RAND

Drug Policy Research Center

The RAND Corporation is a nonprofit institution that helps improve policy and decisionmaking through research and analysis.

This electronic document was made available from www.rand.org as a public service of the RAND Corporation.

Skip all front matter: Jump to Page 1 ▼

Support RAND

Browse Reports & Bookstore

Make a charitable contribution

For More Information

Visit RAND at www.rand.org

Explore the RAND Drug Policy Research Center

View document details

Before the Grand Opening

Measuring Washington State's Marijuana Market in the Last Year Before Legalized Commercial Sales

Beau Kilmer, Jonathan P. Caulkins, Gregory Midgette, Linden Dahlkemper, Robert J. MacCoun, Rosalie Liccardo Pacula

The RAND Corporation is a nonprofit institution that helps improve policy and decisionmaking through research and analysis. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors.

Support RAND—make a tax-deductible charitable contribution at www.rand.org/giving/contribute.html

RAND® is a registered trademark.

RAND OFFICES
SANTA MONICA, CA • WASHINGTON, DC
PITTSBURGH, PA • NEW ORLEANS, LA • JACKSON, MS • BOSTON, MA
DOHA, QA • CAMBRIDGE, UK • BRUSSELS, BE

www.rand.org

Preface

On November 6, 2012, voters in Washington state passed Initiative 502, which legalized marijuana and required the state to regulate and tax a new marijuana industry. This report provides a snapshot of the Washington marijuana market before the anticipated opening of commercial marijuana stores and their associated supply chain. The Washington State Liquor Control Board contracted with BOTEC Analysis Corporation for analytic support while creating the new regulatory regime, and BOTEC subcontracted this research project to RAND. This report is not only intended for decisionmakers in the state of Washington, but also for those in other jurisdictions seeking to learn more about their marijuana markets.

RAND Drug Policy Research Center

The RAND Drug Policy Research Center conducts research to help decisionmakers in the United States and throughout the world address issues involving alcohol and other drugs. In doing so, the center brings an objective and data-driven perspective to this often emotional and fractious policy arena.

The center is part of RAND Health and RAND Justice, Infrastructure, and Environment. RAND Health's mission is to serve as the world's most trusted source of objective analysis and effective solutions for improving health. It is dedicated to reducing the cost of health care while improving the health of individuals, communities, and populations in the United States and worldwide. RAND Justice, Infrastructure, and Environment is dedicated to improving policy and decisionmaking in a wide range of policy domains, including civil and criminal justice, infrastructure protection and homeland security, transportation and energy policy, and environmental and natural resources policy.

Questions or comments about this report should be sent to the project leader, Beau Kilmer (Beau_Kilmer@rand.org). For more information on the RAND Drug Policy Research Center, see http://www.rand.org/multi/dprc.html.

Contents

Figures

Tables

Summary

The passage of both Initiative 502 (I-502) in Washington and Amendment 64 in Colorado in November 2012 was unprecedented. Before then, no modern jurisdiction had removed the prohibition on marijuana and allowed the commercial production, distribution, and possession of marijuana for nonmedical purposes—not even the Netherlands, which has a peculiar system of tolerated retail sale with an enforced ban on wholesale trade.

I-502 mandated that the Washington State Liquor Control Board regulate the newly legal cannabis industry. Among other tasks, the Liquor Control Board is responsible for making decisions about production, allocating and issuing licenses, and ensuring that marijuana businesses comply with regulations. It appears that the first marijuana stores will open in Washington in early 2014.

This report, *Before the Grand Opening*, provides a snapshot of the Washington marijuana market before the anticipated opening of commercial marijuana stores and their associated supply chain. It presents estimates of consumption for the entire state and each of its 39 counties for 2013. It also includes information about the characteristics of recent and heavy consumers and how they obtained marijuana. Knowing the market size is not only critical for making projections about consumption and tax revenues, it is also necessary for making informed decisions about how to distribute commercial licenses. It also provides baseline information for future evaluations of I-502.

While this report focuses on Washington state in 2013, many of the data sources and methods can be used by other jurisdictions seeking to learn about their marijuana markets. An important example is the web survey administered to improve understanding of how much marijuana users in Washington consume and how they obtain this marijuana. The survey did not simply ask respondents how much they spent and used; it also presented them with scaled pictures of marijuana to improve the accuracy of their responses about weights consumed.

Key insights from this report include the following:

- The National Survey on Drug Use and Health (NSDUH) reports that for 2010 and 2011 the average number of individuals in Washington who used marijuana or hashish in the past month was 556,000, with a 95-percent confidence interval of 475,000–650,000. NSDUH excludes some populations from its sampling frame, and self-report surveys typically underestimate consumption. Further, marijuana use has generally been rising, and these figures represent use in 2010 and 2011, not 2013. Thus, the unadjusted figures from the 2010/2011 NSDUH likely understate the number of past-month users in 2013.

- Three counties account for about 50 percent of marijuana users in Washington. King County has about 30 percent of the marijuana users, while Snohomish and Pierce counties have roughly 11 percent each.
- The literature is surprisingly thin concerning how much marijuana users consume during a typical day of use. That knowledge deficit becomes all the more acute when focusing on a particular jurisdiction and time, such as Washington in 2013. The emphasis has traditionally been on counting users, not counting grams. However, by augmenting that thin literature with data from the web-based consumption survey described above, we estimate that Washington residents who use marijuana 21 or more times per month consume, on average, 1.3–1.9 grams during a typical use day.
- Marijuana consumption in Washington in 2013 is greater than the 85 metric tons (MT) previously projected by the Washington Office of Financial Management (OFM, 2012a). Even before adjusting for survey undercounting/misreporting, our estimates suggest a 90-percent confidence interval of approximately 120–175 MT. The difference is largely driven by our use of more recent data.
- It is difficult to know by how much surveys understate actual consumption. Many of the relevant studies were published over a decade ago and times have changed; the NSDUH methodology has been improved substantially, and a national increase in marijuana use over the 2000s may have increased willingness to self-report. It is also unclear how applicable national and regional studies are to the state of Washington. After reviewing the evidence and attempting to adjust for undercounting/misreporting, results from our simulation suggest consumption likely falls within the interval of 135–225 MT, with a median estimate close to 175 MT.
- Multiple datasets provide information about the potency of the marijuana consumed in Washington. None is ideal, and there is no way to take a random sample of the universe of marijuana that is sold or consumed. But the available information suggests that lower-potency forms account for a modest share of the Washington market and probably a smaller share than they do nationwide.

Acknowledgments

Abbreviations

CCS	Cannabis Consumption Survey
EMCDDA	European Monitoring Centre for Drugs and Drug Addiction
HYS	Health Youth Survey
I-502	Initiative 502
MT	metric ton
MTF	Monitoring the Future
NESARC	National Epidemiologic Survey on Alcohol and Related Conditions
NSDUH	National Survey on Drug Use and Health
OFM	Office of Financial Management (Washington)
R-DAS	Restricted Data Analysis System
SAMHSA	Substance Abuse and Mental Health Services Administration
SCOPE	System for Communicating Outcomes, Performance, and Evaluation
THC	tetrahydrocannabinol
YRBS	Youth Risk Behavior Survey

Introduction

Discussions about fundamental marijuana policy reform are becoming very serious in the United States and abroad. While alternatives to marijuana prohibition have been discussed for years in dorm rooms and at dinner parties, these debates are now occurring in town halls, state capitols, and federal hearing rooms.

On November 6, 2012, voters in Washington state passed Initiative 502 (I-502) which removed the prohibition on the production, distribution, and possession of marijuana for non-medical purposes and required the state to tax and regulate the newly legal industry.[1] Outgoing Washington Governor Christine Gregoire signed I-502 into law on December 6, 2012. This made it legal under state law for anyone aged 21 years or older to possess up to one ounce of marijuana, 16 ounces of marijuana-infused product in solid form, or 72 ounces of marijuana-infused product in liquid form.[2] The truly revolutionary aspect of the law—allowing businesses to openly produce and distribute commercial-scale quantities for non-medical use—is expected to be fully implemented in 2014. At the time of this writing, the Washington State Liquor Control Board is finalizing decisions about how the marijuana industry will be regulated.[3] Once operational, a 25-percent tax will be levied at three different levels (producer, processor, and retailer) and the revenues will be used to fund substance use treatment, prevention, research, and other activities.

While marijuana remains illegal under federal law, the U.S. Department of Justice announced in August 2013 that—for now—it would not block the implementation of state legalization in Washington and other states with "strong and effective regulatory and enforcement systems" (Cole, 2013). It is expected that licenses for marijuana businesses in Washington will be distributed in early 2014 and the I-502 marijuana production facilities and stores will open during the first half of 2014. Legal marijuana stores will open in Colorado on January 1, 2014, and we expect other states will put legalization measures on the ballot in 2014 and 2016.

Since no jurisdiction in the modern world has removed the prohibition on marijuana and allowed for-profit companies to produce and distribute marijuana for nonmedical purposes–not even the Netherlands—those tasked with regulating the industry confront questions that have never been addressed. One of the critical decisions is to determine how much marijuana

---

[1] Colorado voters also passed an initiative to legalize marijuana production, distribution, possession, and use in 2012 (Amendment 64).

[2] Producing without a license remains illegal, and Washington's new law (unlike Colorado's Amendment 64) does not allow for home production; however, Washington residents with a medical marijuana recommendation were already allowed to possess up to 24 ounces of usable marijuana and to cultivate up to 15 cannabis plants.

[3] See Washington State Liquor Control Board (2013) for the most recent version of the rules.

should be produced, since that directly influences what happens to consumption, prices, government revenues, and possible diversion to other jurisdictions.

Making informed decisions about production requires knowledge about how much marijuana is currently consumed, and this report presents estimates for Washington state in 2013. This is not a straightforward task since general-population surveys are notorious for underestimating consumption; some users misreport, some refuse to take the survey, and some are not covered by the sampling frame (e.g., Fendrich, Johnson, Wislar, Hubbell, & Spiehler, 2004; Harrison Martin, Enev, & Harrington, 2007). Furthermore, most surveys do not inquire about the amount of marijuana consumed during a use day, and when they do, they typically do not account for sharing.

Given these concerns, this report provides an extensive analysis of undercounting/misreporting in general-population surveys and customizes a range of adjustment factors for Washington in 2013. It also presents results from a new web-based survey that was specifically designed to improve understanding of how much marijuana users in Washington consume and how they obtain this marijuana. The survey not only asked respondents how much they spent and used; it also presented them with scaled pictures of marijuana buds and ground material to improve the accuracy of their responses about weights consumed. It also included multiple questions that sought to get at the issue of sharing.

This report is organized as follows: Chapter Two presents estimates of the size of the marijuana market in Washington in 2013. The focus is on ranges rather than a specific point estimate, given the large amount of uncertainty underlying these figures. Chapter Three estimates how these users are distributed across Washington's 39 counties. Chapter Four presents an exploratory descriptive analysis of marijuana users in Washington and how they obtain marijuana. The report also includes three methodological appendixes, which can be found at http://www.rand.org/pubs/research_reports/RR466.html.

Size of the Marijuana Market in Washington in 2013

Introduction

Estimating the size of marijuana markets is becoming an increasingly common exercise for the United States (e.g., Abt Associates, 2001; Gettman, 2007; Kilmer, Caulkins, Pacula, & Reuter, 2011; Office of National Drug Control Policy [ONDCP], 2012; Kilmer et al., in press) and other jurisdictions (e.g., Bouchard, 2008; Bramley-Harker, 2001; Wilkins, Reilly, Pledger, & Casswell, 2005; Pudney et al., 2006; Wilkins & Sweetur, 2007; Legleye, Ben Lakhdar, & Spilka, 2008; Casey, Hay, Godfrey, & Parrott, 2009; Hakkarainen, Kainulainen, & Perälä, 2009; Kilmer & Pacula, 2009; United Nations Office on Drugs and Crime, 2009; Werb et al., 2012; Caulkins & Kilmer, 2013; van Laar, Frijns, Trautmann, & Lombi, 2013; Vopravil, 2013). Knowing how many people use marijuana and how much they consume can be useful for several reasons. First, it forms the basis for estimating how much money flows to the black market. Second, it can help put seizure and eradication statistics into context. Third, it provides decisionmakers with data necessary to make regulatory decisions (e.g., production limits) and project potential tax revenues.

Approaches for estimating the size of a marijuana market fall into two general categories: supply side and demand side. On the supply side there are production-based and seizure-based estimates, while on the demand side there are consumption-based and expenditure-based approaches. Since Washington state has a bustling market in production for export to other states, and there are no data describing the proportion of production that is exported or seized, we do not consider supply-side estimates. Since there are no adequate publicly available data about marijuana spending and average price paid throughout the state, we cannot take an expenditure-based approach.

Thus we utilize a consumption-based approach, which multiplies the number of users by the product of days of use per month or year ("use days") and grams consumed per use day. That product is computed separately for different types of users and then summed (weighting by the numbers of each type of user) to obtain the overall market estimate.[1] Information about the first two values is readily available from government surveys, caveated as always by the limits of asking individuals to self-report illegal activities and the possibility that changing attitudes might influence reporting rates (which might exaggerate year-to-year changes). Information about grams consumed per day of use is hard to come by and is our primary motivation

---

[1] We do not multiply the overall average number of days of use by the average quantity consumed per day of use—a common but potentially flawed approach that can underestimate consumption since there is a positive correlation between frequency of use and quantity consumed per day of use.

for developing and fielding a new survey as part of this project (the Cannabis Consumption Survey, or CCS).

