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I-502 Evaluation and Benefit-Cost Analysis
Second Required Report

In November 2012, Washington State voters passed Initiative 502 (I-502) which legalized limited possession and private use of marijuana by adults.[1] The law also directed the Washington State Institute for Public Policy (WSIPP) to conduct benefit-cost evaluations of the implementation of I-502 by examining outcomes related to:

- public health,
- public safety,
- substance use,
- the criminal justice system,
- economic impacts, and
- administrative costs and revenues.

WSIPP is required to produce reports for the legislature in 2015, 2017, 2022, and 2032. This report focuses on initial results of outcome analyses examining the effects of I-502 implementation on youth and adult substance use, treatment admissions for cannabis abuse, and drug-related criminal convictions.

Summary

I-502 required WSIPP to conduct a benefit-cost evaluation of implementation of the law from its enactment in 2012 through 2032. In this second required report, we present preliminary findings of outcome analyses to identify effects of I-502 on youth and adult substance use, cannabis abuse treatment admissions, and drug-related criminal convictions.

We used two main analysis strategies. We examined the effect of I-502 enactment on cannabis abuse treatment admissions, comparing Washington to similar non-legalizing states before and after I-502 enactment. We also examined how local differences in the amount of legal cannabis sales affected cannabis abuse treatment admissions, youth and adult substance use, and drug-related criminal convictions.

We found that cannabis abuse treatment admissions were not affected by I-502 enactment. We also found that the amount of legal cannabis sales generally had no effect on outcomes. One exception was that adults 21 and older in counties with more retail cannabis sales were more likely to report using cannabis in the past 30 days and to report using it heavily.

These findings represent a snapshot of our progress to date and are an intermediate step towards the ultimate benefit-cost analysis of I-502.

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[1] Initiative Measure No. 502.

The report is organized as follows: Section I provides background information on I-502 and our study requirements, establishing the specific portion of the overall study requirements that we address in this report. Section II describes the current status of the evolving marijuana policy context. Section III describes current research on effects of medical and non-medical cannabis legalization. Section IV details our analysis strategy. Section V describes our findings. Section VI provides a summary and notes limitations of this report.

Terminology

In this report we use the terms "cannabis" and "marijuana" interchangeably, to refer to all drug preparations of the cannabis genus of plants. We retain the terminology used in existing materials that we cite. We use the term "non-medical" in place of "recreational" to refer to cannabis consumption that is not part of an authorized treatment of a medical condition. Throughout the report, references to non-medical cannabis exclude black market cannabis.

I. Introduction

This report is part of a series of reports WSIPP will release over a 20-year period to assess the effects of I-502, as required by the initiative. The requirements for the study are shown in Exhibit 1.

The study requirements define six broad categories of outcomes to be evaluated: public health, public safety, youth and adult drug use and maladaptive use, economic impacts, criminal justice, and state and local administrative costs and revenues.

The ultimate aim of the study is a benefit-cost analysis of I-502 implementation. Our benefit-cost analysis will account for an array of monetary aspects of I-502 implementation:

- State and local revenues;
- State and local agency costs of implementing the law;
- Effects on substance use, health, traffic safety, crime, workplace safety, etc.; and
- Other economic impacts including employment and wages in the non-medical cannabis industry and ripple effects on the broader economy.

In September 2015, WSIPP released the first report in the series, *I-502 Evaluation Plan and Preliminary Report on Implementation*, in which we articulated our research plan for the overall study.[2] In brief, our research plan includes three main components: a descriptive study, a series of outcome

[2] Darnell, A.J. (2015). *I-502 evaluation plan and preliminary report on implementation.* (Doc. No. 15-09-3201). Olympia: Washington State Institute for Public Policy.

studies to identify potential effects of I-502, and a summative benefit-cost evaluation. The outcome studies will examine both the net effect of I-502 and the effect of specific features of I-502 on:

- Substance use: Youth and adult use and abuse of cannabis, alcohol, and other drugs;
- Health: Physical and mental health problems associated with substance use;
- Traffic safety: Traffic accidents and fatalities involving impaired drivers;
- Criminal justice: Arrests, convictions, and sanctions for charges involving cannabis and other drugs;
- Education: Standardized test scores, disciplinary actions, grade retention, and high school graduation; and
- Workplace safety and productivity: Accidents, injuries, and absenteeism.

The current report presents preliminary results from analyses designed to identify effects of I-502 on a subset of the above non-monetary outcomes. This is a necessary step in accomplishing the larger study aim of a benefit-cost analysis of I-502.

We must emphasize that analyses are ongoing, and the findings here reflect a snapshot of our progress to date. Results may change as implementation of the law progresses and more outcome data become available.

Study Overview

Central to our study of I-502 is the identification of causal effects of the law—changes in outcomes that can be attributed to I-502. As described in Section II of this report, I-502 had multiple components, all of which might affect outcomes.

The primary features of I-502 that may influence outcomes are changes in criminal prohibitions; the formation and growth of a regulated cannabis supply system; and required investments in substance abuse prevention, treatment, and research. These features may produce a variety of possible effects; for illustration, we describe several examples below.

As a result of I-502, limited adult possession and private use are no longer illegal. The licensed production, delivery, and sale of cannabis are also no longer illegal. As a result, cannabis users may be less likely to come into contact with the criminal justice system. The elimination of these prohibitions could lead to increased enforcement of other crimes. On the other hand, I-502 also added a new *per se* blood content limit for cannabis-impaired driving. Although cannabis-impaired driving was illegal prior to I-502, enforcement of this new aspect of the law or an increase in cannabis-impaired driving may increase demands on criminal justice resources.

In addition to changes to criminal prohibitions, I-502 also provided for the formation of a regulated cannabis supply system. The new supply system is expected to increase adult access to cannabis; expected effects on youth access are less clear. Although licensed retailers are not permitted to sell to persons under age 21, access by youth may increase if they are able to obtain legally purchased marijuana secondhand. It is also possible that youth access could decrease if black market supply of cannabis is reduced by successful competition of the legal market. The new

legal market may also produce changes in advertising, product quality, potency, price, and diversification of product types, all of which may influence the use of cannabis and subsequent outcomes.[3] The amount of legal cannabis sales may vary within the state and over time and further affect the use of cannabis and subsequent outcomes.

I-502 also required investments in substance abuse prevention, treatment, and research. Revenues collected from cannabis excise taxes, penalties, and fees are directed to public education campaigns, evidence-based prevention and treatment programming, and cannabis-related research, all of which may mitigate potential harms resulting from increased access to cannabis.

In our outcome analyses examining the effects of I-502, we can apply research strategies that focus on effects of the law as a whole, in which effects of different aspects of the law are combined and the net effect of the law can be identified. Additionally, we can apply strategies that focus on effects of specific aspects of the law, such as the amount of legal cannabis sales or the intensity of prevention programming in an area. Both of these strategies are needed for a complete understanding of effects of I-502.

In the outcome analyses described in this report, we applied two types of strategies in order to detect net effects of I-502 and the effect of a specific aspect of I-502—the amount of legal cannabis sales. We were able to complete both types of analyses to examine cannabis abuse treatment admissions. We used a between-state analysis to examine the effects of I-502 as a whole, comparing changes before and after I-502 enactment in Washington to non-legalizing states, and a within-state analysis to identify whether the amount of legal cannabis sales in different parts of Washington affects cannabis abuse treatment admissions in those areas. We also present within-state analyses on the effects of the amount of legal cannabis sales on youth and adult substance use and drug-related criminal convictions. Both strategies are described in more detail in Section IV.

Ideally, we would use both strategies to investigate effects of I-502 on each outcome. At this time, we do not have access to data that would support between-state analyses for all outcomes examined in this report. Our work is ongoing to access these data. In future reports we will report findings from new between-state analyses on the current outcome domains. We will also report between- and within-state analyses for other outcome domains, such as workplace safety, in our broader study. In future reports, we will also share findings from other aspects of our study which are ongoing, including examining the state and local costs of implementation of I-502; the impact of increased investment in prevention, treatment, and research; and the broader economic impacts of the law. In Appendix Exhibit A4 we provide an update on the status of data access efforts and other components of the overall study.

[3] Kilmer et al. (2010).

Exhibit 1

I-502 Study Requirements Contained in the
Revised Code of Washington (RCW) 69.50.550 (emphasis added)

*(1) The Washington state institute for public policy shall conduct **cost-benefit evaluations** of the implementation of chapter 3, Laws of 2013. A preliminary report, and recommendations to appropriate committees of the legislature, shall be made by September 1, 2015, and the first final report with recommendations by September 1, 2017. Subsequent reports shall be due September 1, 2022, and September 1, 2032.*

(2) The evaluation of the implementation of chapter 3, Laws of 2013 shall include, but not necessarily be limited to, consideration of the following factors:

*(a) **Public health**, to include but not be limited to:*

(i) Health costs associated with marijuana use;

(ii) Health costs associated with criminal prohibition of marijuana, including lack of product safety or quality control regulations and the relegation of marijuana to the same illegal market as potentially more dangerous substances; and

(iii) The impact of increased investment in the research, evaluation, education, prevention and intervention programs, practices, and campaigns identified in RCW 69.50.363 on rates of marijuana-related maladaptive substance use and diagnosis of marijuana-related substance-use disorder, substance abuse, or substance dependence, as these terms are defined in the Diagnostic and Statistical Manual of Mental Disorders;

*(b) **Public safety**, to include but not be limited to:*

(i) Public safety issues relating to marijuana use; and

(ii) Public safety issues relating to criminal prohibition of marijuana;

*(c) **Youth and adult rates** of the following:*

(i) Marijuana use;

(ii) Maladaptive use of marijuana; and

(iii) Diagnosis of marijuana-related substance-use disorder, substance abuse, or substance dependence, including primary, secondary, and tertiary choices of substance;

*(d) **Economic impacts** in the private and public sectors, including but not limited to:*

(i) Jobs creation;

(ii) Workplace safety;

(iii) Revenues; and

(iv)Taxes generated for state and local budgets;

*(e) **Criminal justice impacts**, to include but not be limited to:*

(i) Use of public resources like law enforcement officers and equipment, prosecuting attorneys and public defenders, judges and court staff, the Washington state patrol crime lab and identification and criminal history section, jails and prisons, and misdemeanant and felon supervision officers to enforce state criminal laws regarding marijuana; and

(ii) Short and long-term consequences of involvement in the criminal justice system for persons accused of crimes relating to marijuana, their families, and their communities; and

*(f) **State and local** agency administrative costs and revenues.*

II. Policy Context

Cannabis Policy in Washington State

Relevant policy changes in Washington State begin with medical legalization, which was effected in 1998 by the passage of voters' Initiative 692 (I-692). I-692 provided authorized patients and their designated caregivers a legal defense for charges related to the use or possession of medical cannabis (an "affirmative defense").[4]

In 2011, the legislature passed an overhaul of medical cannabis regulations.[5] The bill created a registry of medical cannabis patients and providers and directed state employees to authorize and license commercial medical cannabis businesses. Those sections of the bill were vetoed due to concerns that they would expose public employees to the risk of federal prosecution.[6] The remaining provisions of the legislation provided an affirmative defense for home cultivation and collective gardens, which were defined as cooperative grow operations among medically authorized patients, with limits placed on the number of patients and plants.

Also in 2011, liquor sales were privatized by passage of Initiative 1183 (I-1183). Effective in June 2012, the initiative removed the state controlled liquor system, allowed liquor sales by private stores, removed uniform pricing, and removed bans on quantity discounts and advertising.[7] I-1183 represents an important part of the policy context because it went into effect less than a year prior to I-502 and could potentially influence outcomes such as traffic safety.

On November 6, 2012, I-502 passed with 55.7% approval in Washington State, legalizing limited adult possession and private consumption of non-medical cannabis as well as its licensed production and sale. I-502 mandated the Washington State Liquor and Cannabis Board (LCB) to oversee the recreational market and imposed a 25% excise tax on cannabis sales at each of the three tiers in the legal supply chain: producers, processors, and retailers. I-502 designated a new budget account for cannabis revenues (the Dedicated Marijuana Account) and required expenditures from that account on a variety of activities, including substance abuse prevention and treatment, supply chain enforcement, and cannabis-related research.[8] I-502 also added a new threshold for driving under the influence of cannabis. The law became effective on December 6, 2012.

