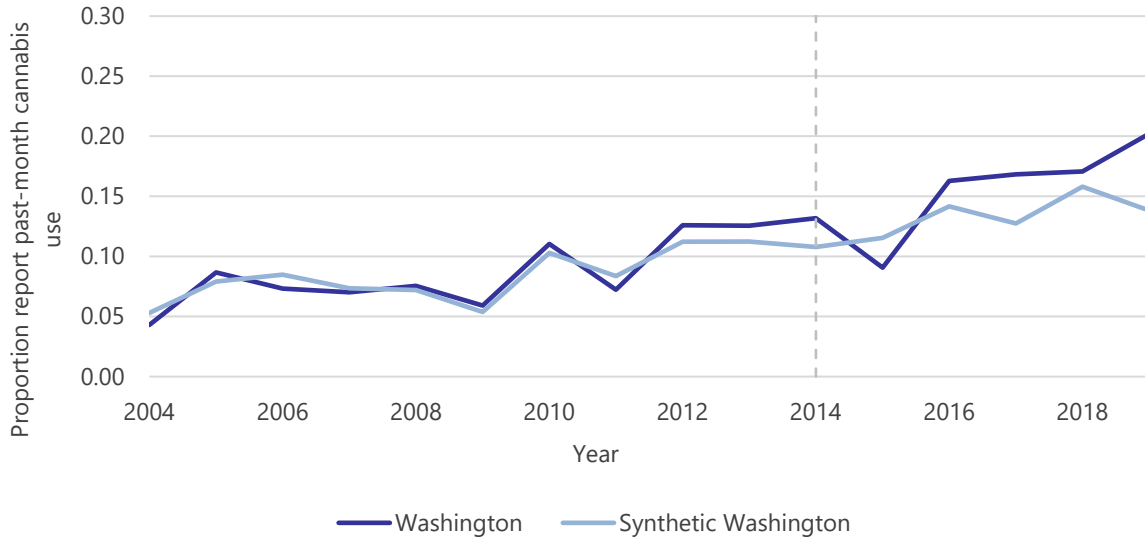
Panel A

Panel B

Notes:
Restricted state identifiers were required for this analysis. Because the analyses required restricted-use data, the data were accessed through the Research Data Center.
Heavy use is defined as any cannabis use during at least 20 of the past 30 days.

Exhibit 4

Average Difference in Rates of Reported Cannabis Use for Washington Versus the Synthetic Control Unit
After Non-Medical Cannabis Legalization/Sales, Adults Ages 21 and Older

	Past-month cannabis use	Heavy past-month cannabis use (i.e., at least 20 days)
Advent of retail sales in WA (2014)		
Average difference post-treatment	0.023	0.013
p-value	0.128	0.425
Enactment of I-502 (2013)		
Average difference in post-treatment	0.026	0.015
p-value	0.125	0.350
Average outcome, WA (2004-2011)	0.074	0.025

Notes:

This table includes synthetic control estimated p-values based on permutation testing of the ratio of mean squared error ratios for the post-treatment and pre-treatment periods.

Restricted state identifiers were required for this analysis. Because the analyses required restricted-use data, the data were accessed through the Research Data Center.

Selected variables used to create the synthetic control include the lagged values of the dependent variables from 2009-2013 and the pre-treatment period average of the following: unemployment rate, percentage population high school graduate, percentage population non-Hispanic White, and average beer sales tax.

We alternatively examine how cannabis-related outcomes in Washington differ from the synthetic group if we define treatment as the first full year I-502 went into effect and adult cannabis use and possession was legalized (2013). The results of these analyses are summarized in the second half of Exhibit 4. The magnitude of the average differences in the proportion of reported past-month and heavy past-month use are not statistically significant and qualitatively equivalent to those found when treatment started with the commencement of sales in 2014.[31]

In analyses not presented here, we examined differences for the following reported outcomes: any cannabis use ever, past-year cannabis use, and cannabis abuse or dependence. Similar to the results discussed in this section, differences in the levels and trends of each of these outcomes between WA and the synthetic comparison are not statistically significant in the years following the advent of cannabis sales.[32]

Our results and the corresponding significance tests demonstrate that there is not enough evidence to conclude that legalized adult cannabis use, possession, and sales in Washington changed average legal cannabis use across all adults ages 21 and older. We observe that both Washington and the synthetic control group of states that did not legalize NMC experienced a similar increasing trend in reported cannabis during this time.

Note the synthetic control approach requires us to aggregate individual-level response data to state-level annual response rates. Analysis with the aggregated outcomes data could make it challenging to detect statistical significance for small or moderate effects.