The next section discusses the data underpinning these calculations. The following section describes the methods used to analyze this information and to account for the uncertainty underlying these figures.

Data

Self-Reported Use from the National Survey on Drug Use and Health

Each year, the U.S. Department of Health and Human Services fields the National Survey on Drug Use and Health (NSDUH). As described by its sponsor, the Substance Abuse and Mental Health Services Administration (SAMHSA), NSDUH "collects information from persons residing in households, noninstitutionalized group quarters (e.g., shelters, rooming houses, dormitories), and civilians living on military bases. In 2010–2011, NSDUH collected data from 137,913 respondents aged 12 or older and was designed to obtain representative samples from the 50 States and the District of Columbia" (SAMHSA, 2011).

State-level estimates, constructed by pooling data from surveys in adjacent years, have been reported since 2002/2003. Figure 2.1 presents information about the number of individuals in Washington who reported using in the past year and the past month. Past-month prevalence was fairly flat from 2005/2006 through 2008/2009, but there was close to a 40-percent

Figure 2.1
Self-Reported Marijuana Users in Washington, 2002–2011
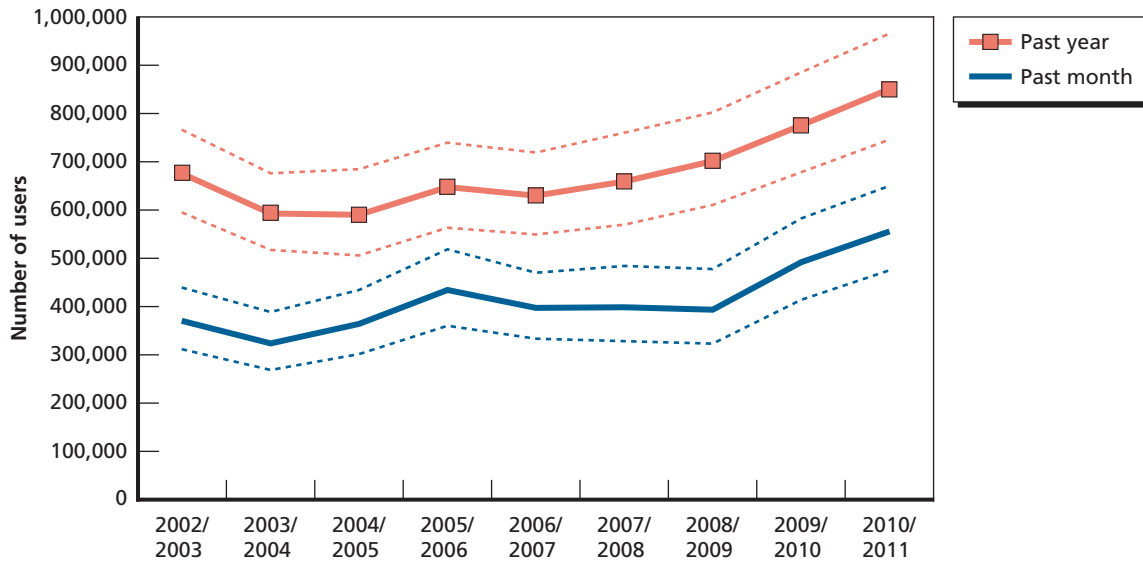
SOURCE: NSDUH state estimates (SAMHSA, annual).
NOTE: Dotted lines show 95-percent confidence intervals.
RAND *RR466-2.1*

increase in the number of past month users from 2008/2009 to 2010/2011;[2] the national increase in past-month users over the same period was only 10 percent.[3]

Self-Reported Use Days

While SAMHSA regularly publishes state-level prevalence information, it has historically been difficult to obtain information about other marijuana variables at the state level. Fortunately, there have been two recent advances. First, SAMHSA now allows researchers to generate custom tables of state-specific values for several variables via online analysis of the NSDUH Restricted Data Analysis System (R-DAS), which is hosted at the Substance Abuse and Mental Health Data Archive (SAMHSA, 2002–2011). Second, researchers can now work directly with individual-level NSDUH data with state-level identifiers via a new data portal; however, access to the portal is restricted.

For example, Figure 2.2, which is based on R-DAS, contrasts the frequency distribution of past-month marijuana use days for those reporting past-month marijuana use in Washington and the rest of the country for 2010 and 2011.

There is a spectrum of frequencies of use, not discrete groups, but it is convenient to break that spectrum into bins. Closely following a typology used by the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA, 2013) we divide past-month users into four groups based on past-month frequency of use: 1–3 days, 4–10 days, 11–20 days, and those using more than 20 days in the previous month. With reference to Figure 2.2, this pools the two rightmost pairs of bars into the highest-frequency group, and the next two pairs of bars

Figure 2.2
Frequency Distribution of Past-Month Marijuana Use Days for Washington and for the Rest of the Country, 2010 and 2011
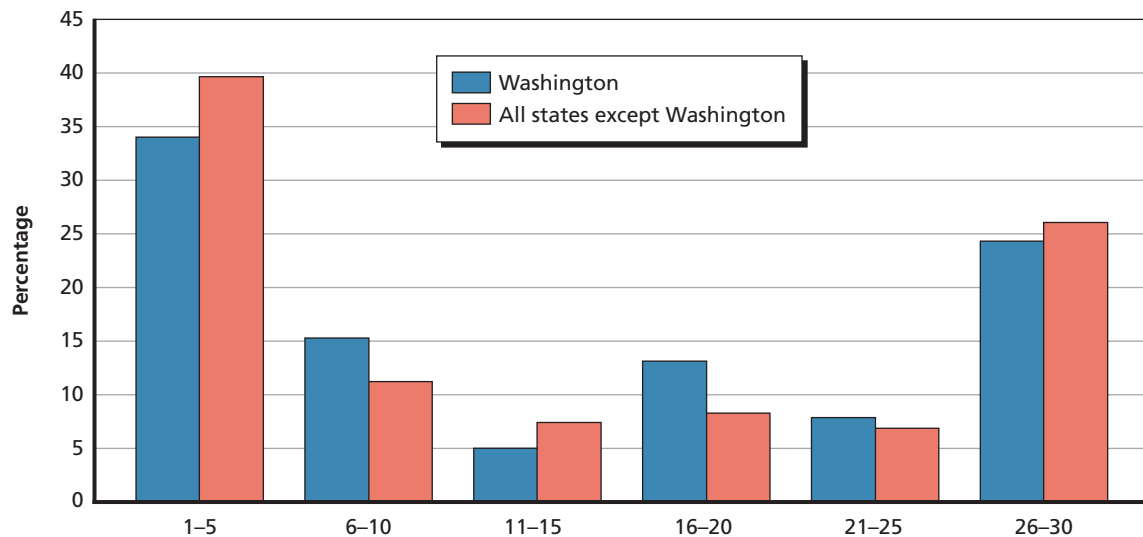
SOURCE: NSDUH R-DAS (SAMHSA, n.d.).

RAND *RR466-2.2*

---

[2] This is very little overlap in the 95-percent confidence intervals: 2008/2009 = 324,000–478,000; 2010/2011 = 475,000–650,000.

[3] National figures for 2008/2009: 16,047,000; 2010/2011: 17,741,000. The 2008 NSDUH reports 15,023,000 past-month users and the 2011 NSDUH reports 18,071,000.

into those using 11–20 days, but divides the two lowest-frequency groups at three days per month instead of five, since there are so many more people who use on 1–5 days than who use 6–10 days.

Our thresholds differ slightly from what is used by the EMCDDA (1–3, 4–9, 10–19, >19) since there was clustering around round numbers and we thought those reporting ten days of use belonged with those who used a few times a week, not those who used more than a few times per week. We then include those reporting exactly 20 days in the third category, not the highest-frequency category, to be consistent, and also because there is a precedent for defining the highest-frequency category as those who use on more than 20 days in the past month (e.g., Cohen, 1999; Zhang, Friedmann, & Gerstein, 2003; Robbins et al., 2006).

Trends in Prevalence Since 2010/2011

Our task is to estimate consumption throughout 2013, but the analysis was done *during* 2013, and the most recent NSDUH data for Washington are based on surveys conducted in 2010 and 2011. Hence, we need to extrapolate forward from slightly older data.

To gain insight into trends in marijuana use since 2011, Figure 2.3 tracks a number of indicators, including (1) past-month marijuana prevalence for 10th grade students from Washington's Health Youth Survey (HYS); (2) past-month marijuana prevalence for 12th grade students from Washington's HYS; (3) share of treatment admissions in the Washington State Division of Behavioral Health and Recovery's System for Communicating Outcomes, Performance and Evaluation (SCOPE) involving marijuana; (4) share of treatment admissions in Washington involving marijuana that did not involve criminal justice referrals; (5) national past-month marijuana prevalence rate for the general population; and (6) national past-month marijuana prevalence for high-school seniors as reported by Monitoring the Future (MTF).

Figure 2.3
Indexed Trends in Marijuana Indicators for Washington and the United States
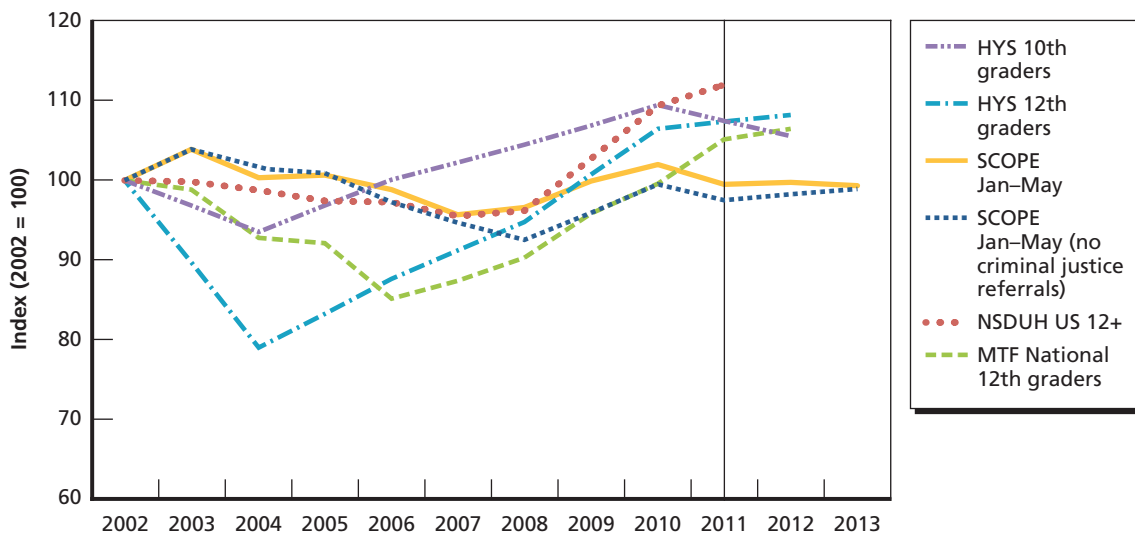
SOURCES: Washington State Department of Health (2003–2013); SAMHSA (2002–2011); Washington State Division of Behavioral Health and Recovery (2013); and Johnston, Bachman, & O'Malley (2002–2013).
NOTE: Since HYS is conducted every other year, the middle years are linearly interpolated. Treatment data are only based on admissions from January–May of each year since the most recent update to SCOPE was May 2013.
RAND *RR466-2.3*

The national past-month prevalence data are presented since NSDUH only generates annual estimates for the country as a whole (state-level estimates are based on a two-year average). Nationally, there appears to be an increase from 2010 to 2011, but it is not as steep as the increase from 2008 to 2010.

MTF past-month prevalence data for high-school seniors nationally shows about a 7-percent increase (from 21.4 percent to 22.9 percent) from 2010 to 2012; however, the 2010–2012 increase is much smaller in past-month prevalence data for high-school seniors in Washington (HYS), and past-month prevalence for 10th graders in Washington actually decreased slightly from 2010 to 2012. These self-report figures are subject to the same underreporting concerns raised in the previous section, although researchers typically take refuge in assuming that the bias is constant over time. However, given the growing acceptance of marijuana in Washington and elsewhere, users may now be more likely to report their use on surveys. Whether this occurs is an empirical question (see Fendrich & Rosenbaum, 2003), but if it does, the decrease observed for 10th graders in Washington between 2010 and 2012 could be even more pronounced.

Of course, there was a big change to marijuana policy in Washington with the passage of I-502 in November 2012. In December 2012, the law went into effect and those aged 21 and older in Washington were allowed to possess up to one ounce of marijuana under state law. How much did marijuana use change from 2012 to 2013? No one knows, and given the lag in data collection and reporting, we may not know for a few years.

Washington does, however, make aggregate treatment admissions data available almost instantaneously through its SCOPE program (May 2013 data were made available in June 2013; displayed in Figure 2.3). This is far from an ideal measure since even if there was an upsurge in consumption it probably would not immediately affect treatment admissions. Further, treatment entry is a function of treatment availability and policy, which suggests that—at a minimum—marijuana admissions should be expressed as a proportion of total admissions. And, finally, marijuana treatment entry is often triggered by law enforcement referrals; it is not yet known how implementation of I-502 will change that pattern.

From 2010 through 2013, the share of treatment admissions involving marijuana, regardless of referral type, was stable (i.e., its normalized value hovered around 100, the rate in 2002). Roughly speaking, both series increased after 2002, decreased from 2003 to 2008, increased from 2008 to 2010, then stabilized.