In October 2013, the LCB adopted the first set of rules regarding cannabis licenses, the application process, requirements, and reporting. License applications were accepted from November to December 2013. The LCB initially capped the number of retailer licenses at 334; there is no cap on producer or processor licenses. The first producer and processor licenses were issued in March 2014. Retailer licenses were allotted for each city and county based on estimates of cannabis demand and incorporated random selection

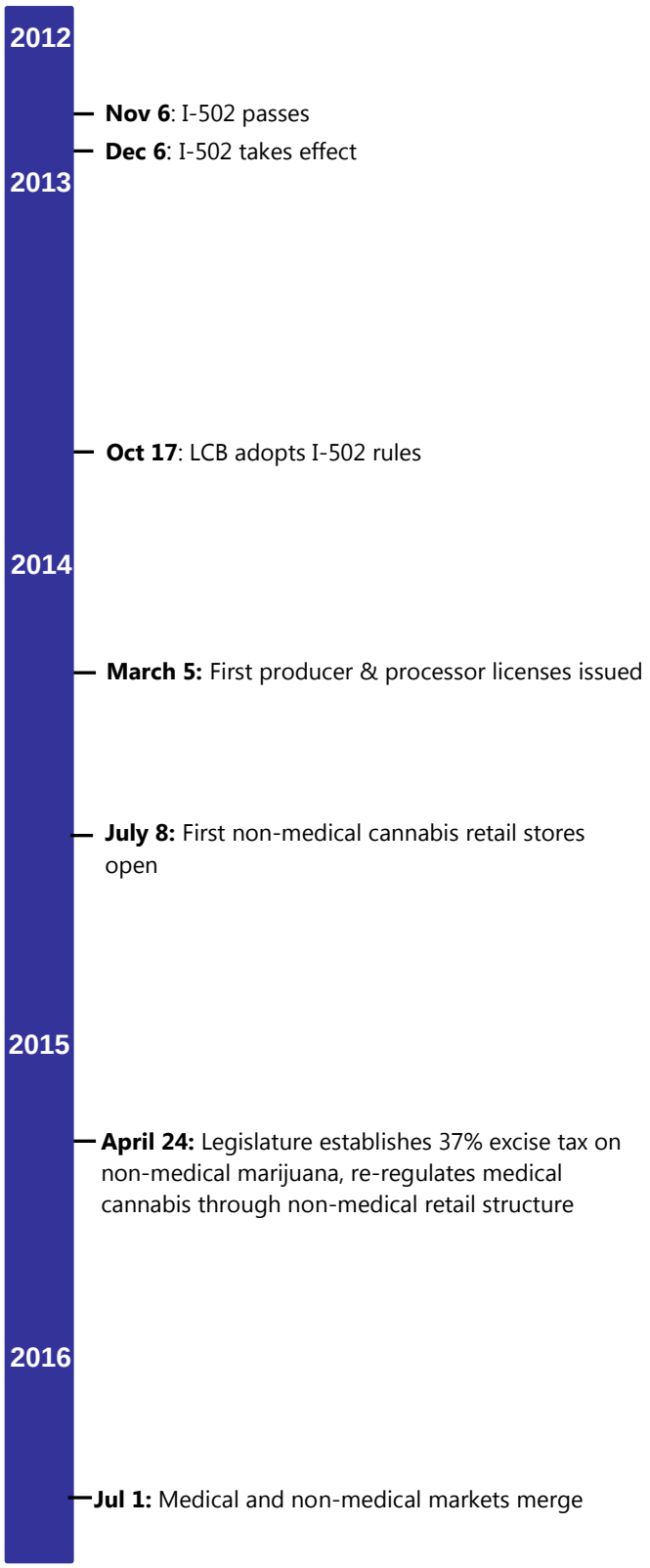
[4] Initiative No. 692.
[5] Engrossed Second Substitute Senate Bill 5073, Chapter 181, Laws of 2011, partial veto.
[6] https://www.sos.wa.gov/elections/initiatives/text/i692.pdf.
[7] Initiative Measure No. 1183, Chapter 2, Laws of 2012; Full text available at http://lawfilesext.leg.wa.gov/biennium/2011-12/Pdf/Initiatives/Initiatives/INITIATIVE%201183.SL.pdf.
[8] RCW 69.50.540.

when the number of applicants exceeded the allotment. The first non-medical cannabis retail stores opened on July 8, 2014.

In 2014, the Washington State Court of Appeals declared that state law only provided an affirmative defense for medical cannabis patients and that the use and possession of medical cannabis, including collective gardens, were still illegal.
The 2015 Legislature passed legislation regulating medical cannabis through the existing non-medical cannabis regulatory structure and created a voluntary registry of medical cannabis patients.[9] The legislation required businesses with a non-medical retail license to obtain a medical marijuana endorsement in order to serve medical patients. In response to expected increased demand from medical patients, the LCB opened an additional application window for retailers from October 2015 to March 2016 and raised the state cap of retail licenses from 334 to 556. The formal integration of medical and non-medical cannabis sales occurred on July 1, 2016.

The 2015 Legislature also changed the tax structure on cannabis, replacing the three-tier tax structure (i.e., the 25% tax on sales by producers, processors, and retailers) with a single 37% excise tax on retail sales.[10] The same law provided for distribution of excise tax revenues to local jurisdictions and allowed jurisdictions to reduce the required buffer zones around cannabis businesses.

Exhibit 2
I-502 Policy Timeline



[9] Second Substitute Senate Bill 5052, Chapter 70, Laws of 2015.
[10] Second Engrossed Second Substitute House Bill 2136, Chapter 4, Laws of 2015.

Local Cannabis Policy in Washington

City and county governments have enacted their own policies concerning regulation of licensed cannabis businesses. In January 2014, the Washington State Attorney General released a memo affirming that local jurisdictions may regulate and/or ban I-502-related businesses. Generally, multiple cities are located within a given county boundary; city governments can legally regulate businesses within city boundaries, and county governments can regulate businesses in unincorporated areas.[11] A recent study found that as of June 30, 2016, six of Washington's 39 counties (15%), and 54 of 142 cities (38%) with populations of 3,000 or more had passed permanent bans on legal retail cannabis sales—approximately 30% of the state's population lived in these areas.[12]

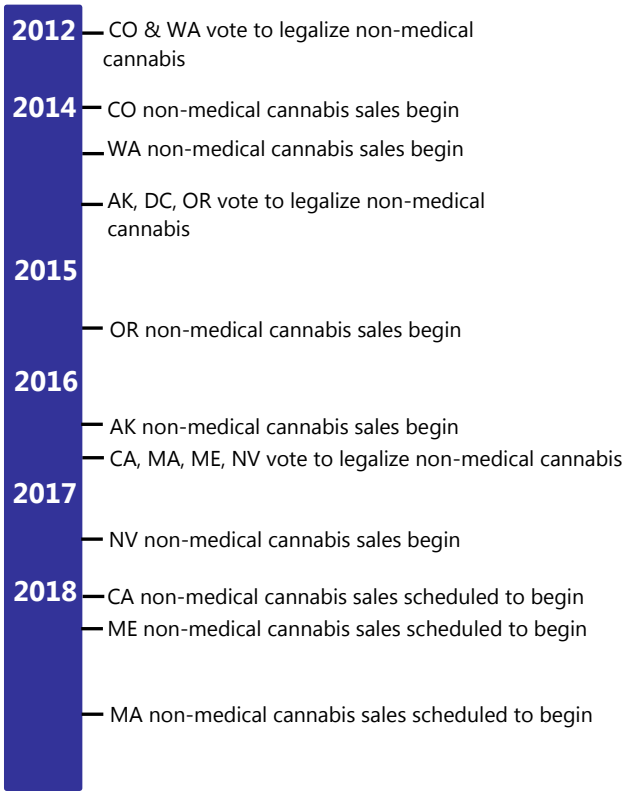
Cannabis Policy in Other States

As of June 30, 2017, 29 states (including Washington) and the District of Columbia had legalized medical cannabis. An additional 15 states allowed limited access to certain forms of cannabis extract high in cannabidiol (referred to as CBD-only laws).[13]

Eight of these states, including Washington, passed ballot initiatives to allow the sale of cannabis for non-medical purposes (Exhibit 5).[14] The District of Columbia legalized cannabis for non-medical purposes but does not allow sales. Oregon's legalization of non-medical cannabis in 2014 is of particular relevance for this study, due to its proximity and the potential impact on Washington cannabis sales to Oregon residents. Under Oregon's law, existing medical dispensaries are allowed to sell cannabis to anyone 21 and older as of October 2015, and the first dedicated non-medical retailers opened in October of 2016.

Exhibit 3

Timeline of Other States' Non-Medical Cannabis Laws



[11] RCW 70.05.030 & 70.05.035.

[12] Dilley et al. (2017).

[13] Cannabidiol (or CBD) and THC (tetrahydrocannabinol) are the two most well-known cannabinoids—chemical compounds in cannabis that act on cannabinoid receptors in the human body. Unlike THC, CBD does not have intoxicating psychoactive effects.

[14] In May 2017, the Vermont Legislature became the first state to pass a non-medical cannabis legalization bill through its legislature; however, the measure was vetoed. http://legislature.vermont.gov/assets/Documents/2018/Docs/CALENDAR/sc170621.pdf#page=1].

Implementation of the legal cannabis supply system

In this section we describe the status of the cannabis supply system created by I-502. Specifically, we describe growth in the amount of retail sales of cannabis and differences in retail sales amounts across the state, which are the subject of many of our outcome analyses.

Legal Cannabis Supply System

The three-tiered cannabis supply system consists of producers, processors, and retailers, as licensed by the LCB. Generally, producers grow cannabis, processors package and create secondary products such as extracts and edibles, and retailers sell cannabis and products for consuming cannabis to consumers.

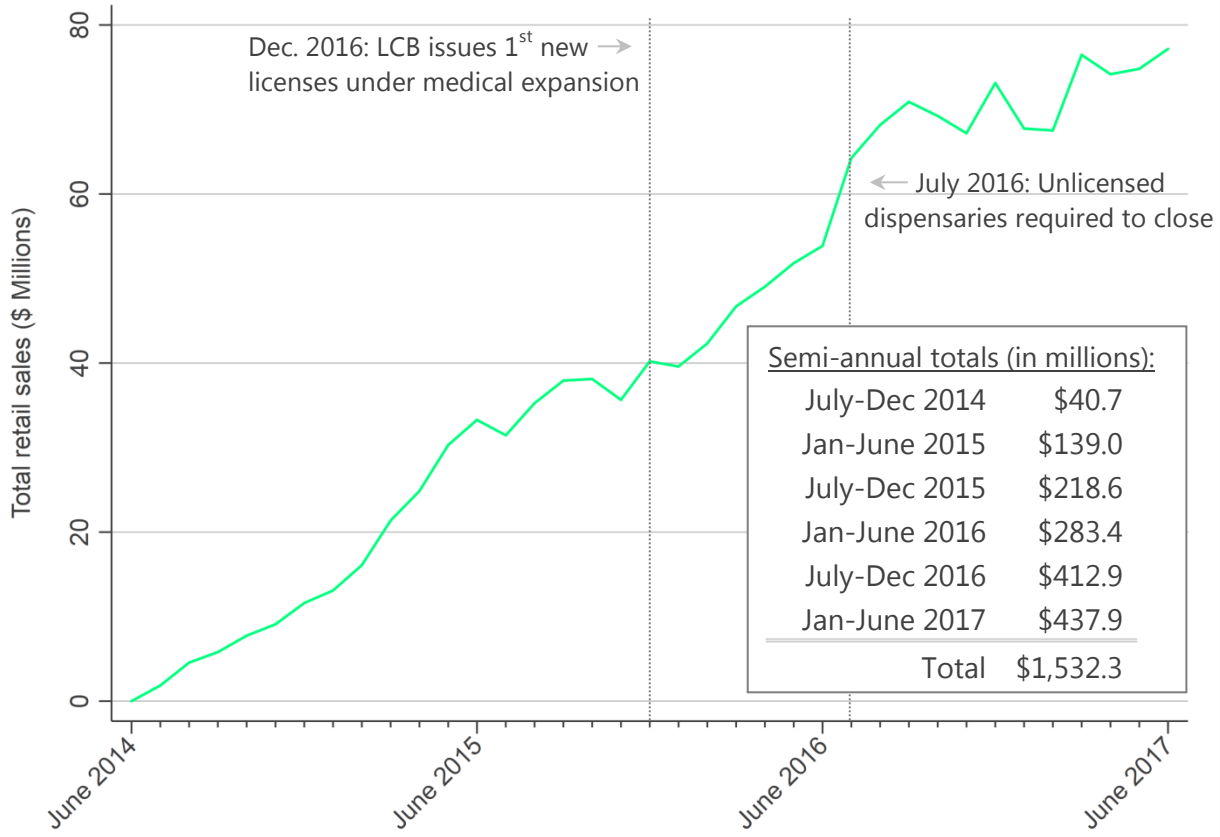
Washington's cannabis supply system is not vertically integrated—businesses holding retail licenses cannot also be involved in other parts of the supply chain, although producer and processor licenses can be held in combination. In terms of the type of license held by businesses reporting active sales in June 2017, there were 383 retailers, 36 producers, 103 processors, and 653 producer/processors.[15] The number of active retailer licenses is currently well below the cap of 556.