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[31] We examine the robustness of our results to two alternative specifications: 1) we exclude border states from the synthetic control donor pool, and 2) we construct the synthetic control unit by weighting only the lagged values of the dependent variables from 2004-2013. Results from these analyses are qualitatively equivalent to the main results presented here.

[32] The results from these analyses are available upon request.

Youth and Young Adults Ages 12 to 20

While I-502 legalized NMC possession, use, and sales for adults 21 and over, there is concern that I-502 and retail cannabis sales may produce spillovers that lead to increases in underage young adult and youth use of cannabis. To examine this, we estimate a similar synthetic control model but for the population of youth and young adults ages 12 to 20.

Panels A and B of Exhibit 5 depict the average trends in the proportion of individuals ages 12 to 20 who reported past-month cannabis use and heavy past-month cannabis use from 2004 to 2019, respectively. Average trends are plotted for Washington and its synthetic counterpart. Similar to what was found when examining outcomes for adults ages 21 and older, the levels and trends of the synthetic group closely follow Washington's trends both before and after the advent of cannabis sales in 2014. The magnitude of the average differences in outcomes between Washington and the synthetic group in the years after sales started in Washington are relatively small in magnitude and are not statistically significant—these values are summarized in Exhibit 6. This indicates that we do not find sufficient evidence that legalized adult use, possession, and sales of cannabis significantly changed reported cannabis use for youth and non-legal-aged adults.

Note that average reported past-month and heavy past-month cannabis use were trending upwards, both before and after sales, among the sample of adults ages 21 and older (Exhibit 3); however, average reported cannabis use remained relatively level across time for the sample of youth and young adults ages 12 to 20 (Exhibit 5).
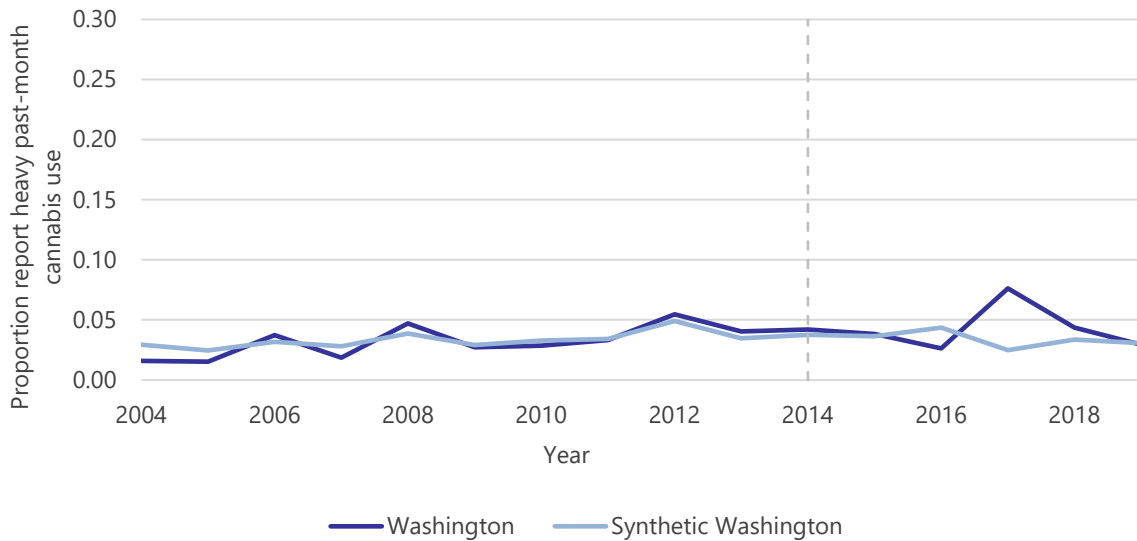
Exhibit 5