Marijuana stores will not open in Washington until 2014, so users will still have to obtain marijuana from the black market or from medical access points. Thus, we should not expect to see serious price declines in 2013 of the sort that *could* influence consumption in future years (see Kilmer, Caulkins, Pacula, MacCoun, & Reuter, 2010). However, there is still the possibility that the change in legal risk and increased social acceptance could increase consumption in 2013. Caulkins, Andrzejewski, and Dahlkemper (2013) assumes the longer-term effect of I-502 on marijuana demand in Washington (beyond price effects and large-scale advertising) could be 5–35 percent, with a best guess of 20 percent. This assumed a mature market with commercialization, which will not happen in 2013; however, there will likely be some normalization and promotion in 2013.

This suggests the 20 percent would probably be too high even for the upper bound in 2013. While we do not have any strong evidence that consumption increased in Washington between 2010/2011 and 2013, we would be surprised if there was not some increase. Thus, we allow for an increase in prevalence from 2010/2011 to 2013 of between 5 percent and 15 per-

cent, with a middle estimate of 10 percent. While this parameter is impossible to know, it has a modest effect on the overall consumption estimates. The main driver of uncertainty—grams consumed per use day—is discussed next.

Grams Consumed per Use Day

The literature is surprisingly thin concerning how much marijuana users consume during a typical day of use, in general, let alone in a particular jurisdiction and time, such as Washington in 2013. While this would seem like a fairly easy figure to estimate, survey respondents understandably have difficulty answering questions about weight. Finding ways to improve respondents' accuracy has not been the subject of much serious academic attention in the United States. (There is more literature on this in Europe: Korf, Benschop, & Wouters, 2007; van Laar et al., 2013; Caulkins & Kilmer, 2013; van der Pol, Liebregts, de Graaf, Korf, van den Brink, & van Laar, 2013.)

Complicating matters, this literature suggests that there are systematic differences in weight consumed per use day across different groups of users. In particular, those who use on more days per month also tend to use more grams per day of use. The good news from an analyst's perspective is that the highest-frequency users (those consuming on 21 or more days per month) utterly dominate the quantity consumed, accounting for close to 80 percent of total consumption (Caulkins, Hawken, Kilmer, & Kleiman, 2012). Hence, to estimate consumption for a jurisdiction, we primarily need to estimate grams consumed per use day for that one particular group. Obtaining current, Washington-specific data on that key parameter was the motivation for conducting the web-based CCS that we developed for this project.

Previous estimates of grams consumed per day of marijuana use in the United States had to multiply estimates of joints consumed per day by assumptions about the average weight of a joint. This is problematic for various reasons, including the fact that marijuana is often consumed by methods other than smoking joints. Nevertheless, it is worth reviewing.

The precursor to the NSDUH only asked about the number of joints used per use day up through 1995. For this analysis, data on joints per day come from the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC), which is a nationally representative repeated-panel survey of the noninstitutionalized U.S. population 18 years of age and older. It includes questions about substance use, including how often cannabis was used in the last 12 months and the number of cannabis joints usually smoked in a day when using in the last 12 months. Using NESARC survey data from 2001, daily and near-daily users consumed 3.9 joints per day of use, while those who used one to three days in the previous month consumed 1.7 joints per day of use (Table 2.1). However, these figures are likely inflated since survey respondents could not report using less than one joint. Marijuana is frequently shared, so it is possible that different respondents who shared a joint might each report that joint in describing their own use. Our web-based survey attempts to improve on past surveys with regard to accounting for sharing.

This pattern is consistent with a recent study of cannabis users in Canada. Zeisser et al. (2011) observed a positive correlation between joints consumed per day and days of use per month. Their data suggest that those using 30 days per month consumed about three times as many joints per day as did those using only 1–4 days per month.

As for the typical amount of marijuana in a joint, Kilmer and Pacula (2009) found that a number of studies reported the amount to range from 0.3 to 0.5 grams. Using self-report purchase data from arrestees who purchase in loose grams or joints from 2000–2003 (roughly

Table 2.1
NESARC: Mean Joints per Day, by User Type (95-Percent Confidence Interval)

Type of User	2001/2002 Total
MJ1: 20+ times a month (every day, nearly every day)	3.87 (3.33–4.39)
MJ2: Less than 20, more than 3 (1–4 times week)	1.92 (1.63–2.20)
MJ3: 1 to 3 days a month (1–3 times a month)	1.68 (1.46–1.89)
MJ4: Less than 1 day per month (<12 times a year)	1.17 (1.12–1.22)
Total	2.00 (1.86–2.15)

the same time NESARC was in the field), Kilmer, Caulkins, Bond, and Reuter (2010, Appendix A) estimated that the average weight of a joint was 0.46 gram (95-percent confidence interval: 0.43, 0.50); however, the authors note a few reasons why this may have been a slight overestimate.[4]

Multiplying 3.87 joints per day for daily users by 0.46 gram per joint suggests that the daily and near-daily users consumed almost 1.8 grams per use day circa 2001; however, a national estimate from 2001 may not apply to Washington state in 2013. While the majority of the marijuana consumed in the United States circa 2001 was commercial-grade marijuana from Mexico (Kilmer, Caulkins, Bond, & Reuter, 2010), such relatively low-potency forms appear to account for a small share of current consumption in Washington, according to interviews with law enforcement and data on seizures.[5] The average potency in Washington today is likely much higher than the average potency for the country in 2001 (see Appendix C). Thus, users in Washington would not have to consume as much weight to achieve the same level of intoxication. However, it is also possible that daily/near-daily users in Washington are consuming the same weight, and therefore just consuming more milligrams of THC per day.

As mentioned earlier, there is growing interest in Europe about estimating grams consumed per use day. Based on survey data from seven European Union countries (Bulgaria, Czech Republic, Italy, Netherlands, Portugal, Sweden, and United Kingdom), Caulkins and Kilmer (2013) estimate consumption of 35 grams per month for those using 20 or more times per month. Similar to what was suggested in NESARC, Figure 2.4 shows how the average

---

[4] From Kilmer, Caulkins, Bond, & Reuter (2010, Appendix A, p. 2):

> There are two minor biases in this analysis. Both will lower the estimate of price per gram of a joint and, so, tend to overestimate the weight of a joint. First, the average "1 g" purchase on the street weighs slightly less than 1.0 g; drug dealers tend to err on the light side when preparing sales. Second, the price per gram for a gram purchase is estimated at a (marginally) higher "market level" than is the price per gram for a single joint. Price as a function of weight is often modeled as a power function with an exponent in the vicinity of 0.8. In such circumstances, the price per gram will tend to be lower for the larger quantity (e.g., with an exponent of 0.8, doubling the quantity would lead to a price per gram that is 13 percent lower).

[5] Of 113 law enforcement–derived samples from Washington that were analyzed quantitatively for tetrahydrocannabinol (THC) content by the University of Mississippi (2013) lab from 2008 and 2009, only one-quarter (28 of 113) had THC potencies less than 10 percent.

Figure 2.4
Average Grams per Day of Use Versus Number of Days of Use in Past Month (Based on Survey Data from Seven European Countries)
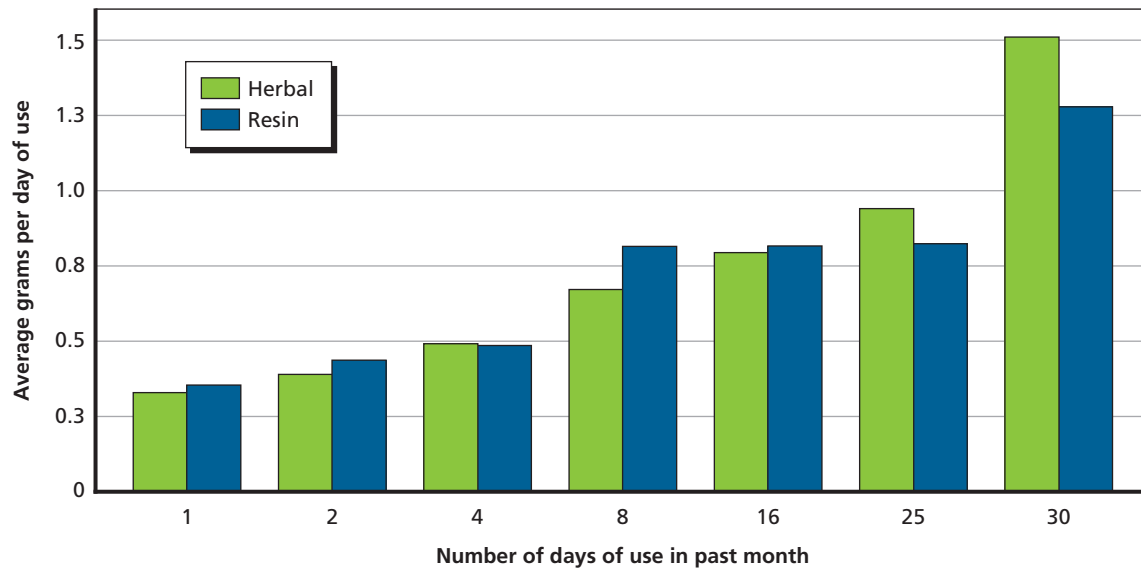
SOURCE: Reproduced from Caulkins and Kilmer (2013).
NOTE: Computed separately for herbal and resin (hashish) and then plotted on the same graph.
RAND *RR466-2.4*

number of grams consumed per day (i.e., the product of units per day and grams per unit) increases with increasing frequency of use in these seven countries, and that pattern holds for both "herbal cannabis" (the most common form consumed in the United States) and "resin" (which is called "hashish" or "hash" in North America). Use days were measured using a categorical variable. For those checking the 21–29 days used in the past month category (labeled 25 here), the average consumption per day of herbal cannabis was 0.9 gram. For those checking the daily use box, it was 1.5 grams. The corresponding figures for hashish are lower, possibly because hashish tends to be more potent than herbal cannabis.

Given differences across countries in potency and other factors, we cannot assume these figures apply in Washington, but Figure 2.4 does provide more documentation of the positive correlation between use days and grams consumed per use day.

The web survey created to generate these European data (van Laar et al., 2013) motivated some of the questions included in our CCS (see Appendix A for detailed information about the survey).[6] Namely, the use of picture cards to help respondents describe their consumption is novel, and this project may be the first time it has been used in the United States.[7]

In particular, the survey said, "Here is a picture of __ grams of ground-up/crumbled marijuana (on the left) and __ grams in intact buds (on the right)." (The ground-up marijuana and the buds were the same weight. Respondents were randomized to see a picture of either 0.5 or

---

[6] The survey was launched at http://www.mjsurvey.org on June 24, 2013. By July 3 we had received almost 3,500 responses, over 1,000 of which reported to be Washington residents who used marijuana 21 or more days in the previous month.

[7] van der Pol et al. (2013) recently reported that their prompt cards resulted in underestimation for the size of a joint; however, our picture cards include much more detail. Future research is needed to assess which kinds of picture cards (if any) are most useful.

1.0 gram of marijuana, displayed alongside a quarter, a ruler, and a credit card to give a sense of scale.) "Now think again about the last time you used dried marijuana bud. How much did you personally use that entire day?" The survey question included categorical responses running from "Less than half this amount" to "More than five times this amount." Respondents were then also asked directly how many grams they usually used on a typical "light" day, on a typical day, and on a typical "heavy" day. These questions allowed us to produce grams-per-use-day variable values for most respondents.

One concern with surveying marijuana users about consumption is the frequency of sharing. Suppose a user and a friend shared one joint in the morning and another in the evening. If the next day a survey asked, "How many joints did you use?" would the user answer "one" or "two"? For our purposes, we want them to think that they consumed half of two joints, which adds up to the equivalent of one joint, but given how most surveys are worded, respondents might instead reasonably answer that they used (parts of) two joints. We sought to prevent such ambiguity by asking about sharing in a variety of ways and with considerable specificity.

We still cannot simply average across survey respondents' answers, however, because survey respondents were not representative of the population of past-month users. For example, more respondents reported growing their own marijuana than NSDUH data imply is the case for past-month users in Washington state more generally, and growers reported considerably greater consumption per day than did non-growers. The three most important attributes in this regard were whether the respondent grew their own marijuana, whether the respondent had a medical access card, and whether the respondent had a college degree. (The first two predicted greater amounts consumed per day of use; having a college degree predicted lower quantities consumed.)

So we split CCS respondents who reported using marijuana 21 or more days in the past month into four mutually exclusive groups: growers, current medical marijuana cardholders who do not grow, nonmedical non-growers with four-year college degrees, and nonmedical non-growers with a two-year degree or less. About 17 percent of CCS respondents report growing cannabis for consumption, which is over four times the rate observed nationally (3.9 percent, 95-percent confidence interval: 2.7–5.6 percent) and nearly eight times the rate reported in Washington in NSDUH 2010/2011. We expect that the true rate is probably in the 2.2–3.9 percent range. Medical access points' market share in Washington is not known, but Caulkins et al. (2013) performed rough calculations suggesting that it may be less than 20 percent. So we consider that non-growing medical users could make up between 20 percent and 40 percent of daily and near-daily users in Washington, where this proportion is close to what was observed in our sample. Nearly 18 percent of CCS respondents report having a four-year college degree, which is considerably higher than the 13.4 percent rate observed among daily and near-daily users in NSDUH data for Washington; we divide the non-growing nonmedical users in two groups, 13.4 percent of them with four-year degrees and the rest without.

To assess the importance of assumptions about the composition of users in the state, we consider the average reported grams per use day for each group over seven scenarios considering different proportions for each of the four groups, shown in Table 2.2. We also separately take into account outliers within groups by calculating Winsorized means, minimizing the influence of the bottom and top 5 percent of the distribution by replacing those values with the 5th and 95th percentile responses, respectively.