Retail sales. Retail sales have climbed since they began in July 2014. They began to stabilize in the second half of 2015, just prior to the beginning of the medical expansion. The medical expansion was fully implemented by July 2016, when all unlicensed dispensaries were required to close. Monthly retail sales totals are shown in Exhibit 4.

[15] More extensive descriptive analysis of businesses and employment in Washington's legal cannabis supply system is reported in Hoagland, C., Barnes, B., & Darnell, A. (2017). *Employment and wage earnings in licensed marijuana businesses* (Doc. No. 17-06-4101). Olympia: Washington State Institute for Public Policy.

Exhibit 4

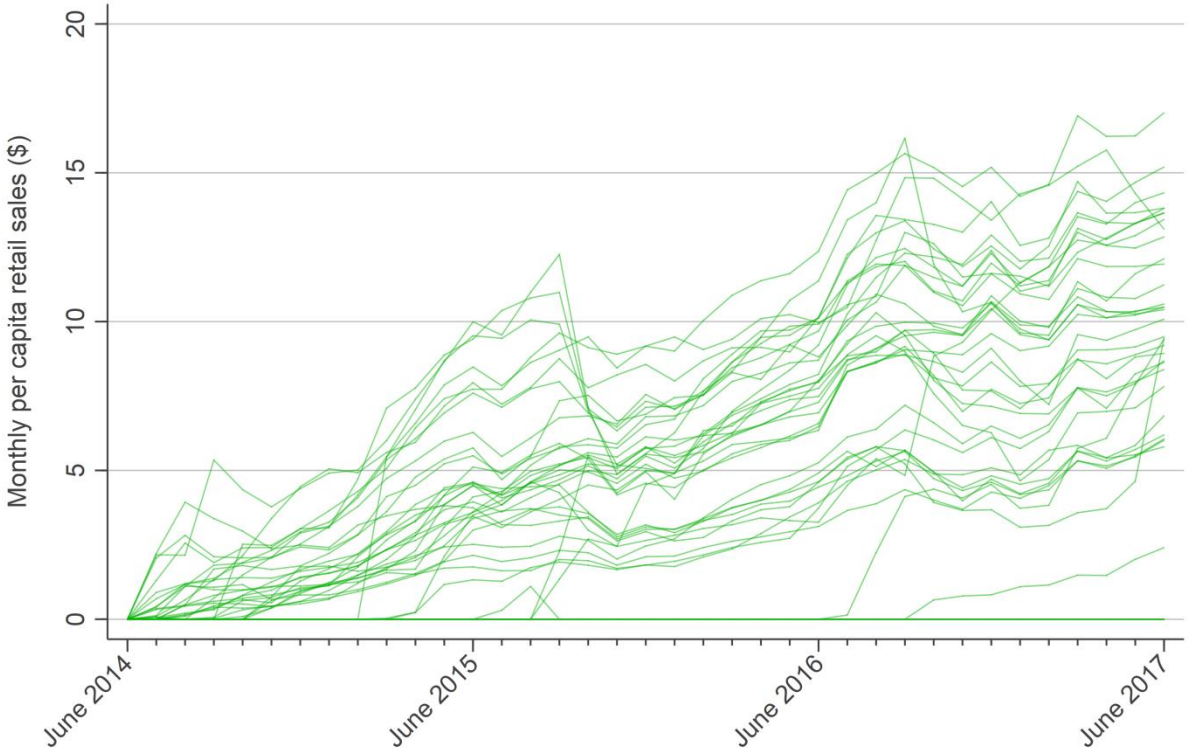
Total Monthly Retail Cannabis Sales



Source:
Washington State Liquor & Cannabis Board.

Exhibit 5

Monthly Per Capita Retail Cannabis Sales by County



Source:
Washington State Liquor & Cannabis Board sales data. County population obtained from: Washington State Office of Financial Management, Forecasting Division (2016). Small Area Demographic Estimates: County 2000-2016.
Note:
Asotin County is omitted from the figure above due to extremely high per capita sales values, which began to increase sharply in February of 2016 and had moved above $30 by July 2016.

Local variation in retail sales.

Exhibit 5 displays monthly per capita retail sales in counties in Washington State.[16] The exhibit illustrates differences in the timing of first legal sales in each county (e.g. the late starter at the bottom right of the exhibit), differences in overall sales levels, and differences in the rate of growth in sales over time. Four counties had no licensed sales through June 2017. Sales amounts and per capita rates for each county on a semi-annual basis are shown in Appendix Exhibits A1 & A2.

The amount of legal cannabis sales is the primary predictor examined in many of the outcome analyses in this report. These analyses focus on differences in sales at the county or school district level. The timing and amount of cannabis sales within Washington school districts also varies substantially (see Appendix Exhibit A3).

[16] Retail sales data are current through June 30, 2017; however, 2017 county population data are not yet available, so we could not compute per capita rates based on annual population here. Instead we used the average population from 2014 through 2016. In outcome models we computed per capita sales rates based on the available data in each analysis.

The Changing Role of the Medical Cannabis Supply System

The distinction between medical and non-medical cannabis has always been an important one for our study. In accordance with the study requirements, our focus has been on the non-medical cannabis system created by I-502. With the integration of the medical and non-medical supply systems in Washington, the medical distinction is becoming more difficult and perhaps less useful to maintain.

Prior to the incorporation of medical cannabis into the regulated system, the quasi-legal network of medical cannabis dispensaries was an important source of cannabis supply to account for in our analyses of the non-medical system. The system was not tightly regulated and there were suspicions that non-medical use was a substantial portion of this gray market. However, there are no available data sources on the number of medical cannabis dispensaries in the state or their sales prior to the integration of the medical supply system into the regulated system.

With the integration of the medical supply system into the regulated system, the number of available retail licenses was increased, and licensed retailers were given the option of obtaining a medical marijuana endorsement. The endorsement allows retailers to sell Department of Health (DOH)-compliant products to qualifying patients and designated providers.[17] Of the 383 retailers reporting active sales in June 2017, 346 (90%) held a medical endorsement. Because nearly all retailers sell both medical and non-medical cannabis, we ignore the medical endorsement distinction for the remainder of this report.

Aside from the supply system itself, it may also be possible to distinguish medical usage based on whether a product is primarily used for medical purposes, whether the people who use cannabis are medically authorized patients, or if a particular instance of consuming cannabis is done for a medical purpose.

The sales data reported thus far include all legal retail cannabis sales, which after the incorporation of the medical system, include both medical and non-medical sales. The LCB's marijuana traceability system monitors all marijuana products in the legal supply system and differentiates nine types of marijuana products. In our outcome models, for computation of per capita sales we omit four types of products that are used primarily for medical purposes: capsules, suppositories, tinctures, and topicals. These products represent a very small share of sales—in January 2017 they accounted for less than 0.1% of all legal cannabis sales.

The remaining cannabis products may be used for either medical or non-medical purposes, and prospects for distinguishing medical and non-medical use of these products are dim. Although the data are not currently available, it is possible to distinguish transactions to medically authorized consumers in the LCB traceability system.[18] However, many medical users report using cannabis for both medical and non-medical purposes,[19] and the research

[17] RCW 69.50.375.

[18] The traceability system distinguishes transactions to medically authorized consumers, but the variable reflecting this distinction is not currently provided with the traceability data available from LCB.

[19] Pacula et al. (2016).

literature on the medical uses of cannabis does not yet support a clearer distinction between "prescribed" use versus abuse, such as the distinction applied for prescription drugs. From this perspective, the notion of distinguishing medical and non-medical cannabis use in our study is seemingly impossible.

Aside from the omission of a small number of products most likely to be used exclusively for medical purposes, we do not distinguish medical and non-medical cannabis further in this report.

Other aspects of I-502

Although not the focus of the current report, there are many aspects of I-502 implementation that can be expected to influence outcomes. Enforcement activities for example, might decrease youth access to cannabis at licensed retailers or might decrease diversion of cannabis products from the legal system to the black market. Other aspects of I-502 implementation, such as the activities funded by required expenditures for substance abuse prevention and treatment, may also affect outcomes. Many of these activities are financed, in whole or in part, by cannabis-related revenues, including excise taxes, license fees, penalties, and forfeitures.

These revenues and required activities will be important in the ultimate benefit-cost evaluation of I-502. We have limited our focus in this report primarily to one specific aspect of I-502 implementation—the amount of cannabis sales in the legal supply system. We look forward to addressing other aspects of I-502 implementation in future reports. For now, it should be noted that these other aspects of I-502 implementation are not explicitly accounted for in our outcome models and thus constitute factors that may be associated with sales and outcomes, which should be kept in mind when we view findings.

In the next section we shift our attention to our outcome analyses. We begin by reviewing prior research on effects of medical cannabis laws and the much smaller number of studies on non-medical legalization, which we draw on in formulating our analysis strategy.

III. Research Context

WSIPP routinely draws on other rigorous research to conduct meta-analyses and inform our benefit-cost analyses.[20] Increases in the number of states legalizing medical or non-medical cannabis have stimulated research on effects of these laws. However, the entire body of research is still in an early stage of development and is not yet sufficient for us to conduct meta-analyses. It can still inform our research direction as we evaluate impacts in Washington.

It is also worth noting that the majority of these studies draw comparisons between states with a medical marijuana law and those without. More recently, researchers have begun to recognize the importance of differences in specific features of medical legalization from one state to the next, comparing states that have enacted more or less strict versions of legalization (e.g., allowing home cultivation or requiring a registry of authorized medical patients).[21] We are aware of two studies that attempted to identify effects of the size of the medical marijuana market.[22] These studies come closest to the methods we used in our outcome models that examine effects of the amount of legal cannabis sales.

Substance use and abuse

Youth and adult cannabis use

Youth cannabis use is one of the most frequently examined outcomes related to cannabis legalization, and findings from these studies have been mixed. Most studies found no evidence that the passage of a medical cannabis law caused an increase in use among adolescents.[23] We are aware of three studies that found evidence suggesting that youth cannabis use increased as a result of medical legalization; one of these studies failed under replication.[24]

In contrast, studies consistently suggest that adult use increases as a result of medical legalization.[25] Several studies found that these effects are limited to adults older than 26.[26]

One study found evidence of an increase in both youth and adult use in the general population associated with growth in the number of patients registered in state medical marijuana registries.[27]

We are aware of one published study examining effects of non-medical legalization on substance use, which found

[20] Note that the I-502 benefit-cost evaluation will look at the broad impacts of I-502 on Washington State as a whole, while WSIPP's routine approach examines the impact of an intervention on a per-participant basis. As such, the I-502 evaluation will necessarily take a different form than WSIPP's standard approach, although many of the underlying principles and methods will remain the same.

[21] Pacula et al. (2015); Choi et al. (2014); Hasin et al. (2015); Smart (2015); and Wen et al. (2015).

[22] Salomonsen-Sautel et al. (2014) focused on a policy shift that led to the proliferation of medical dispensaries; Smart (2015) examined effects of the number of patients in state medical cannabis registries.

[23] Anderson & Rees (2011); Harper et al. (2012); Lynne-Landsman et al. (2013); Anderson et al. (2014); Choo et al. (2014); Hasin et al. (2015); and Martins et al. (2016).

[24] Pacula et al. (2015); Stolzenberg et al. (2015); and Wen et al (2015). The findings of Stolzenberg et al. were later contradicted in a replication study—Wall et al. (2016) which found no evidence of increasing youth use. The findings of Pacula et al. were specific to medical marijuana laws providing legal protection for dispensaries and allowing for home cultivation.

[25] Anderson & Rees (2011); Hasin et al. (2017); and Wen et al. (2015).

[26] Martins et al. (2016) and Williams et al. (2017).