NSDUH Rates of Cannabis Use for Washington and the Synthetic Control Washington,
Youth and Young Adults Ages 12 to 20
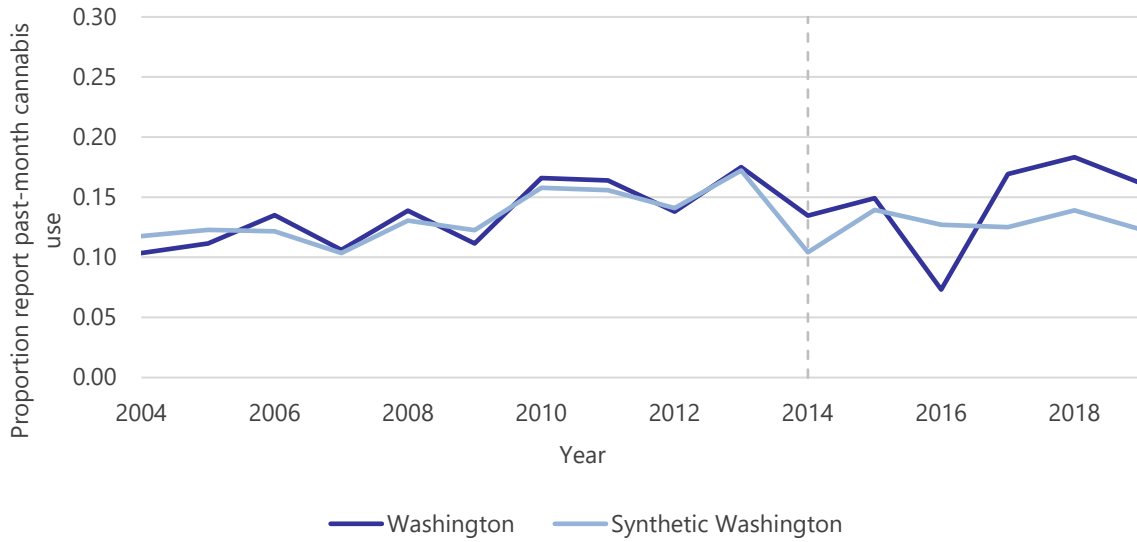
<u>Notes</u>:

Restricted state identifiers were required for this analysis. Because the analyses required restricted-use data, the data were accessed through the Research Data Center.

Heavy use is defined as any cannabis use during at least 20 of the past 30 days.

Exhibit 6

Average Difference in Rates of Reported Cannabis Use for Washington Versus the Synthetic Control Unit
After Non-Medical Cannabis Legalization/Sales, Youth and Young Adults Ages 12 to 20

	Past-month cannabis use	Heavy past-month cannabis use (i.e., at least 20 days)
Advent of retail sales in WA (2014)		
Average difference in post period	0.019	0.008
p-value	0.154	0.200
Enactment of I-502 (2013)		
Average difference in post period	0.019	0.009
p-value	0.231	0.150
Average outcome, WA (2004-2011)	0.129	0.028

Notes:
This table includes synthetic control estimated p-values based on permutation testing of the ratio of mean squared error ratios for the post-treatment and pre-treatment periods.
Restricted state identifiers were required for this analysis. Because the analyses required restricted-use data, the data were accessed through the Research Data Center.
Selected variables used to create the synthetic control include the lagged values of the dependent variables from 2009-2013 and the pre-treatment period average of the following: unemployment rate, percentage population high school graduate, percentage population non-Hispanic White, and average beer sales tax.

Other Reported Substance Use

The relationship between NMC laws and alcohol, cigarettes, and other controlled substance use is still largely unknown, given that the limited related literature has produced mixed results. Therefore, concerns persist that laws such as I-502 may inadvertently increase other substance use. To examine this relationship, we estimate the same synthetic control model for the following outcomes: past-month alcohol use, heavy past-month alcohol use, past-month cigarette use, past-month cocaine use, and past-month heroin use.

Adults Ages 21 and Older
Exhibit 7 summarizes the average difference in the proportion of reported adult substance use in Washington versus the synthetic control group in the years after the advent of cannabis retail in 2014. Across all types of reported past-month substance use, the magnitudes of the differences are relatively small and statistically insignificant. This indicates that we do not find significant deviations in the levels and trends of reported past-month substance use in Washington in the years after cannabis sales began in 2014.

Exhibit 7
Average Difference between Washington and the Synthetic Control Washington Rates of Substance Use Post-Treatment, Adults Ages 21 and older

	Past-month alcohol use	Heavy past-month alcohol use (i.e., at least 20 days)	Past-month cigarette use	Past-month cocaine use	Past-month heroin use
Advent of retail sales in WA (2014)					
Average difference in post period	0.018	-0.005	0.009	0.003	0.000
p-value	0.744	0.475	0.125	0.500	0.590
Enactment of I-502 (2013)					
Average difference in post period	-0.005	0.004	0.010	0.003	0.000
p-value	0.692	0.575	0.275	0.675	0.650
Average outcome, WA (2004-2011)	0.614	0.086	0.237	0.007	0.001

Notes:
This table includes synthetic control estimated p-values based on permutation testing of the ratio of mean squared error ratios for the post-treatment and pre-treatment periods.

Restricted state identifiers were required for this analysis. Because the analyses required restricted-use data, the data were accessed through the Research Data Center.

Selected variables used to create the synthetic control include the lagged values of the dependent variables from 2009-2013 and the pre-treatment period average of the following: unemployment rate, percentage population high school graduate, percentage population non-Hispanic White, and average beer sales tax.