Results across all composition assumptions fall in the range of 1.3–1.9 grams per use day, with a modal value around 1.6 grams (see Table 2.2). This is consistent with the average

Table 2.2
Sensitivity Analysis of Composition Assumptions Driving the Estimate of Grams per Use Day

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Growers	17.2%	3.9%	3.9%	2.2%	2.2%	3.9%	3.9%
Medical non-growing users	37.5%	20.0%	20.0%	42.7%	42.7%	42.7%	42.7%
College grad, no grow, no med	19.0%	76.1%	10.2%	55.1%	16.0%	53.4%	16.3%
Less than college grad, no grow, no med	26.3%		65.9%		39.1%		37.1%
Typical Grams per Use Day							
Weighted mean	1.89	1.45	1.58	1.57	1.61	1.61	1.64
Weighted Winsorized mean	1.59	1.36	1.49	1.45	1.49	1.47	1.50

NOTE: These figures are based on a question about typical use that was not prompted by the picture cards. In Scenarios 2, 4, and 6, the "college grad" and "less than college grad" groups were merged, hence a single percentage is provided.

reported consumption for users based on the picture-prompting questions: 1.54 grams.[8] For more information on the picture-prompt responses, see Appendix A.

Addressing Undercounting/Misreporting in NSDUH

When surveying respondents about sensitive behaviors, misreporting is a perennial concern. It is common to adjust marijuana consumption estimates upward by an ad hoc factor of 1.25 (e.g., Kilmer et al., 2011).[9] The authors of ONDCP's *What America's Users Spent on Illicit Drugs, 2000–2006* (Abt Associates, 2012) used a slightly larger adjustment of 1.33 based on a 2001 investigation of 12–25-year-old respondents to an earlier version of the household survey (NHSDA, the precursor to NSDUH), that collected urine samples and compared self-report with positive urinalysis test results (Harrison et al., 2007).

Sometimes undercounting/misreporting is thought of only in terms of respondents' underreporting of their activity, but we are interested in a more general concept: How much do respondents' self-reports underestimate true consumption by the entire population? For this, one must distinguish between four phenomena:

---

[8] For those who received the 0.5-gram picture, we code responses of less than one-half this amount as 0.125 gram and responses of more than five times this amount as 5. For those who received the 1-gram picture, we code responses of less than one-half this amount as 0.25 gram and responses of more than five times this amount as 7.5.

[9] As noted by Kilmer et al. (2011):

The relative lack of social disapprobation about marijuana use may make this [underreporting] less of a problem than it is for drugs like cocaine and heroin, but it is still an issue. Kilmer and Pacula (2009) partially based their 20 percent underreporting estimate on Fendrich et al.'s (2004) study of a household population in Chicago, which found that 78% of marijuana users self-reported their use. This is also consistent with the share of arrestees who self-reported their marijuana use in the 2008 Arrestee Drug Abuse Monitoring (ADAM) survey (82%; ONDCP, 2009). Additionally, Hser, Maglione, and Boyle (1999) looked at the validity of self-reported marijuana use for three populations in Los Angeles (those visiting a sexually transmitted disease clinic, emergency room patients, and jail inmates) and found that of those testing positive for marijuana, 12.2%, 18.9%, and 23%, respectively, denied using marijuana in the previous 30 days.

1. Use by people outside the NSDUH's sampling frame (e.g., homeless who are not in shelters, active members of the military).
2. Use by people who are in the sampling frame but nonetheless are not surveyed (e.g., because they were never home or refused to answer).
3. Misreporting of past-month use by people who are successfully surveyed.
4. Misreporting of quantities consumed (e.g., days used in the past month) even if some use is acknowledged.

These factors are discussed in detail in Appendix B. Our review of the evidence suggests their combined effects warrant adjustment factors ranging from 1.02 to 1.43 for Washington in 2013. But arguments can be made for higher values. For example, Cook (2007) found that a general population survey focused on alcohol consumption missed about 50 percent of alcohol consumed based on tax receipts; this would suggest a multiplier closer to two.

Summary of Datasets

We conclude this review of data sources with a table summarizing key attributes of the primary data sets employed (Table 2.3).

Methods and Results

The quantity of marijuana consumed in Washington in 2013 can be computed as:

(1) Metric Tons Consumed =
   # of past month marijuana users in Washington in 2010–2011 estimated by NSDUH
   x Growth in use since 2010/2011
   x Average grams per year per past-month user
   x Adjustment for survey undercounting/misreporting
   ÷ 1,000,000 (to convert grams to metric tons).

Annual consumption per past-month user is obtained by multiplying average grams per month by 12 rather than working directly with data on grams per year. Average grams per month per past-month user is based on a weighted average across frequencies of use:

(2) Average grams per month per past-month user =

$$\frac{\sum_{i=1}^{30} Number\ of\ users_i \times i \times Grams\ per\ day\ of\ use_i}{\sum_{i=1}^{30} Number\ of\ users_i}$$

where *number of users$_i$* is the number of people in Washington who used marijuana on *i* days in the last 30 days, and is based on the frequency distribution presented in Figure 2.2.

Grams per day of use for those who used *i* = 1 day, 2 days, . . . 30 days in the past month is linearly interpolated between two anchor points: estimates for those only using one day a month and those using daily or near daily. As discussed in the section on undercounting, the expected value for the high anchor (average grams per day for daily/near-daily users) is 1.6 grams. The lower anchor for people consuming only one day in the past month divides that

Table 2.3
Dataset Summary

Dataset	Time period	Description of variables
NSDUH	2010/2011	Prevalence of marijuana use, expenditures, and characteristics of users among those 12+ years old for Washington and the nation Establishes baseline number of marijuana users in Washington
NESARC	2001	Joint consumption per use day
Washington HYS	2002–2012	Past-month use by 10th and 12th graders in Washington
Washington SCOPE	2002–2012	Substance use treatment admissions for marijuana in Washington
MTF	2002–2012	Past-month use by 12th graders nationwide
CCS	June 2013	Characteristics of daily and near-daily marijuana users, use patterns, and expenditures in Washington

figure by two to three, since surveys (in Europe, Canada, and earlier in the United States) show daily/near-daily users use two to three times more per use day than do once-a-month users.

There is uncertainty about all of these the parameters. Monte Carlo simulation is a tool for exploring how much uncertainty there is about an outcome (such as total statewide consumption) when considering uncertainty in all of the parameters simultaneously. It asks a computer to repeatedly draw sets of random values for each parameter from a plausible distribution of values, and then compute the outcomes of interest with that set of parameter values. After the computer has done this 10,000 times, for example, the distribution of outcomes obtained gives a sense of how much uncertainty there is about the outcome of interest.

We first present estimates that do not account for survey undercounting/misreporting. That adjustment is discussed in the final section.

State Consumption Estimate—Unadjusted for Survey Undercounting/Misreporting

The parameter ranges and distributions used for the simulation are presented in Table 2.4.

Figure 2.5 presents the frequency distribution of the quantity of marijuana consumed in Washington in 2013, before adjusting for survey undercounting (based on 10,000 trials). The mean and median of the unadjusted distribution are approximately 145 metric tons (MT), and 90 percent of the trials fall within the interval from 120 MT to 175 MT. These unadjusted estimates are larger than the value estimated by the Office of Financial Management (OFM) (85 MT),[10] and this difference is largely driven by our use of more recent data (2010/2011 vs. 2008/2009).

---

[10] From OFM (2012a):

> There is no way to determine with precision the consumption of marijuana in the state before or after the effective date of the initiative. Therefore, for purposes of this fiscal impact statement only, an estimate of marijuana users was created using the U.S. Department of Health and Human Service, Substance Abuse and Mental Health Services Administration's National Survey on Drug Use and Health, 2008–2009 data for Washington. The survey estimates the percentage of marijuana users to be 17.18 percent for persons 18 to 25 years of age and 5.57 percent for those 26 years of age or older. Assuming Washington's population of marijuana users is increasing at the same rate as the national use contained in the survey, the number of users in calendar year 2013 is estimated to be 18.4 percent for persons 18 to 25 years of age and 6.1 percent for those 26 years of age or older. *Applying those percentages to the state's forecasted 2013 population, estimates assume 363,000 Washington marijuana users in calendar year 2013.* Estimates also assume a 3 percent increase in sales beginning in 2015 to account for population growth and inflation. Frequency of consumption is estimated using the pattern contained in the United Nations Office on Drug and Crime, 2006 Bulletin on Narcotics, Review of the World Cannabis Situation,

Table 2.4
Parameter Values and Distributions Used to Estimate Total Marijuana Consumption in Washington (Unadjusted for Survey Undercounting/Misreporting)

Quantity	Low	Medium	High	Distribution
# past month marijuana users in Washington in 2010–2011, as reported by NSDUH	475,000	556,000	650,000	Normal (SD= 44,644)
Increase in past-month use from 2010/2011 to 2013	1.05	1.1	1.5	Triangle
Average grams per day for daily/near-daily users	1.3	1.6	1.9	Triangle
Ratio of grams per day for daily/near-daily vs. once-a-month users	2		3	Uniform

NOTE: Ranges discussed in previous section.

State Consumption Estimate—Adjusted for Survey Undercounting/Misreporting

As mentioned previously, self-report surveys such as the NSDUH typically underestimate consumption.

Appendix B reviews evidence on undercounting and misreporting in the NSDUH. Many of the relevant studies were published over a decade ago, and there have been important changes since then; most notably, improvements to the NSDUH methodology[11] and large increases in both support for marijuana legalization[12] and use. Combining the data from Table 2.4 with an undercount/misreporting adjustment factor assumed to be normally distributed with mean 1.22 and standard deviation 0.13 (i.e., about 90-percent chance of falling between 1.02 and 1.43) suggests a range of 135 MT to 225 MT, which might loosely be thought of as a 90-percent confidence interval, with a median estimate close to 175 MT (Figure 2.6).

Applying this adjustment factor to SAMHSA's best estimate for past-month users in Washington and assuming a ten-percent increase since 2010/2011 generates a figure close to 750,000 past-month users for 2013 (556,000 x 1.1 x 1.22 = 746,152).

---

page 48. The frequency of consumption by users ranged from a low of 18 percent consuming once a year to 3 percent consuming daily. Applying this consumption pattern to an estimated 363,000 Washington marijuana users, *and assuming 2 grams of marijuana per use*, the number of grams consumed annually *is estimated at 85,100,000 grams*. (emphasis added)

[11] From the 2002 NSDUH:

[R]esults of the 2002 survey, as well as more recent analyses of data from the 2001 experiment, suggest that the incentive, and possibly the other survey changes, did have an impact on the estimates produced from the 2002 survey. Estimates of rates of substance use, dependence and abuse, and serious mental illness (SMI) were significantly higher in 2002 than in 2001. Analysis of the 2001 and 2002 data has shown that many of these "increases" could not possibly be real and are likely to be artifacts of the changes in the survey procedures. A key finding was that the increases in rates of lifetime use were inconsistent with rates of new use. For example, NHSDA data for recent years have consistently shown fewer than 3 million persons had tried marijuana for the first time each year; however, the estimated number of persons who had ever used marijuana, based on the 2002 NSDUH, was 10.5 million greater than the estimate from the 2001 survey. (SAMHSA, 2008)

[12] The share of Americans indicating that marijuana should be legal increased from about 30 percent in 2000 to more than 50 percent in 2013. (Pew Research Center, 2013)

Figure 2.5
Frequency Distribution of Estimated Quantity Consumed in Washington in 2013 *Without* an Adjustment for Survey Undercounting/Misreporting (Metric Tons)
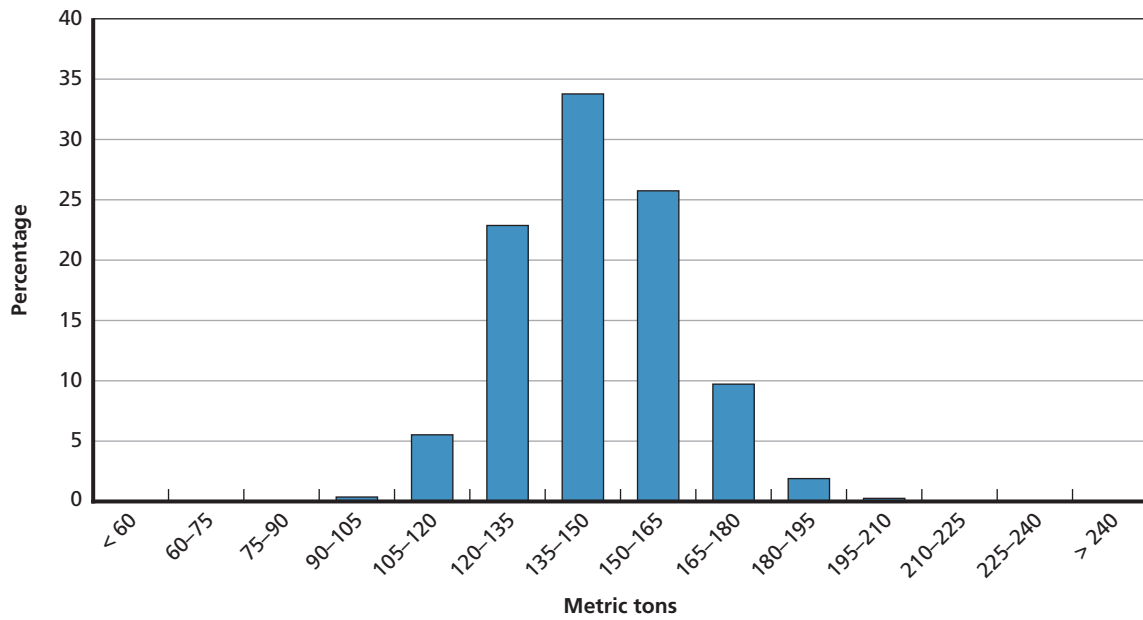
SOURCE: Authors' calculations.
RAND *RR466-2.5*