[27] Smart (2015).

that youth cannabis use was higher in Washington following non-medical legalization relative to comparison states.[28] Several other studies have found that attitudes favorable to cannabis use have increased following medical or non-medical cannabis legalization.[29]

Cannabis abuse treatment admissions

We found three studies that examined effects of cannabis legalization on treatment admissions for cannabis abuse in different populations, and results are not consistent. One study found that after enactment of medical legalization, cannabis abuse treatment admissions increased relative to states without medical legalization.[30] That study focused on admissions among adults who were not referred by the criminal justice system. Another study focused on cannabis abuse treatment admissions among youth and found no evidence of an effect of medical legalization.[31] Finally, the third study found that cannabis abuse treatment admissions (age not differentiated) decreased after medical cannabis legalization relative to comparison states, but the effect varied substantially depending on specific features of the medical cannabis policy (e.g., protections for dispensaries).[32]

Alcohol, tobacco, and other drugs

The relationship between use of cannabis and other substances, especially alcohol and tobacco, will likely be a major factor in the ultimate economic impact of the law. Researchers have noted that the potential effect of cannabis legalization on use of alcohol and tobacco, even if small, may outweigh the economic impact of increased cannabis use, due to the strong evidence of long-term health consequences of tobacco use and alcohol abuse.[33]

Regarding alcohol, research has yet to determine whether cannabis and alcohol are more likely to be used as complements or as substitutes, and in turn, what effect legalized cannabis may have on alcohol use.[34] One study found lower probability of any drinking and binge drinking and fewer drinks consumed in states after the passage of a medical marijuana law, relative to comparison states.[35] Another study found that growth in the number of medical cannabis patients was linked to a reduction in alcohol poisoning deaths.[36]

In contrast, another study found the frequency of binge drinking and the likelihood of simultaneous use of marijuana and alcohol were significantly higher following medical legalization, relative to comparison states.[37]

We are aware of only one study examining effects on tobacco use, which found a small decrease in cigarette smoking associated with medical legalization.[38]

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[28] Cerda et al. (2016).
[29] Cerda et al. (2016); Keyes et al. (2016); and Schuermeyer (2014).
[30] Chu (2014).
[31] Anderson et al. (2014).
[32] Pacula et al. (2015).
[33] Caulkins et al. (2012).
[34] Wen et al. (2015).
[35] Anderson et al. (2012).
[36] Smart (2015).
[37] Wen et al. (2015).
[38] Choi (2016).

Research on opioids suggests favorable effects of medical legalization, including lower rates of prescription opioid overdose deaths,[39] opioid use among fatally-injured drivers age 21 to 40,[40] and hospitalizations related to prescription opioid dependence and overdose.[41] One study found that growth in medical marijuana markets was linked to a decrease in prescription opioid poisoning deaths.[42]

Another study examined the effects of medical legalization on use of other illegal drugs and found no impact on hard drug use in adolescents or adults.[43]

Crime

One study found no evidence that state medical marijuana laws caused an increase in property and violent crimes reported by the FBI but did find evidence of decreased homicide and assault associated with medical legalization.[44] Another study examining effects of non-medical legalization found evidence that non-medical legalization in Washington and Oregon may have led to a drop in rape and murder rates.[45] Regarding effects on cannabis-specific crimes, another study found that higher marijuana arrest rates among adult males were associated with medical legalization.[46]

[39] Bachhuber et al. (2015).
[40] Kim et al. (2016).
[41] Shi (2017).
[42] Smart (2015).
[43] Wen et al. (2015).

[44] Morris et al. (2014).
[45] Dragone et al. (2017).
[46] Chu (2014).

IV. Analysis Strategy

I-502 requires WSIPP to produce a benefit-cost evaluation of the law's implementation. Identifying causal effects of I-502 is necessary for that aim. However, I-502 is a multi-faceted and complex intervention. It imposed a number of different changes on the state including changes to criminal prohibitions; the creation of a regulated cannabis supply system; and mandated investments in substance abuse prevention, treatment, and research. Each aspect of I-502 may have its own effects on outcomes.

Further, the way the law was implemented in the state had clear differences by geographic region over time. For example, sales grew at varying rates in different parts of the state, which could influence outcomes differently in regions across the state. Thus, there are multiple ways to explore the potential effects of I-502, all of which are important to consider in a comprehensive assessment of the impact of I-502 on Washington.

In this report we report findings for analyses of the following outcomes:

- Youth and adult use of cannabis, alcohol, and cigarettes;
- Clinically disordered cannabis use, as indicated by substance abuse treatment admissions; and
- Convictions for drug-related criminal charges.

We use two main analysis strategies in this report. To identify effects of I-502 as a whole, we use between-state analyses to compare changes before and after I-502 enactment in Washington to changes in non-legalizing states over the same period.

We also use within-state analyses to identify effects of one aspect of I-502 implementation—the amount of legal cannabis sales.

We rely entirely on existing data sets for our outcome analyses, and the structure of these datasets in large part determines our research strategy. Outcome data sets available for multiple states provide opportunities to examine effects of the law as a whole. On the other hand, data sources only available for Washington have more limited capabilities for identifying effects of the law as a whole[47] and are better suited to identifying effects of specific aspects of the law's implementation, especially those that vary within the state.

At the time of this report, WSIPP only had access to one multi-state dataset, allowing us to conduct between-state analyses to examine the net effect of I-502 on cannabis abuse treatment admissions. The majority of data sources we currently have access to only contain data for Washington State. Thus, the majority of analyses in this report examine the effect of the amount of legal cannabis sales, applying a within-state analysis strategy.

We describe our between-state and within-state analysis strategies in more detail below.

[47] Analyses of state-level trends for a single state (e.g., time series analysis), which draw comparisons before and after implementation of the law, tend to be weaker designs for causal inference because time-related factors that may coincide with the timing of I-502 are difficult to eliminate as alternative explanations of an observed effect.

Between-State Analysis

Our analysis of the impact of I-502 on cannabis abuse treatment admissions relies on data from the Treatment Episode Data Set (TEDS-A), which is available for all U.S. states. In this analysis we examined effects of I-502 enactment in 2012, contrasting the number of admissions to treatment for cannabis abuse before and after I-502 enactment to comparable changes in other states that did not legalize non-medical cannabis (i.e., comparison states). We used the synthetic control method (SCM) for this analysis.[48]

SCM is a method of constructing a comparison group from states that have not legalized non-medical marijuana. This allows us to model what would have likely happened in Washington, had I-502 never become law. Using SCM, comparison states that are most similar to Washington before I-502 are weighted more heavily in the "synthetic" comparison group to maximize comparability to Washington. After establishing that the synthetic comparison group is similar to Washington before I-502, changes in outcomes after I-502 that are different for Washington than for the synthetic comparison group can be interpreted as effects of the law. We describe the methods for this analysis in more detail in the I-502 Technical Appendix.[49]

Due to data availability limitations, this is the only analysis in this report that is focused on identification of the effect of I-502 as a whole. We plan to analyze data from the National Survey on Drug Use and Health (NSDUH), which measures substance use among youth and adults across the country, as soon as these data become accessible.[50] We will conduct and publish additional between-state analyses in future reports, as we gain access to additional national datasets.

Within-state analyses

The majority of the analyses in this report focus on effects of the amount of legal cannabis sales on various outcomes.[51] For each outcome examined, we applied the general analysis strategy described below. Specific features of this strategy vary based on the specific outcome examined. These variations are discussed in more detail in the I-502 Technical Appendix.

In the absence of data from multiple states, analyses must draw comparisons from elsewhere—either by examining differences in outcomes in different places in Washington (which vary in I-502 implementation) or by examining changes in outcomes over time. The strongest designs take advantage of both.

Our within-state analysis strategy does both. In the previous section we discussed how the amount of legal cannabis sales varied substantially across the state and over time. We paired sales data with outcome data sources, examining the relationship between sales amounts and outcomes as they vary in

[48] Abadie & Gardeazabal (2003) and Abadie et al. (2010).
[49] Darnell, A., & Bitney, K. (2017). I-502 evaluation and benefit-cost analysis: Second required report—technical appendix. Olympia, Washington State Institute for Public Policy.

[50] We received a license for access to the restricted-use version of the NSDUH, but shortly after, access to the data was closed by the Substance Abuse and Mental Health Data Archive (SAMHDA) for administrative reasons. We are awaiting notification of when we can access the data.
[51] See the I-502 Technical Appendix for definition of sales variable in within-state outcome analyses.

different locations throughout the state and over time.

General design of within-state analyses

Our within-state outcome models belong to a category of methods referred to as fixed effects models, which are a common method for identifying effects of macro-level interventions, such as state laws, in non-experimental settings. It is the approach used in many studies of medical legalization.[52]

In the fixed effects approach, a relationship between the intervention and the outcome variable is established. For example, in our case there may be a relationship between cannabis sales and crime. Sales may be represented at the individual level, as the amount of legal cannabis sold to each person, or at some higher level such as the amount of cannabis sold in each county. A similar decision must be made about time—whether to analyze effects of sales on a daily, monthly, or yearly basis.

Even if we establish a relationship between the intervention and the outcome, we cannot assume that the intervention causes the outcome to change, without eliminating alternative possible causes. For example, if we observe that crime increases as sales increase in a particular county over time, there may be differences between counties with higher levels of sales that explain differences in crime, such as county economic conditions. There may also be changes occurring over time that cause both sales and crime to change, such as the passage of a state law affecting liquor consumption.

The basic strategy of a fixed effects model is to eliminate these two sets of possibilities categorically. If our intervention variable is a county-level sales variable, a fixed effect for county is included in the model that accounts for all differences between counties that do not change over time. And, if our sales variable is measured at a monthly frequency, a fixed effect for time is included in the model to account for all differences from one month to the next that are shared by all counties.

One of the major strengths of the fixed effects strategy is that we do not need to have data sources with variables representing all the possible differences between counties—they are all accounted for at once with the specification of a county fixed effect.

While the general approach remains the same, the specific units of geography and time vary for each analysis. Characteristics of available data sources determined the units of geography and time fixed effects for each outcome analysis. Across outcome data sources, for the fixed effect for geography, we had the option of analyzing the data at county, school district, or ZIP code levels. For the fixed effect for time, options included monthly, quarterly, and annual metrics of time. The specifications we settled on for each outcome data source are shown in Exhibit 6.

For clarity, we continue this discussion using the example of a fixed effects analysis with county and month fixed effects. However, some outcome analyses are also conducted with district or state fixed effects, instead of county, and with quarter or year fixed effects, instead of month.

[52] Anderson et al. (2014); Choo et al. (2014); Harper et al. (2012); Hasin et al. (2017); Pacula et al. (2015); Smart (2015); and Wen et al. (2015).

Exhibit 6

Analysis Characteristics by Data Source

Outcome area	Data source	Geographic unit	Time unit	Overall time period
Youth substance use	Healthy Youth Survey (HYS)	School district	Biennium	2002-2016
Adult substance use	Behavioral Risk Factors Surveillance System (BRFSS)	County	Quarter	2011-2015
Disordered cannabis use	TARGET	County	Month	2002-2016
Disordered cannabis use	Treatment Episodes Data Set	State	Year	2005-2014
Drug-related crime	Administrative Office of the Courts	County	Month/ quarter	2005-2016

Addressing County Differences that Change Over Time

Despite their strengths, fixed effects models are not a magic bullet. Fixed effects for county and month do not account for differences between counties that change over time. For example, other features of I-502 implementation, such as substance abuse prevention funded by I-502 revenues, may also influence outcomes, competing with the effects of sales in our models. If these other possible causes of changes in outcomes occur in the same counties at the same time as legal sales, our understanding of the effect of sales will be distorted. We applied several analysis techniques to address these so-called time-varying confounds.

First, in each analysis we included a set of time-varying control variables. For example in our analysis of how the amount of retail sales might drive drug-related criminal convictions, we included annual total convictions in the county to account for changes in the overall capacity of the county criminal justice system. Other time-varying control variables account for changes in demographic composition and socioeconomic conditions. The specific time-varying control variables included in each analysis are listed in the I-502 Technical Appendix.

Although we hypothesize that increases in legal cannabis sales cause outcomes to change, it is also possible that outcomes cause sales to change—for example, people who commit more crime may purchase more legal cannabis. In our outcome models, the cannabis sales variable was typically "lagged" to allow a period of time for possible effects of sales to register in the outcome. Lagging the sales variable has the effect of shifting the timing of sales and outcomes. Before lagging, observations are paired by the time they were observed (e.g., sales and outcomes measured in September) but lagging the intervention variable means we can examine the effect of sales in July or August on outcomes in September. A relationship between sales prior to outcomes has a more likely causal interpretation than a contemporaneous relationship, in which the direction of the relationship is less clear. The length of the lag was determined for each data source based on data structure and conceptual rationale.