Youth and Young Adults Ages 12 to 20

Exhibit 8 similarly reports the results of these analyses conducted on the sample of youth and young adults ages 12 to 20. We again find that after sales began in 2014, the average difference in outcomes between Washington and the synthetic group is relatively small and not statistically significant.

Exhibit 8

Average Difference between Washington and the Synthetic Control Washington Rates of Substance Use Post-Treatment, Youth and Young Adults Ages 12 to 20

	Past-month alcohol use	Heavy past-month alcohol use (i.e., at least 20 days)	Past-month cigarette use	Past-month cocaine use	Past-month heroin use
Advent of retail sales in WA (2014)					
Average difference in post period	0.005	0.000	-0.011	0.000	-0.001
p-value	0.333	0.700	1.000	0.275	0.718
Enactment of I-502 (2013)					
Average difference in post period	0.019	0.000	-0.004	0.000	0.000
p-value	0.333	0.800	0.725	0.154	0.750
Average outcome, WA (2004-2011)	0.279	0.009	0.174	0.008	0.002

Notes:
This table includes synthetic control estimated p-values based on permutation testing of the ratio of mean squared error ratios for the post-treatment and pre-treatment periods.
Restricted state identifiers were required for this analysis. Because the analyses required restricted-use data, the data were accessed through the Research Data Center.
Selected variables used to create the synthetic control include the lagged values of the dependent variables from 2009-2013 and the pre-treatment period average of the following: unemployment rate, percentage population high school graduate, percentage population non-Hispanic White, and average beer sales tax.

IV. Limitations and Discussion

Limitations

There are several limitations to consider when interpreting results.

From a research design perspective, the nature of the aggregated outcomes data could make it challenging to detect statistical significance for small or moderate effects using a synthetic control methodology. Furthermore, the synthetic methodology uses aggregated annual state-level data, which focuses on the overall average effect of any cannabis retail sales statewide and therefore does not account for the separate impact of other components of I-502 or differences in the impact of retail sales across different regions of the state.

Another major limitation of this study is that the synthetic control method cannot account for other factors that may have impacted cannabis and/or other substance use in Washington over the same period. For example, Washington privatized the retail sale of liquor in 2012, shortly before I-502 was enacted.[33] Additionally, Washington voluntarily expanded Medicaid in 2014 under the Affordable Care Act, which extended healthcare coverage to hundreds of thousands of individuals and, therefore, may impact rates of substance use in the state. Because these policies were enacted around the same time non-medical cannabis was legalized and retailers opened, it is difficult to disentangle how much of the observed effects of our analyses can be solely attributed to I-502.

Our analysis uses NSDUH data from a voluntary survey, and therefore the population of participants who complete the survey may systematically differ from non-respondents in unobserved ways. Another limitation arising from using NSDUH data is the inability to conduct analyses across subgroups of interest (e.g., sex or race/ethnicity) due to relatively small annual state-level samples. Due to changes in survey design over time, we were not able to explore the impact of I-502 on other relevant outcomes, such as binge drinking behavior and prescription opioid use. NSDUH's questions regarding cannabis use do not inquire about specific details of importance to potential health outcomes such as the types of cannabis products used (e.g., concentrate, edibles, flower, etc.), the THC concentration of cannabis products used, or updated definitions and severity of substance use disorder.

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[33] Initiative 1183.

Conclusion

We do not find evidence that the enactment of I-502 *or* the advent of cannabis retail sales in Washington significantly increased (or decreased) reported cannabis use, alcohol use, or other substance use compared to non-legalizing states. Although we observe a steady upward trend in reported adult past-month cannabis use in Washington, we observe this same pattern in the synthetic control unit composed of states that did not legalize NMC. Therefore, we ultimately cannot attribute changes in cannabis use to the advent of cannabis retail sales in Washington. Furthermore, we do not find a significant relationship between the advent of cannabis retail sales and reported youth cannabis or other substance use. While this work provides an overall picture of Washington relative to other states, it is important to note that within Washington, geographical access to licensed cannabis retailers varies largely. Therefore, further exploration of how greater access might differentially impact cannabis and other substance use is required. We focus on questions regarding retailer access in other analyses evaluated as a part of our third required report, to Initiative 502 and Cannabis-Related Public Health and Safety Outcomes: *Third Required Report*.[34] In particular, using data from Washington State, we examine the relationship between access to licensed non-medical cannabis retailers and public health and safety outcomes. We focus on outcomes related to the following:

- substance use disorder diagnoses,
- cannabis-related convictions, and
- traffic fatalities.

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[34] Rashid (2023).

Acknowledgments and Disclaimers

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