Figure 2.6
Frequency Distribution of Estimated Quantity Consumed in Washington in 2013 *With* an Adjustment for Survey Undercounting/Misreporting (Metric Tons)
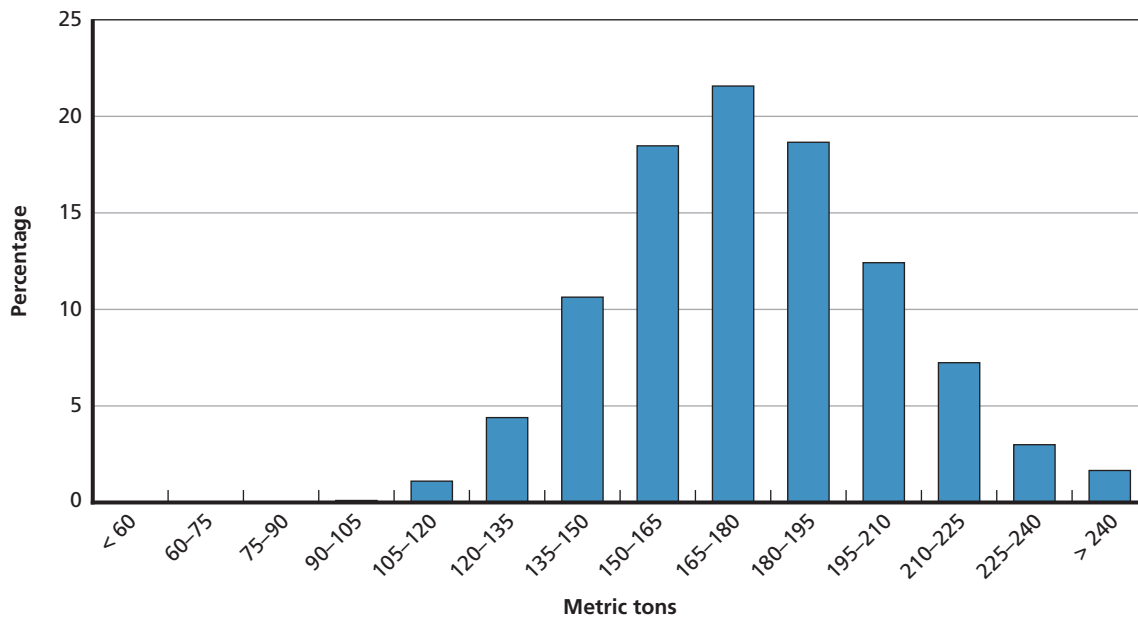
SOURCE: Authors' calculations.
RAND *RR466-2.6*

Distribution of Past-Month Marijuana Users and Amount Consumed Across Counties

Introduction

Knowing the range of total consumers in a state and the amount they consume is important for making decisions about how much production to allow and projecting tax revenue. However, understanding how these users are distributed throughout the state can be useful for making local decisions (e.g., how many retail stores to license). This chapter presents multiple approaches for estimating these values across Washington's 39 counties.

Our estimates are rooted in NSDUH and augmented with data from several additional sources. Every three years, SAMHSA releases past-month marijuana prevalence estimates for more than 300 "sub-state regions" throughout the country. Figure 3.1 displays the six sub-state regions created for Washington state.[1] All represent multiple counties except Region 4, which only includes King county.

Multiplying a region's estimated prevalence by its population yields the number of past-month users in that region, but there remains the question of how these past-month users and their demand are distributed across counties. No ideal county-level measure of marijuana use—heavy or otherwise—exists for Washington. To distribute the number of marijuana users implied by our regional estimates to the state's counties, we employ data from several sources. Ideally, we would like to capture the heavy marijuana users well, as they account for a very large share of the total market.

The following section presents information about data sources; the subsequent sections offer approaches for using this information to generate county-level estimates.

Data

In addition to the regional-level NSDUH data, five series from three county-level datasets were considered: (1) total population and population between 15 and 34 years of age from the 2010 Census and the 2007 Washington state OFM population projections, (2) self-reported past-month marijuana use from the Washington HYS for 10th and 12th graders, and (3) the share of substance abuse treatment admissions for which marijuana was listed as primary or secondary substance recorded in the Washington State Division of Behavioral Health and Recovery SCOPE program.

---

[1] Starting in 2008, NSDUH consolidates estimates for the six regions referred to in this document into three larger regions, though it continues to report six separate estimates.

Figure 3.1
Washington's Six NSDUH Sub-State Regions

SOURCE: NSDUH (SAMHSA, n.d.).
NOTE: Starting in 2008, NSDUH consolidates estimates for the six regions referred to in this
document into three larger regions, though it continues to report six separate estimates.
RAND *RR466-3.1*

Past-Month Marijuana Users in Washington's Six NSDUH Regions

Four NSDUH sub-state prevalence estimates were produced between 2002 and 2010, indicating
varied but generally increasing use over the period (see Table 3.1). Each sub-state estimate is based
on three years of survey data in order to capture a large enough sample of respondents to reliably
estimate prevalence. Even so, the point estimates remain uncertain, with confidence intervals for
some regions in some periods spanning more than 50 percent of the size of the point estimate
itself. For example, the 6.49-percent point estimate for Region 1—based on the 2008–2010
surveys—has a 95-percent confidence interval running from 4.7 percent to 8.8 percent.

The combination of a general upward trend with the uncertainty around the point esti-
mates presents a challenge for making an estimate of the current market. One could generate
regional estimates by pooling point estimates for each region across all years, as the confidence
intervals over time overlap. Such an approach, however, would ignore what appears to be an
upward trend in marijuana use by giving older data equal weight with newer data.

We might instead use a weighted moving average—e.g., assigning weights of 0.1, 0.2,
0.3, and 0.4 to the four surveys to consider all the data but emphasize the most recent survey.
However, inasmuch as there seems to be an overall upward trend, even that weighted average
may tend to underestimate current prevalence.

We chose to employ a third method to project the current and future prevalence from
the past data. We passed a linear regression line through the four data points for each region

Table 3.1
**Past Month Marijuana Prevalence (and 95-Percent Confidence Intervals) for Those
12 Years and Older in Washington's Six NSDUH Regions**

Region	2002/2004	2004/2006	2006/2008	2008/2010
Region 1	6.31 (4.72–8.40)	7.49 (5.59–9.97)	7.09 (5.32–9.39)	6.49 (4.74–8.83)
Region 2	5.66 (4.06–7.84)	5.78 (4.26–7.81)	6.36 (4.62–8.69)	6.80 (4.77–9.60)
Region 3	6.69 (5.18–8.61)	7.28 (5.43–9.68)	7.13 (5.29–9.54)	10.50 (8.04–13.62)
Region 4	7.30 (5.74–9.24)	8.76 (6.92–11.02)	8.34 (6.36–10.86)	8.87 (7.01–11.18)
Region 5	6.84 (5.23–8.90)	5.88 (4.34–7.93)	6.62 (4.94–8.82)	8.74 (6.70–11.32)
Region 6	6.18 (4.61–8.23)	7.46 (5.63–9.83)	7.62 (5.85–9.87)	8.80 (6.78–11.35)

and extrapolated it two steps forward, as a sort of forecast of what we might expect SAMHSA to report based on the 2012–2014 NSDUHs.[2] These regression-based forecasts do not seem wholly unreasonable, although they perhaps overstate future prevalence for Regions 3 and 6 by rigidly extrapolating their recent sharp increases (see Figure 3.2).

Figure 3.2
Estimated Prevalence by Region Over Time, Linearly Extrapolated with Region-Specific Slopes
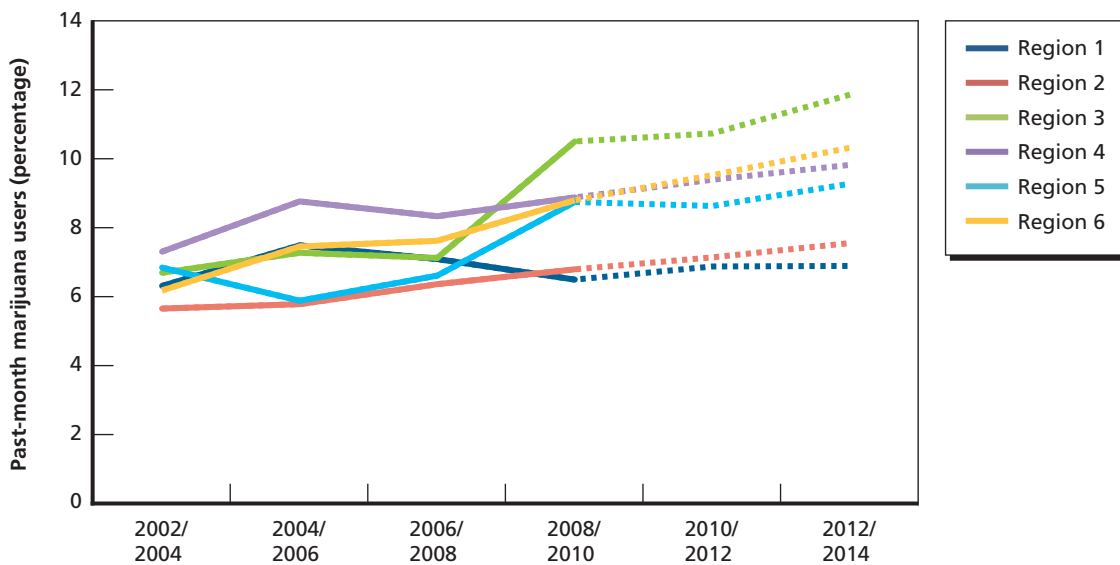
SOURCE: Authors' calculations.

RAND *RR466-3.2*

---

[2] The simple linear regression used only a linear time trend as a predictor. This process fits a line minimizing prediction error through the known data points and extends it out through our forecast period.

County Total and 15–34-Year-Old Populations

Naturally, the number of marijuana users in a county is determined in large part by how many people reside in that county. So, we could simply distribute a region's demand in proportion to the population of each of its counties. That is equivalent to assuming that prevalence of use is the same in each county within the region. Since we have no information at all concerning county-level prevalence there is nothing to directly contradict that assumption.

However, there are reasons to suspect that demand might not be so uniformly distributed. For example, Stevens and Whitman are two counties in Region 1 with very nearly the same total population (43,531 and 44,776, respectively), but entirely different age structures. The median age in Stevens County (45 years old) is much higher than in Whitman County (24.4 years old), presumably because Washington State University is in Pullman. So it would seem somewhat naïve to presume that marijuana demand in Stevens County matches that in Whitman County. It might make more sense to focus not on total population but rather on the number of 15–34 year-olds, of which Whitman County has almost three times as many as Stevens County (23,411 versus 8,587). As prevalence rates among young adults are higher than those for any other age group (see Table 3.2), we also consider the concentration of people in the 15–34 age demographic within a county relative to its NSDUH region.[3]

Washington State Healthy Youth Survey of 10th and 12th Graders

Another source of data is the Washington HYS. This data set includes information on prevalence of substance use among Washington 6th, 8th, 10th, and 12th graders, as well as a count of enrolled students, available at the county level (via askhys.net) for every biannual survey between 2004 and 2012. Since the minimum age for leaving high school is 16 years old and this may bias rates for high-school seniors, we focus on substance use among 10th grade students. In doing this, we trade better coverage of youth users (10th grade students) for a two-

Table 3.2
Past-Month Marijuana Prevalence (Percentage) in Washington, by Age Group from NSDUH

	18–25	26+	Overall (12+)
2002/2003	21.22	4.82	7.41
2003/2004	17.28	4.25	6.36
2004/2005	18.11	5.12	7.01
2005/2006	20.05	6.32	8.25
2006/2007	19.03	5.55	7.44
2007/2008	17.32	5.83	7.39
2008/2009	17.18	5.57	7.23
2009/2010	22.74	6.69	8.86
2010/2011	25.56	7.32	9.88

---

[3] We base our estimates of county-level 15–34 year olds on 2007 Washington State OFM population "Medium" projections (OFM, 2012b). NSDUH does not report estimates for 15–34 year olds.

year-older, less complete survey of students approximately 18 years old (12th grade students). Reported prevalence among 12th graders is marginally higher than among tenth graders.

To generate a user series from the HYS data, we first multiply county-level reported past-month use by the number of enrolled 10th graders in the county to get an estimate of 10th grade marijuana users in the county (see Figures 3.3 and 3.4). None of the regions show an increase in 10th grade past-month prevalence from 2010–2012. Comparable HYS data for 12th grade students shows a very slight (2010: 26.3 percent; 2012: 26.7 percent), but not statistically significant, increase over the period.[4]

Washington State Treatment Admissions from SCOPE-WA

At the time of this analysis, Washington's SCOPE-WA treatment database provided county-level data through May 2013 on the number of people admitted to treatment who listed marijuana as the primary substance of abuse, and also the corresponding counts for those listing marijuana as the secondary substance of abuse. These series may act as proxies for heavy use, as most people admitted for substance abuse treatment for marijuana are heavy users.