To further address the possibility that an apparent relationship between the amount of sales and outcomes does not in fact indicate that changes in sales are causing the changes in outcomes, we also examined models in which sales was specified as a "leading" variable.[53] The opposite of a lagged version of sales, a leading version of sales would identify the relationship between future sales and past outcomes. For example, outcomes measured in September can be examined for relationship to sales in October or November. Evidence that future sales are associated with today's outcomes would suggest that outcomes affect sales, that both effects apply (effects move in both directions), or that an unknown underlying cause affects both variables.[54] Our analyses were not equipped to determine which of these possibilities is the correct one, and we take a cautious approach in avoiding causal interpretations of legal sales estimates in the presence of significant leading estimates.

In the next section we provide brief summaries of analysis methods and findings for each data source. For each analysis, additional detail on the data source, methods, and results are available in the I-502 Technical Appendix.

[53] Angrist & Pischke (2009).

[54] A leading effect could also reflect anticipatory effects—Malani & Reif (2015). For example, people may change their behavior in advance of an intervention if they know it is coming. One could argue that these anticipatory effects should be considered part of the effect of the intervention.

V. Results

In the sections that follow, we present brief summary descriptions of trends in outcomes, as well as methods and results from outcome analyses. Additional detail on trends, data sources, methods, and outcome findings are available in the I-502 Technical Appendix.

We begin with a discussion of youth and adult substance use and abuse, covering trends in use among adults and youth as well as trends in disordered cannabis use as indicated by substance abuse treatment admissions involving cannabis. We then discuss our findings of the effect of I-502 enactment on cannabis abuse treatment admissions, followed by findings on the effect of legal cannabis sales on cannabis abuse treatment admissions and substance use among youth and adults.

Following that, we discuss trends in drug-related criminal convictions and our findings of the effect of legal cannabis sales on convictions.

Substance Use and Abuse

Trends in substance use

Youth substance use and attitudes—Washington Healthy Youth Survey.

Washington's Healthy Youth Survey (HYS) is administered biennially on even-numbered years to a representative sample of students in grades 6, 8, 10, and 12 in Washington schools.[55] The HYS addresses a range of risk behaviors that contribute to the health and safety of youth in Washington State. In this section, we report statewide results using the HYS census dataset for selected items concerning cannabis for years 2002 through 2016, separated by grade level.[56]

Exhibit 7 illustrates that across grades 6, 8, 10, and 12, cannabis use indicators have been stable or fallen slightly since I-502 enactment. Beliefs that cannabis is difficult to obtain and that using cannabis is harmful began a downward trend in 2006, especially among older students. Since 2010, the view that cannabis is difficult to access has been stable or increased. The downward trend in perceived harm of cannabis use stabilized from 2014 to 2016.

[55] http://www.askhys.net/.

[56] See I-502 Technical Appendix for details on the HYS census data set.

Adult substance use—Washington Behavioral Risk Factors Surveillance System.
Washington State administers the national Behavioral Risk Factor Surveillance System (BRFSS), an annual telephone survey of adults that provides epidemiological data on modifiable risk factors for chronic disease.[57]

Statewide BRFSS results concerning cannabis indicate that since the enactment of I-502, statewide cannabis use has increased among adults, whereas heavy alcohol use and cigarette use have remained stable or fallen (see Exhibit 8).

Trends in Cannabis Abuse Treatment Admissions

Substance use rising to the level of clinical disorder can be measured by substance abuse treatment admissions. As shown in Exhibit 9, Washington TARGET[58] data indicate that the number of state-funded admissions for cannabis abuse in Washington has fallen since 2008. The number of cannabis abuse admissions fell in the three years following I-502 enactment, dropping from 7,843 in 2012, to 7,374 in 2013, 6,885 in 2014, and 6,142 in 2015 (the most recent year available).[59]

Cannabis abuse treatment admissions include a subset of individuals referred to treatment due to involvement with the criminal justice system. When we isolate trends for the group of individuals who were not referred by criminal justice, cannabis abuse admissions did not begin to decline until 2011.

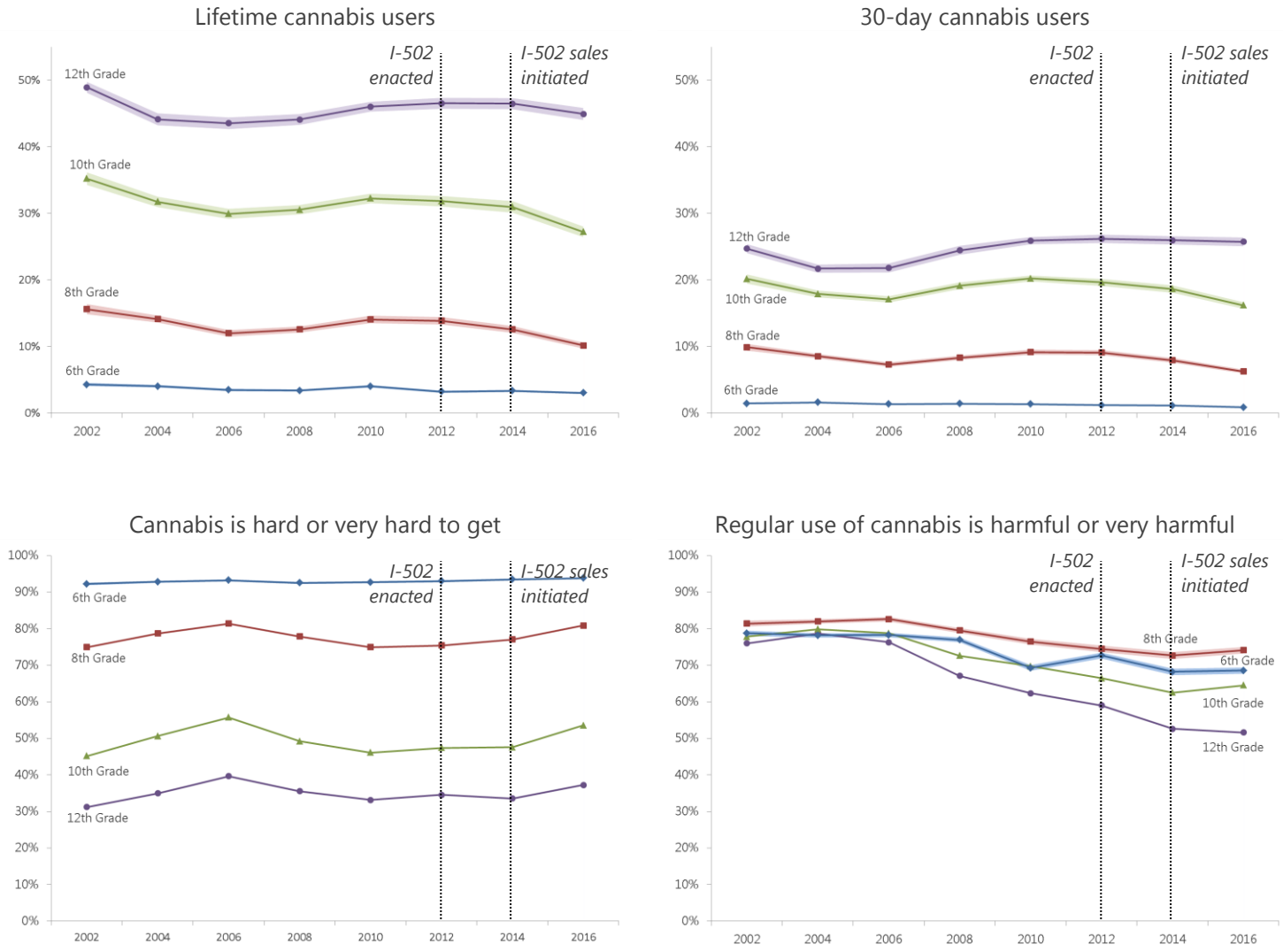
[57] Washington State Department of Health, Center for Health Statistics, Behavioral Risk Factor Surveillance System, supported in part by the Centers for Disease Control and Prevention, Cooperative Agreement U58/DP006066-01 (2015).

[58] https://www.dshs.wa.gov/bha/division-behavioral-health-and-recovery/target.

[59] Admissions for cannabis abuse defined as admissions for which cannabis was the first drug identified as a problem at intake.

Exhibit 7

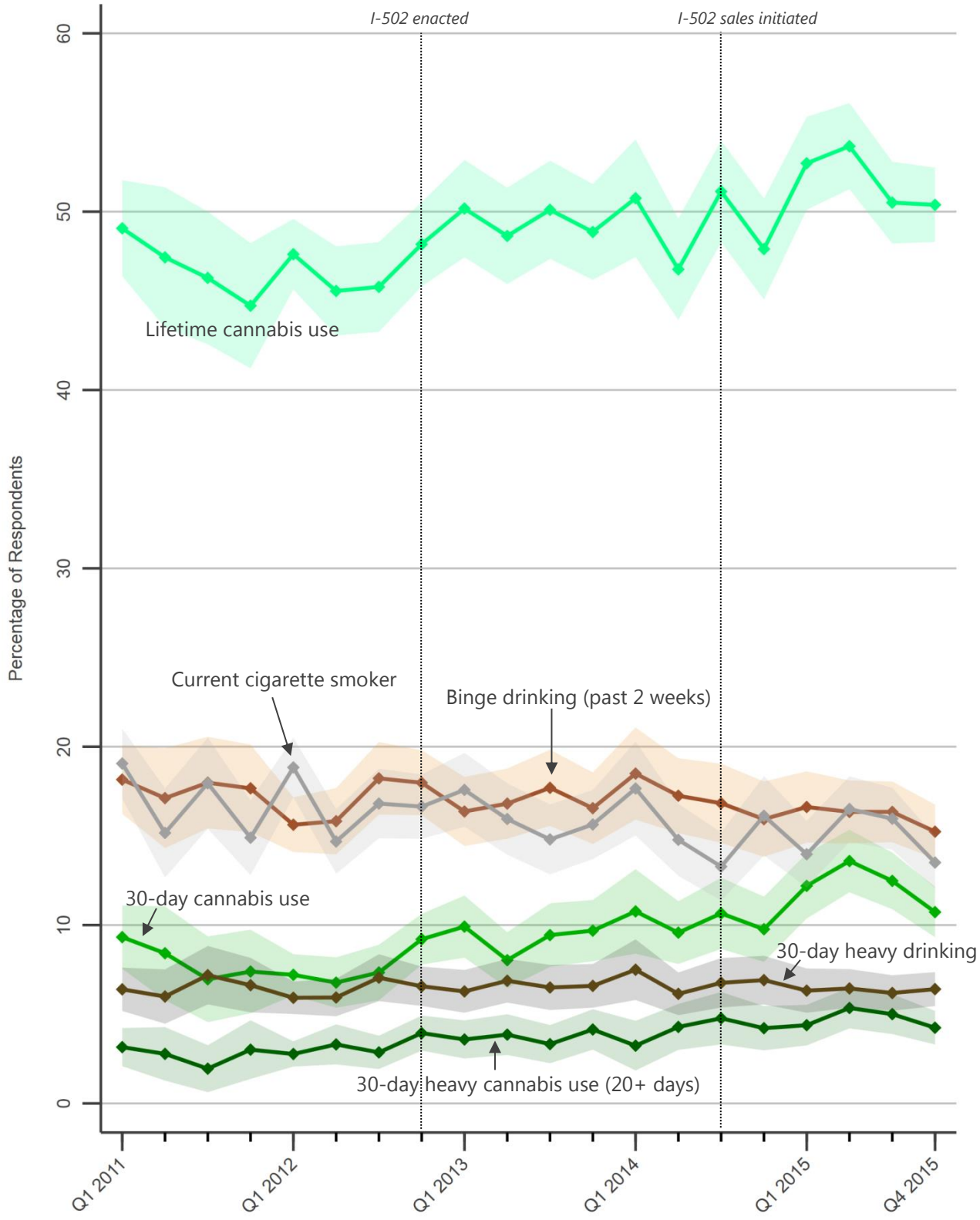
Washington Healthy Youth Survey, Selected Cannabis Items by Grade



Source:
Washington Health Youth Survey, Census Data Set.
Note:
Shaded regions represent 95% confidence intervals.