There is significant geographic variation in reported marijuana-related treatment admissions that may not be tied directly to use, but rather to counties' treatment facility availability, funding, or social and attitudinal factors we cannot effectively measure (see Table 3.3). For example, the Puget Sound area (Regions 3–5) has substantially lower rates of treatment per capita (107–150 admissions with marijuana as the primary substance of abuse per 10,000 people) than does the rest of the state (201–280 such admissions per 10,000). However, variation across regions is not problematic to our model, since these data are only used to allocate users across counties within a region.

Figure 3.3
Estimate of 10th Graders Reporting Past-Month Marijuana Use from HYS
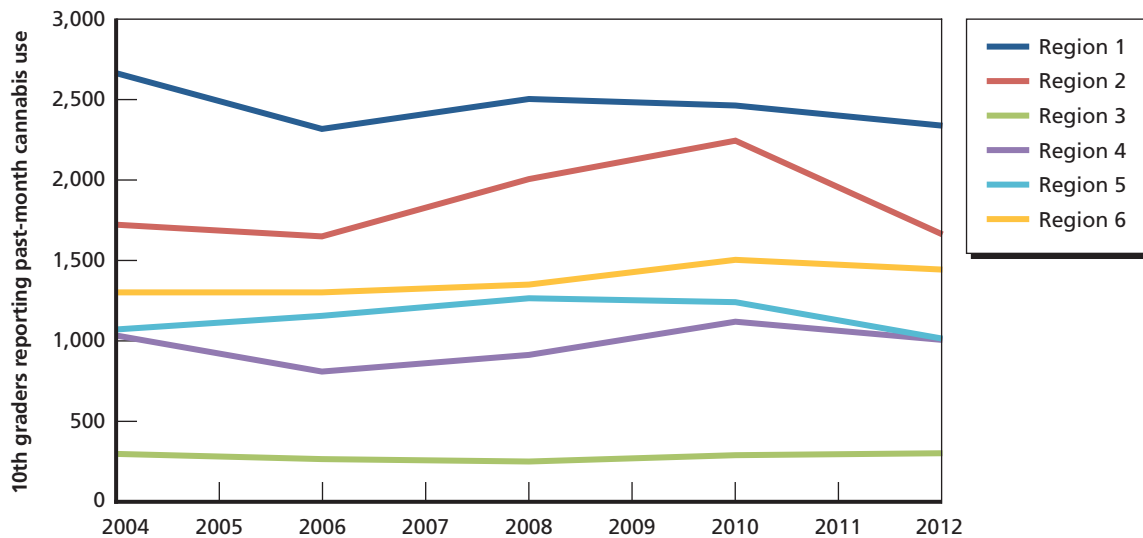
SOURCE: Authors' calculations based on the Washington State Healthy Youth Survey (Washington State Department of Health, 2003–2013).
RAND *RR466-3.3*

---

[4] See Chapter Two for an in-depth discussion of trends in prevalence since 2010/2011.

Figure 3.4
Average Prevalence of Past-Month Marijuana Use Among 10th Graders in HYS (2010–2012)
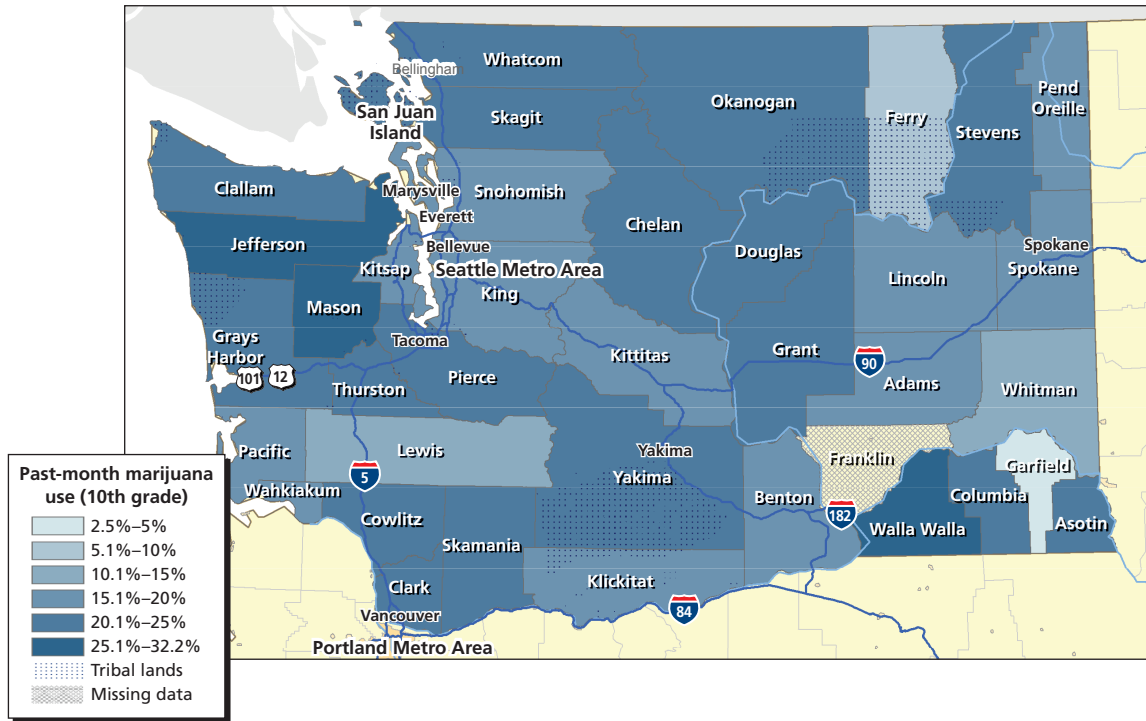
SOURCE: Authors' calculations based on the Washington State Healthy Youth Survey (Washington State Department of Health, 2003–2013).
NOTE: Estimates for 2010 and 2012 were combined to account for missing values due to low response rates for four counties in the 2012 survey. Prevalence estimates from the 2010 and 2012 surveys were averaged when county values were reported for both years. Franklin County has no reported value for either year of the survey; the average of all years of HYS data for Franklin County is 16.7 percent.
RAND *RR466-3.4*

Methodology

This analysis seeks to estimate how many marijuana users and how much marijuana each county contributes to the state total. To develop our estimates, we follow the following steps:

Step 1: State estimate of total number of past-month users and the size of the marijuana market measured in metric tons in 2013.

This section is based on estimates that are not adjusted for survey undercounting/misreporting (556,000 × 1.1 = ~610,000 past-month users; 130 × 1.1 = ~145 MT). Thus, all of these estimates should be considered low by the same amount, but that does not affect the relative numbers in any county, which is the focus here. Those who have a preferred adjustment factor can simply multiply these estimates by that factor to generate their value of interest.

Step 2: Divide past-month marijuana users across the six NSDUH regions.

We calculate the counts of users based on each series at the region level for a time period.

$$(1) \text{ Region total number of past-month users}_i =$$

$$Prevalence_i \times Population\ 12\ and\ over_i$$

Table 3.3
Marijuana-Related Treatment Admissions Rate per 10,000 Residents Aged 15–34 (2012)

County	Treatment Admission Rate	County	Treatment Admission Rate
Region 1		Region 3	
Adams	37.0	Island	53.4
Chelan	151.1	San Juan	155.1
Douglas	142.0	Skagit	227.2
Ferry	112.7	Snohomish	81.9
Grant	53.2	Whatcom	109.7
Lincoln	144.7	Region 4	
Okanogan	194.5	King	55.0
Pend Oreille	133.4	Region 5	
Spokane	115.1	Kitsap	96.7
Stevens	121.1	Pierce	67.7
Whitman	12.0	Region 6	
Region 2		Clallam	340.8
Asotin	150.1	Clark	98.9
Benton	98.7	Cowlitz	178.8
Columbia	244.6	Grays Harbor	201.8
Franklin	86.0	Jefferson	165.4
Garfield	48.0	Lewis	132.6
Kittitas	55.6	Mason	172.1
Klickitat	149.2	Pacific	301.6
Walla Walla	109.0	Skamania	143.0
Yakima	162.8	Thurston	92.4
		Wahkiakum	304.0

where each region, i, of the six in Washington has a specific NSDUH prevalence estimate and population. As these estimates are constructed from NSDUH data, their sum is identical to our state total past-month user estimate.

Step 3: Allocate users to each county.

The regional estimates are apportioned to counties based on a weighted average of the counties' shares in the population, HYS, and treatment series.

The five series used are total population, population 15–34 years old, HYS 10th graders reporting past-month use, treatment admissions with marijuana as a primary substance, and treatment admissions with a marijuana as a secondary substance.

We investigate placing various weights on each of these series. (e.g., putting 100-percent weight on total population is equivalent to assuming prevalence is the same in every county.)

Multiplying those average proportions by the total number of past-month users in the region produces a county-specific estimate of the number of past-month users. Table 3.4 walks through the calculation for the counties in Region 1 with the base-case weighting. As the shaded cells indicate, we assign equal weight to the four types of data, and split the 0.25 weight on treatment data to give slightly more weight (0.15) to the number of people listing marijuana as a primary substance of abuse versus those listing it as a secondary substance of abuse (0.10).

Table 3.5 presents estimates for each county's share of its region's and statewide marijuana prevalence, along with the resulting estimates for past-month users and metric tons of marijuana consumed in 2013. Table 3.6 shows the counties ordered by the size of their market.

Sensitivity to Weighting Assumptions

We set our factor weights above at 0.25 for population, 0.25 for proportion of region's 15–34 year olds, 0.15 for the primary treatment data, 0.1 for the secondary treatment data, and 0.25 for the HYS data. We do so simply to treat each indicator equally, since the weights assigned to the treatment data add up to 0.25.

Other weighting choices are possible, but varying the weights does not drastically change the final allocation of stores. Three different logical weight structures yield very similar estimated users (estimates for only eight counties change by more than 10 percent, and no county estimate changes by more than 20 percent). This implies that the choice of weights will have limited effect on the final allocation of resources among counties (see Table 3.7).

Table 3.4
Example of Past-Month User Calculation Using Data for Region 1

	Base Count for Each Measure				
County	Population	15–34 Year Olds	Primary Tx	Secondary Tx	HYS 10th Grade Avg # of Users
Adams	18,728	5,408	97	158	38
Chelan	72,453	17,869	1,923	2,278	192
Douglas	38,431	9,791	759	711	110
Ferry	7,551	1,597	228	484	11
Grant	89,120	24,983	1,059	1,602	258
Lincoln	10,570	1,935	133	190	25
Okanogan	41,120	8,997	886	1,732	101
Pend Oreille	13,001	2,323	231	481	31
Spokane	471,221	135,129	10,617	13,361	1,149
Stevens	43,531	8,587	804	1,211	55
Whitman	44,776	23,411	398	496	40
Region 1 total	850,502	240,030	17,135	22,704	2,011

	Share of Region 1 Total and Weighted Average Share of Region's Users				
	Population (%)	15–34 Year Olds (%)	Primary Tx (%)	Secondary Tx (%)	HYS 10th Grade Avg. No. of Users (%)	Weighted Average Share of Region's Users (%)
Weight	.25	.25	.15	.10	.25	
Adams	2.2	2.3	0.6	0.7	1.9	1.7
Chelan	8.5	7.4	11.2	10.0	9.6	9.1
Douglas	4.5	4.1	4.4	3.1	5.5	4.5
Ferry	0.9	0.7	1.3	2.1	0.5	0.9
Grant	10.5	10.4	6.2	7.1	12.8	10.1
Lincoln	1.2	0.8	0.8	0.8	1.2	1.0
Okanogan	4.8	3.7	5.2	7.6	5.0	4.9
Pend Oreille	1.5	1.0	1.3	2.1	1.5	1.4
Spokane	55.4	56.3	62.0	58.8	57.2	57.4
Stevens	5.1	3.6	4.7	5.3	2.8	4.1
Whitman	5.3	9.8	2.3	2.2	2.0	4.8
Region 1 total*	100	100	100	100	100	100

* Columns do not necessarily total exactly 100 due to rounding.

Table 3.5
County-Level Estimates of Past-Month Marijuana Users and Marijuana Consumption in 2013 (Unadjusted for Survey Undercounting/ Misreporting)

County	Share of Region (%)	Share of State (%)	Number of Past-Month Users	Metric Tons of Marijuana
Region 1				
Adams	1.7	0.2	970	0.2
Chelan	9.1	0.8	5,038	1.2
Douglas	4.5	0.4	2,499	0.6
Ferry	0.9	0.1	518	0.1
Grant	10.1	0.9	5,594	1.3
Lincoln	1.0	0.1	565	0.1
Okanogan	4.9	0.5	2,747	0.7
Pend Oreille	1.4	0.1	792	0.2
Spokane	57.4	5.2	31,896	7.6
Stevens	4.1	0.4	2,278	0.5
Whitman	4.8	0.4	2,676	0.6
Region 2				
Asotin	3.2	0.2	1,479	0.4
Benton	24.8	1.9	11,434	2.7
Columbia	0.6	0.0	290	0.1
Franklin	10.9	0.8	5,040	1.2
Garfield	0.2	0.0	105	0.0
Kittitas	5.8	0.4	2,698	0.6
Klickitat	2.9	0.2	1,333	0.3
Walla Walla	8.8	0.7	4,045	1.0
Yakima	42.7	3.2	19,701	4.7
Region 3				
Island	6.1	1.3	7,747	1.8
San Juan	1.4	0.3	1,806	0.4
Skagit	13.9	2.9	17,615	4.2
Snohomish	56.5	11.7	71,481	17.0
Whatcom	22.0	4.6	27,759	6.6
Region 4				
King	100.0	29.5	179,734	42.7
Region 5				
Kitsap	26.6	4.0	24,482	5.8
Pierce	73.4	11.1	67,494	16.0
Region 6				
Clallam	7.3	1.3	8,018	1.9
Clark	35.5	6.4	39,139	9.3
Cowlitz	9.8	1.8	10,754	2.6
Grays Harbor	7.4	1.3	8,165	1.9
Jefferson	2.5	0.5	2,789	0.7
Lewis	6.5	1.2	7,174	1.7
Mason	5.4	1.0	5,982	1.4
Pacific	2.0	0.4	2,225	0.5
Skamania	1.0	0.2	1,106	0.3
Thurston	22.2	4.0	24,462	5.8
Wahkiakum	0.3	0.1	369	0.1
State total		100	610,000	145

NOTE: State totals do not add exactly due to rounding.