Exhibit 8

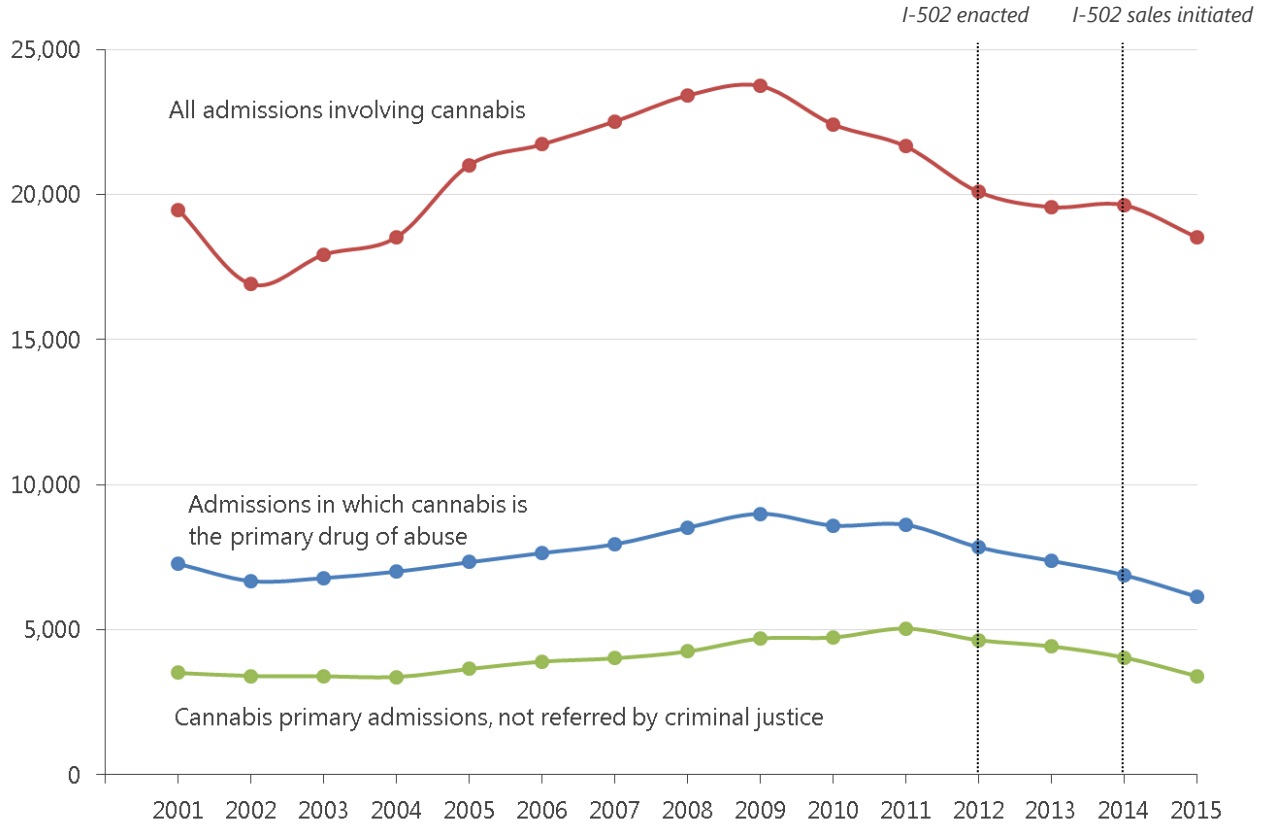
State Trends in Adult Substance Use (BRFSS), Quarterly 2011-2015



Note:
Shaded regions represent 95% confidence intervals.

Exhibit 9

State Trends in Treatment Admissions for Cannabis Abuse (TARGET), Annually 2001-2015



Summary Results of Outcome Analyses

I-502 enactment and Cannabis Abuse Treatment Admissions

Summary

The TEDS-A data set contains data for all 50 states and the District of Columbia. As such, we were able to conduct a between-state analysis in an effort to identify the effect of I-502 as a whole, upon its enactment in 2012.

Using the synthetic control method with the TEDS-A data, we identified a similar set of states that did not legalize non-medical marijuana and had rates of cannabis abuse treatment admissions similar to Washington prior to 2012. We used data from this set of states to serve as a counterfactual for Washington—our best estimate of what would have happened in Washington had I-502 not been enacted.

Findings

Our outcome models found no meaningful differences between treatment admissions for cannabis abuse in Washington and those in comparison states following I-502 enactment. That is, although admissions to substance abuse treatment for cannabis abuse fell as a percentage of all admissions in Washington in recent years, there is no evidence that the enactment of I-502 caused this change.

Detailed analytic methods and results are shown in the I-502 Technical Appendix.

Exhibit 10

Description of Data for Between-State Analysis of Cannabis Abuse Treatment Admissions

Data source	U.S. Treatment Episode Data Set—Admissions (TEDS-A)
Data contents	Census of all state-funded substance abuse treatment episodes, age 12+
Geography	50 states and the District of Columbia
Time period	2005-2014
Outcomes	Percent of admissions with cannabis as primary substance of abuse Percent of admissions involving cannabis
I-502 feature	Enactment in 2012

Per Capita Sales and Cannabis Abuse Treatment Admissions

Summary

In addition to our between-state analysis of the effect of I-502 on cannabis abuse treatment admissions, we used the TARGET data system to further focus our analysis on effects of one specific feature of I-502—the amount of retail cannabis sales in a county. We examined how differences in the amount of legal cannabis sales in each county might affect cannabis abuse treatment admissions for persons residing in the county.

The design of the analysis accounts for a range of alternative possible causes of changes in substance abuse treatment admissions, including the following:

- All differences between counties that do not change over time, such as differences in county unemployment rates that remain consistent across time;
- All changes over time that are shared by all counties, such as a national trend in unemployment rates that affects all counties;
- Some, but not all, county differences that change over time, such as demographic shifts unique to a county; and
- The possibility that differences in treatment admissions actually cause differences in cannabis sales, rather than sales causing changes in treatment admissions.

Findings

Our outcome models that examined the effect of the amount of legal cannabis sales on the number of cannabis abuse treatment admissions in each county produced no evidence that the level of sales had an effect on admissions.

Detailed analytic methods and results are shown in the I-502 Technical Appendix.

Exhibit 11

Description of Data for Within-State Analysis of Cannabis Abuse Treatment Admissions

Data source	TARGET data system (Treatment and Assessment Report Generation Tool)
Data contents	Census of all state-funded substance abuse treatment admissions
Geography	Washington counties
Time period	2002-2016
Outcomes	Count of admissions with cannabis as primary substance of abuse Count of admissions involving cannabis
I-502 feature	Per capita legal cannabis sales

Per Capita Sales and Youth Substance Use

Summary

Our analysis of the HYS does not address effects of cannabis legalization as a whole but instead focuses on the effect of one specific feature of I-502—the amount of retail cannabis sales in an area. We examined how differences in the amount of legal cannabis sales in each school district affect youth substance use behavior and attitudes in the district.

The design of the analysis accounts for a range of alternative possible causes of youth substance use, including the following:

- All differences between school districts that do not change over time, such as differences in high school completion rates that remain consistent across time; and
- All changes over time that are shared by all districts, such as a trend in high school completion rates that is common across districts.

Findings

We found no evidence of effects of the amount of legal cannabis sales on indicators of youth cannabis use in grades 8, 10, and 12. Among the other outcomes examined, which included use of alcohol and tobacco and attitudes about cannabis use, there were two statistically significant findings ($p < 0.05$), both among 8th graders:

- 8th graders in districts with higher per capita legal cannabis sales were significantly less likely to report smoking cigarettes.
- 8th graders in districts with higher per capita legal cannabis sales were significantly less likely to report the belief that one would get caught by the police if they used cannabis.

Analytic methods for the HYS were limited by certain characteristics of the available data, so results of these analyses are considered particularly preliminary. The strength of conclusions regarding causal effects of the law can be improved when more current data on sales and control variables are available.

Detailed analytic methods and results are shown in the I-502 Technical Appendix.

Exhibit 12

Description of Data for Within-State Analysis of Youth Substance Use

Data source	Washington Healthy Youth Survey (HYS)
Data contents	Substance abuse behavior and attitudes for Washington public school students in grade 8, 10, & 12
Geography	Washington public school districts
Time period	Even-numbered years 2002-2016
Outcomes	Lifetime cannabis use, 30-day cannabis use and heavy use, 30-day alcohol use and binge drinking, cigarette use, and attitudes about cannabis use
I-502 feature	Per capita legal cannabis sales

Per Capita Sales and Adult Substance Use

Summary

Our analysis of the BRFSS does not address effects of cannabis legalization as a whole but instead focuses on the effect of one specific feature of I-502—the amount of retail cannabis sales in an area. We examined how differences in the amount of legal cannabis sales in each county affect adult substance use in the county.

The design of the analysis accounts for a range of alternative possible causes of adult substance use, including the following:

- All differences between counties that do not change over time, such as differences in county unemployment rates that remain consistent across time;
- All changes over time that are shared by all counties, such as a national trend in unemployment rates that affects all counties;
- Some, but not all, county differences that change over time, such as demographic shifts unique to a county; and
- The possibility that differences in adult substance use actually cause differences in cannabis sales, rather than sales causing changes in substance use.

Findings

We found no evidence that greater levels of legal cannabis sales caused increases in overall adult cannabis use. Several analyses of the effect of sales among subgroups of the BRFSS sample did produce statistically significant findings ($p < 0.05$).

Among respondents 21 and older, those living in counties with higher levels of legal cannabis sales were significantly more likely to report any cannabis use in the past 30 days and heavy cannabis use (defined as use on 20 or more of the past 30 days).

Among respondents under age 21, those living in counties with higher sales were significantly less likely to report use of cannabis in the past 30 days, but the likelihood of heavy use was unaffected. The subgroup analyses by age were somewhat sensitive to model specification.

We also found that among cigarette smokers, respondents living in counties with higher levels of legal cannabis sales were significantly less likely to report using cannabis in the past 30 days.

Detailed analytic methods and results are shown in the I-502 Technical Appendix.

Exhibit 13

Description of Data for Within-State Analysis of Adult Substance Use

Data source	Washington Behavioral Risk Factors Surveillance System (BRFSS)
Data contents	Substance use for a representative sample of Washington adults (age 18+) in telephone households
Geography	Washington counties
Time period	2011-2015
Outcomes	Lifetime cannabis use, 30-day cannabis use and heavy use, 30-day heavy drinking and binge drinking, and cigarette use
I-502 feature	Per capita legal cannabis sales

Per Capita Sales and Drug-related Criminal Convictions

Trends

We used data from Washington's Administrative Office of the Courts to identify trends in drug-related criminal convictions over time. Among offenders 21 and older, misdemeanor cannabis possession convictions began a sharp decline in 2012, dropping from 297 convictions in January 2012, to 0 by January 2013, the first month following enactment of I-502 (Exhibit 14).

Among offenders under 21, for whom prohibitions did not change under I-502, misdemeanor cannabis possession convictions began to decline in 2012, dropping from 1,015 convictions in the first three months of 2012, to 722 in the first quarter of 2013, the first quarter following enactment of I-502 (Exhibit 15).

Exhibit 14

Adult Convicted Charge Counts

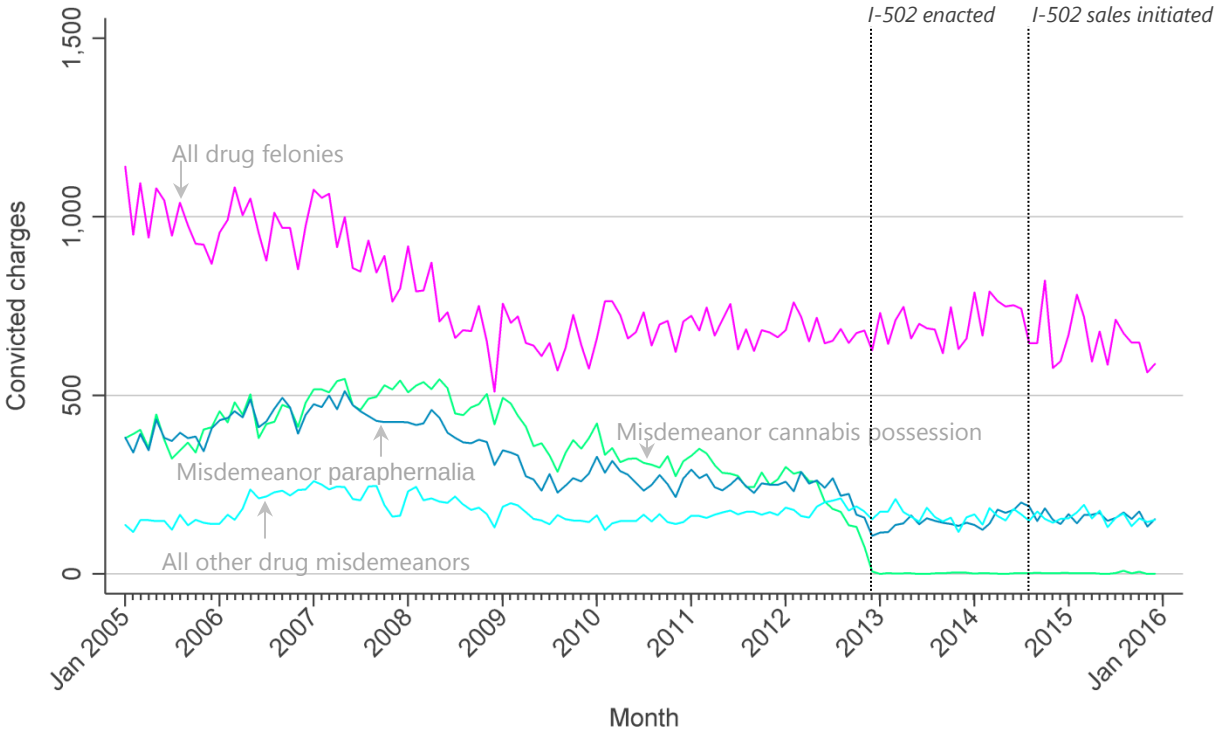
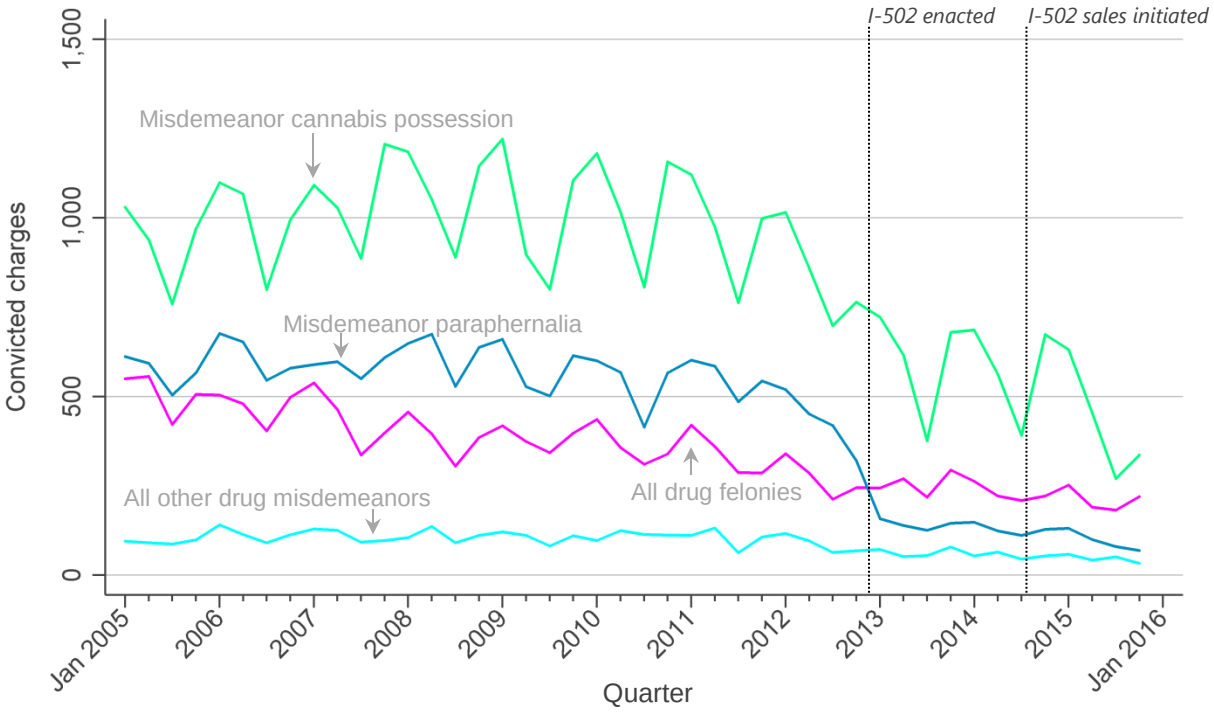


Exhibit 15

Under 21 Convicted Charge Counts



Outcome Analysis of Drug-Related Convictions

Summary

Our analysis of drug convictions does not address effects of cannabis legalization as a whole but instead focuses on the effect of one specific feature of I-502—the amount of retail cannabis sales in an area. We examined how differences in the amount of legal cannabis sales in each county affect the number of drug-related convictions in the county.

The design of the analysis accounts for a range of alternative possible causes of drug-related convictions, including the following:

- All differences between counties that do not change over time, such as differences in county unemployment rates that remain consistent across time;
- All changes over time that are shared by all counties, such as a national trend in unemployment rates that affects all counties;
- Some, but not all, county differences that change over time, such as demographic shifts unique to a county; and
- The possibility that differences in criminal convictions actually cause differences in cannabis sales, rather than sales causing changes in crime.

Findings

Outcome models examining effects of legal cannabis sales on drug-related convictions in each county produced no evidence of effects of retail cannabis sales on any of the drug-related charge categories.

Detailed analytic methods and results are shown in the I-502 Technical Appendix.

Exhibit 16

Description of Data for Within-State Analysis of Drug-Related Criminal Convictions

Data source	Administrative Office of the Courts
Data contents	Census of all convicted drug-related misdemeanor and felony charges
Geography	Washington counties
Time period	2005-2016
Outcomes	Convictions for drug-related misdemeanors (marijuana possession, paraphernalia, DUI, negligent driving, and all other drug-related misdemeanors) and felonies (DUI and all other drug-related felonies)
I-502 feature	Per capita legal cannabis sales

VI. Conclusions

Summary of findings

Our outcome analyses were designed to identify causal effects of I-502. However, I-502 is a multi-faceted law that may affect outcomes through a variety of mechanisms including changes to criminal prohibitions; the creation of a regulated cannabis supply system; and investments in substance abuse prevention, treatment, and research.

The findings we present in this report are only one portion of a larger body of work designed to address multiple aspects of the law.

In these initial investigations, we found no evidence that I-502 enactment, on the whole, affected cannabis abuse treatment admissions. Further, within Washington State, we found no evidence that the amount of legal cannabis sales affected cannabis abuse treatment admissions.

The bulk of outcome analyses in this report used the within-state approach to focus on identifying effects of the amount of legal cannabis sales. We found no evidence that the amount of legal cannabis sales affected youth substance use or attitudes about cannabis or drug-related criminal convictions.

We did find evidence that higher levels of retail cannabis sales affected adult cannabis use in certain subgroups of the population. BRFSS respondents 21 and older who lived in counties with higher levels of retail cannabis sales were more likely to report using cannabis in the past 30 days and heavy use of cannabis in the past 30 days.

We also found two effects that are difficult to interpret. Among the portion of the population aged 18 to 21, BRFSS respondents living in counties with higher sales were less likely to report using cannabis in the past 30 days, in some analyses. It may be that legal cannabis sales have made cannabis more difficult to access by persons below the legal age, for instance, by reducing black market supply through competition.

We also found that in the portion of the BRFSS sample who smoked cigarettes, respondents living in counties with higher levels of legal cannabis sales were less likely to report past-month cannabis use. It is particularly difficult to explain why increased sales would lead to lower cannabis use among cigarette smokers.

We look forward to updating these results with additional data to see if these effects persist.

Limitations

The main limitation of our outcome analyses is that there may be other differences between intervention units that change over time at the same time as the intervention and that also influence outcomes. For example, in between-state analyses other events that occur in Washington and not in comparison states coinciding with I-502 enactment, such as the enactment of private liquor sales roughly six months prior, could influence outcomes at the same time that I-502 does, distorting our understanding of the effect of I-502.

Similarly, in within-state analyses, a factor such as substance abuse prevention activities that are funded by revenues from legal cannabis sales could coincide with legal cannabis sales. If these prevention activities tend to occur in the same times and places as legal cannabis sales, and they also influence outcomes, they could distort our understanding of the effect of legal cannabis sales.

Within-state analyses examining effects of the amount of legal cannabis sales do not address the question of whether cannabis use, or any other outcome, has changed as a result of I-502 enactment. Trend data concerning adult substance use indicates that cannabis use among adults has increased in recent years. We have not yet addressed the question of whether these trends are caused by I-502. We look forward to updating our results with findings from additional between-state analyses as we gain access to additional multi-state data sources.

It should also be noted that we conducted a large number of analyses (described more fully in the I-502 Technical Appendix). By the logic of statistical significance testing, with each analysis we accept a 5% chance of identifying an estimate as significant when there really is no effect. Because of the large number of analyses we conducted, we could expect to find the number of significant estimates we did strictly by chance variation alone.

Whether or not our evidence of null effects of I-502 enactment and legal cannabis sales is convincing is a slightly different question. There are several possible reasons for findings of null effects. One possible reasons is that there truly are no effects.

Null effects can also be found when there is an effect but our sample size is too small to identify it or there is not enough variation in sales within our state to detect an effect. For example, if legal cannabis sales began at the same time in all counties and grew at the same rate, we would be unable to identify an effect of the amount of legal sales using the within-state analysis strategy. In Washington, there was variation in patterns of sales between counties over time; it is unknown if this variation is sufficient to detect potential effects of sales.

Overall, these analyses should be considered preliminary. The most current outcome data available reflect the first two years of legal cannabis sales, and the supply system is still growing. In upcoming reports we will update these analyses as more current data become available and report findings from new analyses to address other of our study requirements.

Our study is ultimately required to produce a benefit-cost analysis of I-502. Identification of causal effects of the law on outcomes is a necessary step towards that goal. In future reports we will report additional findings from outcome analyses as well as findings from other aspects of our overall benefit-cost evaluation.

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Exhibit A1

Semi-Annual Retail Cannabis Sales Totals, by County

	2014		2015		2016		2017
County	**1st half**	**2nd half**	**1st half**	**2nd half**	**1st half**	**2nd half**	**1st half**
Adams	$0	$0	$0	$0	$0	$378,975	$713,356
Asotin	$0	$0	$78,390	$401,931	$1,988,574	$3,775,827	$4,121,539
Benton	$0	$1,144,012	$1,696,360	$2,034,014	$2,936,180	$6,595,001	$8,279,841
Chelan	$0	$147,714	$1,244,365	$2,293,107	$2,508,655	$3,684,383	$3,765,110
Clallam	$0	$90,704	$1,309,700	$2,075,734	$3,141,466	$5,195,848	$5,475,861
Clark	$0	$6,175,592	$18,556,670	$23,878,865	$22,240,827	$27,949,164	$28,902,019
Columbia	$0	$0	$0	$0	$0	$0	$0
Cowlitz	$0	$1,108,480	$3,475,182	$4,546,725	$5,449,413	$7,186,783	$7,665,828
Douglas	$0	$697,342	$816,454	$755,303	$941,832	$1,231,718	$1,290,971
Ferry	$0	$0	$0	$130,537	$287,263	$396,395	$350,544
Franklin	$0	$0	$0	$123,213	$0	$0	$0
Garfield	$0	$0	$0	$0	$0	$0	$0
Grant	$0	$240,323	$1,085,377	$1,390,630	$2,324,847	$3,635,736	$4,179,944
Grays Harbor	$0	$95,965	$884,464	$2,436,274	$3,887,351	$5,511,267	$5,853,110
Island	$0	$115,190	$1,069,845	$2,503,568	$3,226,453	$4,273,093	$4,390,246
Jefferson	$0	$397,967	$1,132,938	$1,494,072	$1,671,963	$2,455,975	$2,586,412
King	$0	$8,893,834	$39,272,602	$64,710,476	$86,700,143	$122,885,382	$125,884,200
Kitsap	$0	$955,998	$3,980,099	$7,854,783	$9,822,177	$13,869,388	$15,375,423
Kittitas	$0	$319,081	$1,055,339	$1,656,437	$2,260,308	$3,012,473	$3,212,532