Table 3.6
County-Level Estimates of Past-Month Marijuana Users and Marijuana Consumption, by Rank in 2013 (Unadjusted for Survey Undercounting/ Misreporting)

Rank	County	Number of Past-Month Users	Metric Tons of Marijuana
1	King	179,734	42.72
2	Snohomish	71,481	16.99
3	Pierce	67,494	16.04
4	Clark	39,139	9.30
5	Spokane	31,896	7.58
6	Whatcom	27,759	6.60
7	Kitsap	24,482	5.82
8	Thurston	24,462	5.81
9	Yakima	19,701	4.68
10	Skagit	17,615	4.19
11	Benton	11,434	2.72
12	Cowlitz	10,754	2.56
13	Grays Harbor	8,165	1.94
14	Clallam	8,018	1.91
15	Island	7,747	1.84
16	Lewis	7,174	1.71
17	Mason	5,982	1.42
18	Grant	5,594	1.33
19	Franklin	5,040	1.20
20	Chelan	5,038	1.20
21	Walla Walla	4,045	0.96
22	Jefferson	2,789	0.66
23	Okanogan	2,747	0.65
24	Kittitas	2,698	0.64
25	Whitman	2,676	0.64
26	Douglas	2,499	0.59
27	Stevens	2,278	0.54
28	Pacific	2,225	0.53
29	San Juan	1,806	0.43
30	Asotin	1,479	0.35
31	Klickitat	1,333	0.32
32	Skamania	1,106	0.26
33	Adams	970	0.23
34	Pend Oreille	792	0.19
35	Lincoln	565	0.13
36	Ferry	518	0.12
37	Wahkiakum	369	0.09
38	Columbia	290	0.07
39	Garfield	105	0.02

Table 3.7
Sensitivity Analysis on Factor Weighting Assumptions (Unadjusted for Survey Undercounting/ Misreporting)

	Base weights		Alternative 1		Alternative 2		Alternative 3	
Population	.25		.10		.20		.20	
15–34 Olds	.25		.40		.30		.20	
Primary Tx	.15		.15		.25		.20	
Secondary Tx	.10		.05		.15		.20	
HYS 10th Graders	.25		.30		.10		.20	
County	**Users**	**Metric Tons**	**Users**	**Metric Tons**	**Users**	**Metric Tons**	**Users**	**Metric Tons**
Adams	970	0.2	1,008	0.2	863	0.2	848	0.2
Chelan	5,038	1.2	4,935	1.2	5,114	1.2	5,199	1.2
Douglas	2,499	0.6	2,527	0.6	2,363	0.6	2,405	0.6
Ferry	518	0.1	455	0.1	601	0.1	616	0.1
Grant	5,594	1.3	5,749	1.4	5,061	1.2	5,220	1.2
Lincoln	565	0.1	540	0.1	518	0.1	543	0.1
Okanogan	2,747	0.7	2,585	0.6	2,797	0.7	2,936	0.7
Pend Oreille	792	0.2	729	0.2	781	0.2	835	0.2
Spokane	31,896	7.6	31,923	7.6	32,235	7.7	32,196	7.7
Stevens	2,278	0.5	2,078	0.5	2,415	0.6	2,387	0.6
Whitman	2,676	0.6	3,045	0.7	2,826	0.7	2,390	0.6
Asotin	1,479	0.4	1,408	0.3	1,473	0.4	1,534	0.4
Benton	11,434	2.7	11,484	2.7	10,812	2.6	10,949	2.6
Columbia	290	0.1	264	0.1	298	0.1	318	0.1
Franklin	5,040	1.2	5,170	1.2	5,017	1.2	4,802	1.1
Garfield	105	0.0	89	0.0	120	0.0	112	0.0
Kittitas	2,698	0.6	2,822	0.7	2,752	0.7	2,587	0.6
Klickitat	1,333	0.3	1,251	0.3	1,346	0.3	1,381	0.3
Walla Walla	4,045	1.0	4,067	1.0	4,021	1.0	3,995	0.9
Yakima	19,701	4.7	19,569	4.7	20,285	4.8	20,446	4.9
Island	7,747	1.8	7,723	1.8	7,365	1.8	7,392	1.8
San Juan	1,806	0.4	1,697	0.4	1,773	0.4	1,887	0.4
Skagit	17,615	4.2	16,855	4.0	18,567	4.4	19,641	4.7
Snohomish	71,481	17.0	71,936	17.1	70,626	16.8	68,924	16.4
Whatcom	27,759	6.6	28,197	6.7	28,077	6.7	28,564	6.8

Table 3.7—Continued

	Base weights		Alternative 1		Alternative 2		Alternative 3	
Population	.25		.10		.20		.20	
15–34 Olds	.25		.40		.30		.20	
Primary Tx	.15		.15		.25		.20	
Secondary Tx	.10		.05		.15		.20	
HYS 10th Graders	.25		.30		.10		.20	
County	**Users**	**Metric Tons**	**Users**	**Metric Tons**	**Users**	**Metric Tons**	**Users**	**Metric Tons**
King	179,734	42.7	179,734	42.7	179,734	42.7	179,734	42.7
Kitsap	24,482	5.8	24,433	5.8	23,906	5.7	24,827	5.9
Pierce	67,494	16.0	67,542	16.1	68,070	16.2	67,149	16.0
Clallam	8,018	1.9	7,570	1.8	8,952	2.1	8,923	2.1
Clark	39,139	9.3	39,835	9.5	37,381	8.9	37,503	8.9
Cowlitz	10,754	2.6	10,625	2.5	10,857	2.6	11,074	2.6
Grays Harbor	8,165	1.9	8,063	1.9	8,597	2.0	8,592	2.0
Jefferson	2,789	0.7	2,615	0.6	2,782	0.7	2,903	0.7
Lewis	7,174	1.7	7,064	1.7	7,580	1.8	7,346	1.7
Mason	5,982	1.4	5,913	1.4	6,006	1.4	6,044	1.4
Pacific	2,225	0.5	2,090	0.5	2,315	0.6	2,418	0.6
Skamania	1,106	0.3	1,029	0.2	1,239	0.3	1,229	0.3
Thurston	24,462	5.8	25,050	6.0	24,066	5.7	23,736	5.6
Wahkiakum	369	0.1	329	0.1	409	0.1	414	0.1
State totals	610,000	145.0	610,000	145.0	610,000	145.0	610,000	145.0

NOTE: Some state totals do not add exactly due to rounding.

Characteristics of Washington's Marijuana Users and Their Methods of Obtaining Marijuana

Introduction

This chapter presents an exploratory descriptive analysis of marijuana users in Washington, with a focus on how users acquire marijuana. While Washington's biennial HYS describes characteristics of *students* who use marijuana, we are not aware of any attempts to describe the characteristics of all marijuana users in the state. Further, we are not aware of any research that has examined how users acquire marijuana in Washington.

The chapter compiles information about marijuana user and purchase characteristics in Washington.[1] The first section outlines the demographic and socioeconomic characteristics and includes some preliminary information about use of drugs other than marijuana. The second section describes the relationship between use of marijuana and other drugs, and how users typically acquired marijuana. This component draws from NSDUH and the Centers for Disease Control and Prevention Youth Risk Behavior Survey (YRBS) dataset. The third section includes information from the CCS.

Demographic and Socioeconomic Characteristics of Marijuana Users in Washington

This section examines some of the key demographic and socioeconomic characteristics recorded in NSDUH, including distributions of educational attainment, age, race and ethnicity, gender, income, and uptake of government-funded social assistance programs. As a baseline, we contrast these characteristics with users in the country as a whole, and also in the adjacent state of Oregon. Oregon was used as a comparison not only due to its proximity to Washington, but also because both states have liberal medical marijuana policies and both are among the ten states with the largest proportion of past-month users (Oregon ranks sixth, Washington ninth; see Table 4.1).

To learn about state-level characteristics of marijuana users we use the NSDUH R-DAS system which allows for two-way cross-tabulation of many variables (but does not allow for regression analysis of individual-level data). R-DAS internally weights respondents prior to providing output and can generate confidence intervals. Since there is a large amount of sampling

---

[1] NSDUH data were accessed using SAMHSA's R-DAS, selection filter: YRPRIND(8). For USA, no additional Selection Filter was used. Selection Filters State(53) and State(41) were used for Washington and Oregon, respectively. The R-DAS tool is available from SAMHSA, n.d.

Table 4.1
Past-Month Marijuana Use, Percentage of the Population, NSDUH 2010–2011

State	12 or Older Est.	12 or Older (95% CI lower)	12 or Older 95% CI (upper)	12–17 Est.	12–17 95% CI (lower)	12–17 95% CI (upper)	18–25 Est.	18–25 95% CI (lower)	18–25 95% CI (upper)	26 or Older Est.	26 or Older 95% CI (lower)	26 or Older 95% CI (upper)
USA	6.94	6.71	7.17	7.64	7.30	8.00	18.78	18.22	19.35	4.80	4.54	5.07
Oreg.	10.98	9.31	12.90	10.26	8.45	12.40	25.35	22.14	28.87	8.73	6.88	11.00
Wash.	9.88	8.44	11.55	9.59	7.86	11.65	25.56	22.40	29.00	7.32	5.77	9.25

variability at the state level, the vast majority of these differences do not meet conventional levels of statistical significance; thus, differences across groups should be interpreted with considerable caution. That said, these point estimates provide the best information available about the characteristics of marijuana users in particular states.

In this section we define "heavy users" to be those who report 21 or more days of use in the past month. We refer to those who use marijuana or other marijuana products at least once during the past month but on less than 21 days as "past-month users" and "occasional users" interchangeably, and those who used in the past year but not past month as "past-year users" or "infrequent users." Thus, the three groups are defined to be mutually exclusive; "past-year" means "past-year but not past-month," and "past-month" means "past-month but not heavy."

Educational Attainment of Marijuana Users

Compared to the nation, and to Oregon, Washington appears to have more marijuana users reporting "some college" education, with relatively fewer users of low education and of higher-level education (see Figure 4.1). This finding holds across heavy users, past-month users, and past-year users. These trends may reflect higher incidence of marijuana use among survey respondents in Washington with some college education, or instead relatively high reported college graduation rates outside of Washington. According to 2010 statistics compiled by the College Board, Washington and Oregon have very similar shares of people reporting some college but no degree, at rates relatively higher than the country as a whole (Lee & Rawls, 2010). This is suggestive evidence in support of the former notion, that respondents in Washington with some college education are more likely to use marijuana than similar respondents in Oregon, or in the balance of the nation.
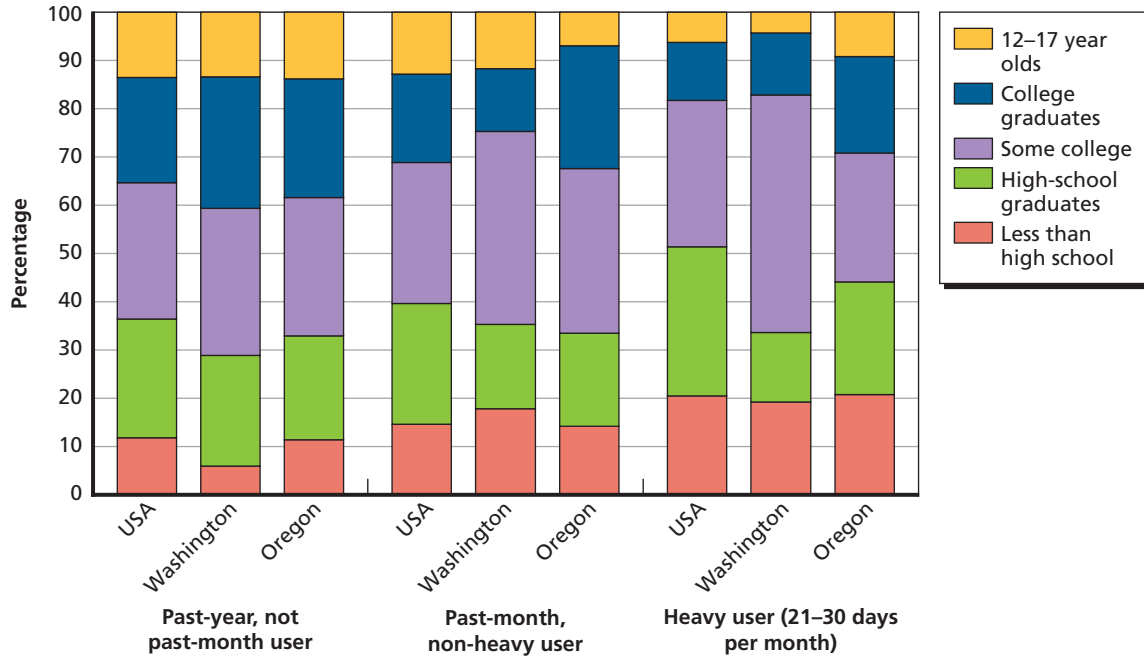
Age Distribution of Marijuana Users

Just over half of all infrequent users in the nation, as in Washington and Oregon, are over 25 years old. Nearly two-thirds of heavy users in Washington are over 25. This finding seems to be influenced by a larger proportion of heavy users being over 34 in Washington as compared to Oregon and the balance of the nation. While past-year users in Washington approximately match the national age distribution and past-month users in Washington are slightly older than the national average, they are slightly younger than in Oregon (see Figure 4.2).