County	2014 1st half	2014 2nd half	2015 1st half	2015 2nd half	2016 1st half	2016 2nd half	2017 1st half
Klickitat	$0	$467,266	$883,970	$1,061,061	$1,140,547	$1,611,472	$1,367,743
Lewis	$0	$0	$208,480	$785,043	$1,261,229	$2,287,319	$2,538,551
Lincoln	$0	$0	$0	$0	$0	$0	$0
Mason	$0	$0	$365,731	$1,753,630	$2,091,755	$3,139,902	$3,129,568
Okanogan	$0	$219,391	$398,342	$848,429	$953,596	$1,272,983	$1,359,395
Pacific	$0	$33,090	$314,974	$440,163	$402,909	$915,732	$1,657,566
Pend Oreille	$0	$0	$0	$0	$0	$29,876	$127,503
Pierce	$0	$3,935,665	$12,488,780	$20,471,415	$28,766,492	$47,747,924	$51,329,640
San Juan	$0	$40,677	$210,430	$321,379	$336,354	$449,383	$447,780
Skagit	$0	$868,171	$3,535,551	$4,752,515	$6,143,135	$8,488,439	$9,046,885
Skamania	$0	$0	$351,594	$533,908	$455,757	$546,663	$444,624
Snohomish	$0	$4,909,716	$12,542,107	$21,003,774	$28,859,784	$43,238,955	$45,957,454
Spokane	$0	$4,653,768	$17,446,709	$25,734,152	$31,927,547	$43,992,835	$46,565,263
Stevens	$0	$133,870	$862,388	$1,004,739	$974,569	$1,295,697	$1,341,659
Thurston	$0	$1,064,428	$4,823,474	$7,969,899	$11,422,594	$19,087,934	$21,023,049
Wahkiakum	$0	$0	$0	$0	$0	$0	$0
Walla Walla	$0	$0	$0	$667,299	$2,465,360	$3,140,589	$3,130,690
Whatcom	$0	$2,849,676	$5,155,812	$7,317,131	$10,010,255	$13,822,842	$14,603,922
Whitman	$0	$380,502	$1,637,167	$2,526,428	$2,758,200	$3,805,843	$4,132,042
Yakima	$0	$713,015	$2,095,888	$3,119,103	$3,994,846	$5,967,333	$7,626,912

Source:
Washington State Liquor & Cannabis Board.

Exhibit A2

Semi-Annual Per Capita Retail Cannabis Sales, by County

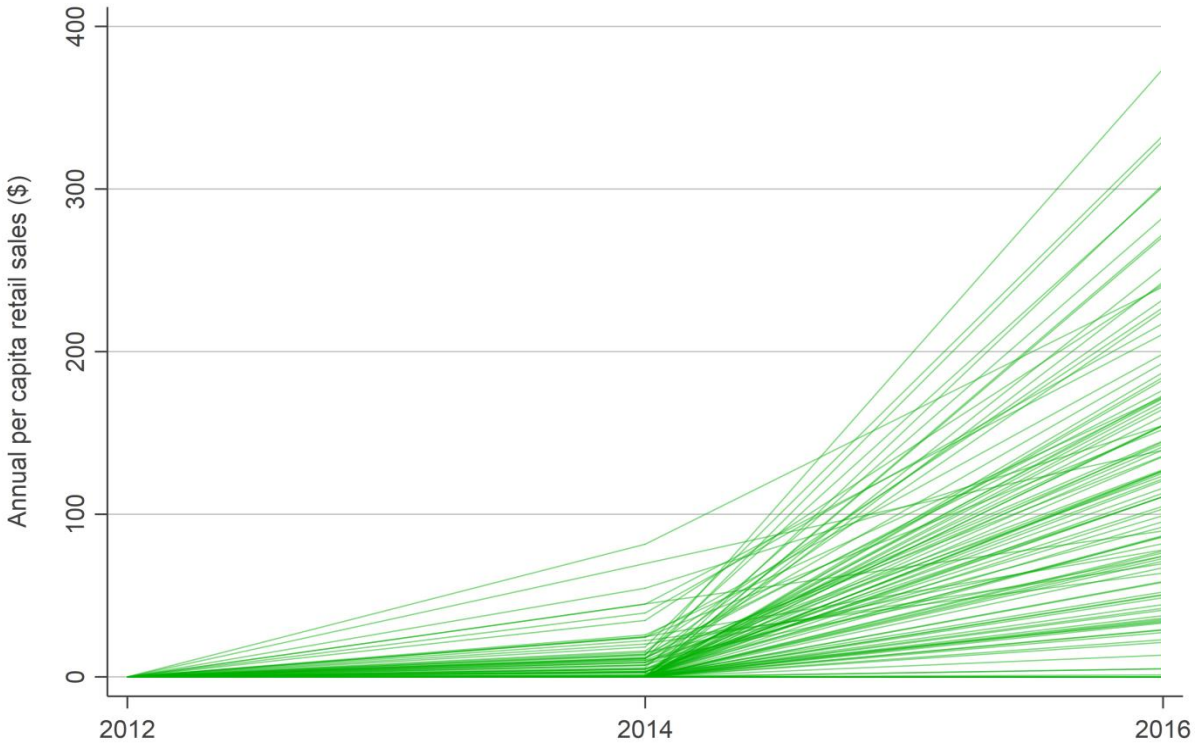
County	Average population 2014-2016	2014		2015		2016		2017
		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half
Adams	19,446	$0	$0	$0	$0	$0	$19	$37
Asotin	22,051	$0	$0	$4	$18	$90	$171	$187
Benton	188,857	$0	$6	$9	$11	$16	$35	$44
Chelan	75,206	$0	$2	$17	$30	$33	$49	$50
Clallam	72,910	$0	$1	$18	$28	$43	$71	$75
Clark	453,341	$0	$14	$41	$53	$49	$62	$64
Columbia	4,072	$0	$0	$0	$0	$0	$0	$0
Cowlitz	104,370	$0	$11	$33	$44	$52	$69	$73
Douglas	40,207	$0	$17	$20	$19	$23	$31	$32
Ferry	7,695	$0	$0	$0	$17	$37	$52	$46
Franklin	87,614	$0	$0	$0	$1	$0	$0	$0
Garfield	2,232	$0	$0	$0	$0	$0	$0	$0
Grant	93,961	$0	$3	$12	$15	$25	$39	$44
Grays Harbor	73,041	$0	$1	$12	$33	$53	$75	$80
Island	81,359	$0	$1	$13	$31	$40	$53	$54
Jefferson	30,921	$0	$13	$37	$48	$54	$79	$84
King	2,065,018	$0	$4	$19	$31	$42	$60	$61
Kitsap	259,380	$0	$4	$15	$30	$38	$53	$59
Kittitas	42,944	$0	$7	$25	$39	$53	$70	$75
Klickitat	21,071	$0	$22	$42	$50	$54	$76	$65
Lewis	76,668	$0	$0	$3	$10	$16	$30	$33
Lincoln	10,685	$0	$0	$0	$0	$0	$0	$0
Mason	62,201	$0	$0	$6	$28	$34	$50	$50
Okanogan	41,774	$0	$5	$10	$20	$23	$30	$33

County	Average population 2014-2016	2014		2015		2016		2017
		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half
Pacific	21,174	$0	$2	$15	$21	$19	$43	$78
Pend Oreille	13,253	$0	$0	$0	$0	$0	$2	$10
Pierce	833,691	$0	$5	$15	$25	$35	$57	$62
San Juan	16,216	$0	$3	$13	$20	$21	$28	$28
Skagit	121,006	$0	$7	$29	$39	$51	$70	$75
Skamania	11,444	$0	$0	$31	$47	$40	$48	$39
Snohomish	759,759	$0	$6	$17	$28	$38	$57	$60
Spokane	489,083	$0	$10	$36	$53	$65	$90	$95
Stevens	44,028	$0	$3	$20	$23	$22	$29	$30
Thurston	268,684	$0	$4	$18	$30	$43	$71	$78
Wahkiakum	3,995	$0	$0	$0	$0	$0	$0	$0
Walla Walla	60,568	$0	$0	$0	$11	$41	$52	$52
Whatcom	210,360	$0	$14	$25	$35	$48	$66	$69
Whitman	47,348	$0	$8	$35	$53	$58	$80	$87
Yakima	250,066	$0	$3	$8	$12	$16	$24	$30

Source:
Washington State Liquor & Cannabis Board. Average population source from Washington State Office of Financial Management, Forecasting Division (2016). Small Area Demographic Estimates: County 2000-2016.

Exhibit A3

Annual Per Capita Retail Cannabis Sales, by School District



Source:
Sales data source from Washington State Liquor & Cannabis Board; sales data shown for Health Youth Survey years (even-numbered years); Population data source from U.S. Census Bureau, Small Area Income and Poverty Estimates. (2017). School District Data 1995, 1997, 1999-2015. Retrieved from: https://www.census.gov/did/www/saipe/data/schools/; these data were only current through 2015 so we used the average of 2014 and 2015 population to compute per capita sales rates.

Exhibit A4

Inventory of the Status of our Work on all Study Components

Study component	Data source	Status
I-502 implementation		
I-502 business locations and sales	LCB	Analysis ongoing
LCB enforcement activity	LCB	Analysis ongoing
Prevention, treatment, and research	Descriptive information on DSHS, DOH, and university expenditure of cannabis funding	To be included in future reports
Washington State Patrol (WSP) laboratory testing of controlled substances and DUI enforcement	WSP	To be obtained
State agency implementation costs	Individual state agencies	Assessment of state agency costs of I-502 implementation is underway
Local implementation costs	Survey data collection of city and county government costs of regulating cannabis businesses completed	Initial survey completed; to be included in future reports; plans for assessment of other local implementation costs to be determined
Local policy data	Seattle and King County Public Health Department	Analysis ongoing
State and local cannabis revenues	OFM & DOR	Analysis ongoing
Substance use and abuse		
Adult substance use	Behavioral Risk Factor Surveillance System (BRFSS)	Analyzed in this report, current through 2015; 2016 data received Aug. 2017
Youth substance use	Healthy Youth Survey (HYS)	Analyzed in this report, current through 2016; 2018 data anticipated Spring 2019

Substance use in a college-age sample	Young Adult Survey	We will explore the prospect of analyzing
Youth and adult substance use	National Survey of Drug Use and Health (NSDUH)	License for access to restricted-use data approved by US Substance Abuse and Mental Health Services Administration; awaiting notification of when we can access the data;
Physical and mental health associated with drug use		
Prenatal cannabis use	Pregnancy Risk Assessment Monitoring System (PRAMS)	To be obtained
Health service utilization involving cannabis use	Drug Abuse Warning Network (DAWN)	To be obtained
	Emergency Department Information Exchange (EDIE)	To be obtained
	Provider One (P1)	To be obtained
	Seattle-King County Syndromic Surveillance System (SSS)	To be obtained
	Comprehensive Hospital Abstract Reporting System (CHARS)	To be obtained
Substance abuse treatment admissions involving cannabis	Treatment and Assessment Report Generation Tool (TARGET)	Analyzed in this report current through 2016; the TARGET data system has been decommissioned and will be replaced by a new system that is not yet available;
Substance abuse treatment admissions involving cannabis	Treatment Episode Data Set (TEDS-A)	Analyzed in this report current through 2014; 2015 data anticipated by fall 2017
Public safety		
Fatal accidents involving cannabis	Washington FARS with linked toxicology data from Washington Traffic Safety Commission	Data received current through 2015. Analysis ongoing
Non-fatal accidents	All crash data from Washington Department of Transportation	To be obtained

Criminal justice		
Filed and convicted charges	Criminal History Database (CHD)	Analyzed in this report current through 2015; data are updated quarterly
Arrests	National Incident Based Reporting System (NIBRS) & WSP Washington State Identification System (WASIS)	Data received; Analysis ongoing
Sentencing, incarceration, and supervision	Washington sentencing and jail and prison data	Data received; Analysis ongoing
Education		
Attendance, discipline, grade retention, graduation	Comprehensive Education Data and Research System (CEDARS)	To be obtained
Workplace safety & productivity		
Workplace safety	Census of Fatal Occupational Injuries (CFOI)	To be obtained
	Survey of Occupational Injuries and Illnesses (SOII)	To be obtained
Economic impact		
Employment and wages in the legal cannabis industry	Unemployment Insurance data from Employment Security Department	Analyzed in separate WSIPP report current through 2016*
Indirect and induced economic impact	Possible economic impact modeling using REMI or IMPLAN	Plan to be determined

Note:
* Hoagland, C, Barnes, B., & Darnell, A. (2017). *Employment and wage earnings in licensed marijuana businesses* (Doc. No. 17-06-4101). Olympia: Washington State Institute for Public Policy.

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