Race and Ethnicity of Marijuana Users

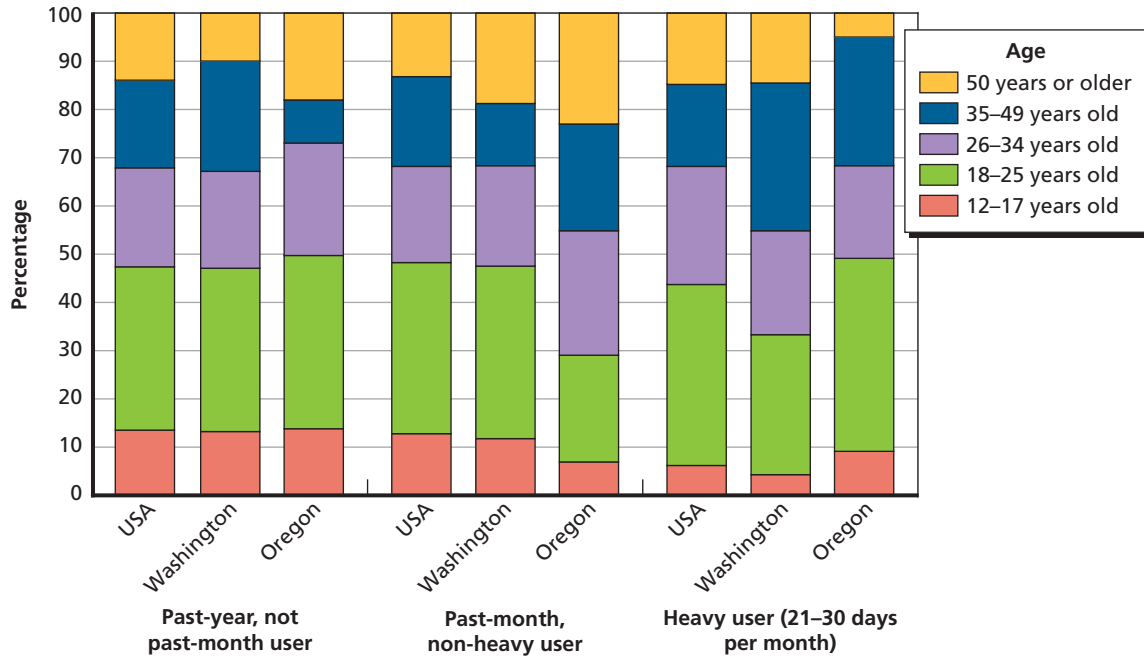In NSDUH, all markets are dominated by white non-Hispanic users. Approximately 65–70 percent of users in the nation, 70–80 percent in Washington, and 80–90 percent in Oregon

**Figure 4.1
Educational Attainment of Marijuana Users, NSDUH 2010/2011**

SOURCE: NSDUH (SAMHSA, n.d.).

RAND *RR466-4.1*

**Figure 4.2
Age Distribution of Marijuana Users, NSDUH 2010/2011**

SOURCE: NSDUH (SAMHSA, n.d.).

RAND *RR466-4.2*

reported being white non-Hispanic, and this was found to be basically constant across use categories. By comparison, 64 percent, 73 percent, and 79 percent of the current population identifies as white non-Hispanic in the nation, Washington, and Oregon, respectively. Figure 4.3 excludes white non-Hispanic respondents, allowing us to focus on variation among populations other than white non-Hispanics. By comparing the distribution of races and ethnicities at each use level to their overall distributions in Washington and the nation, we can see the relative differences in composition. Notably, black respondents make up a larger share of heavy users in both Washington and the nation, while a preponderance of Native Hawaiian/Pacific Islander respondents were seen among Washington's heavy and past-month users, but not nationally.

Figure 4.4 displays prevalence rates among the four largest race and ethnicity groups in Washington based on the categories offered in NSDUH: white non-Hispanic, black non-Hispanic, Asian non-Hispanic, and Hispanic. In general, non-Hispanic Asians show lower prevalence rates than other racial ethnic groups, with the exception of past-month users, where the non-Hispanic Asian prevalence rate matches or exceeds the rates of all groups except black non-Hispanic. Black non-Hispanic respondents show higher prevalence rates in both past-month and heavy use than other races or ethnicities. Overall, the rates of heavy use appear higher across each race and ethnicity in Washington than seen nationally.
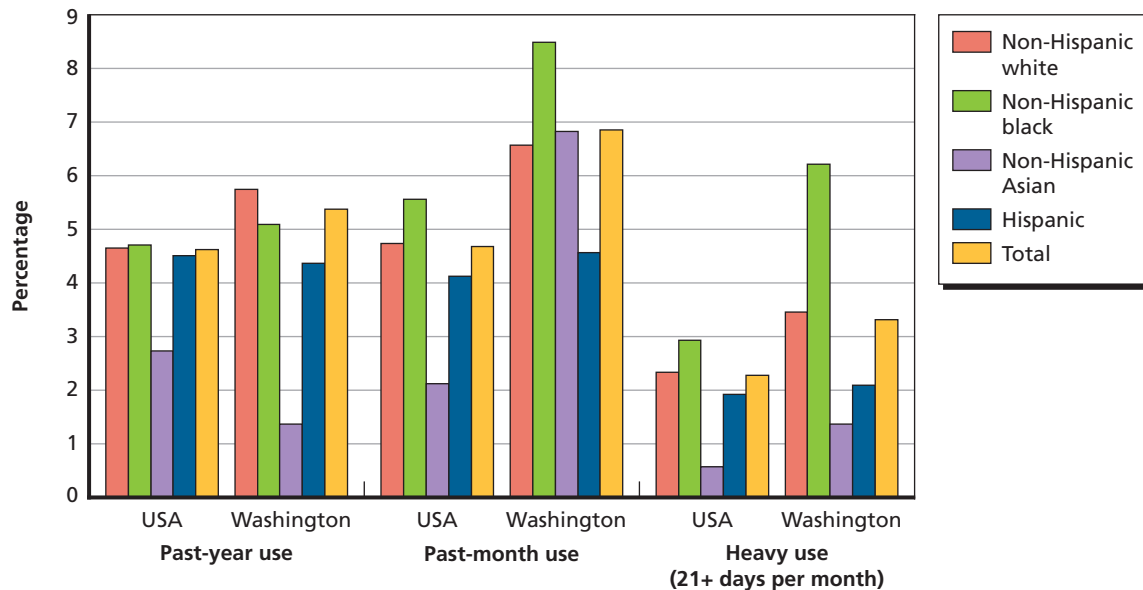
Figure 4.3
Race and Ethnicity (Excluding White Non-Hispanic) of Marijuana Users, NSDUH 2010/2011
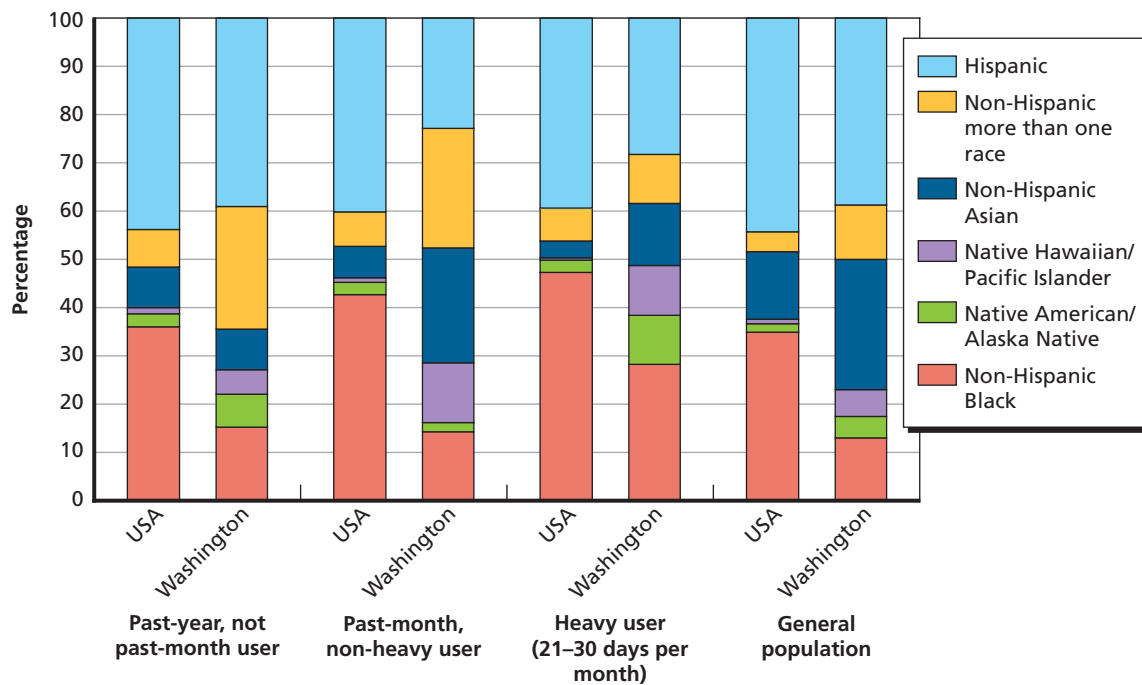
SOURCE: NSDUH (SAMHSA, n.d.).

RAND *RR466-4.3*

Figure 4.4
Prevalence Rates of Marijuana Users in the Four Largest Racial and Ethnic Groups, NSDUH 2010/2011

SOURCE: NSDUH (SAMHSA, n.d.).

RAND *RR466-4.4*

Gender Breakdown of Marijuana Users

Washington appears to have a market slightly less dominated by males than Oregon or the United States as a whole. Across all geographies, the male share of users increases with increasing use, from roughly 51–55 percent for past-year users to 60–75 percent for heavy users (see Figure 4.5).

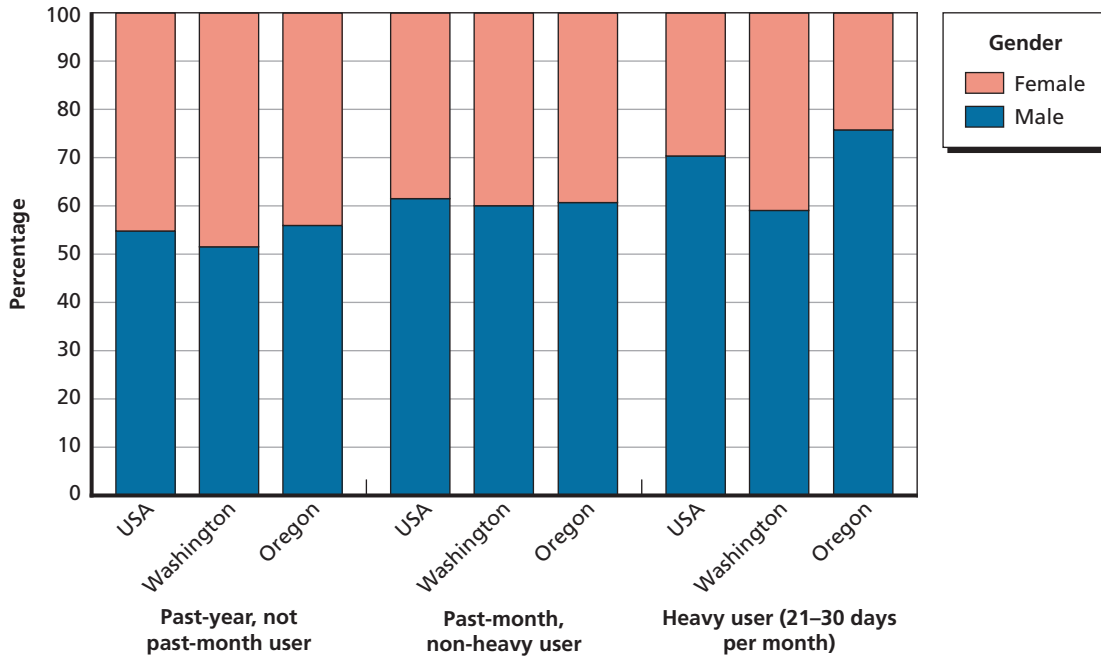## Income Level of Marijuana Users

For many intoxicants, including marijuana, total quantity demanded is dominated by lower income users (Caulkins et al., 2012). This trend is especially evident in Washington, particularly among heavy users, as those who report annual incomes below $20,000 make up over 40 percent of heavy users in the state, as opposed to 25 percent in neighboring Oregon. High-income earners in Washington make up a relatively large share of infrequent users in the state compared to Oregon and the nation (see Figure 4.6).

Past-Month Use of Illegal Drugs Other Than Marijuana

The overall rate of use of other illicit drugs generally increases with the frequency of marijuana use, as is seen in Figure 4.7.[2] The drugs considered here are hallucinogens, heroin, cocaine, inhalants, and nonmedical use of psychotherapeutics. The share of Washingtonians using an illegal drug other than marijuana in the past month is not very different from the nation as a whole among infrequent and occasional users; however, Washington's heavy marijuana users report a somewhat higher rate of other drug use than Oregon and the nation.
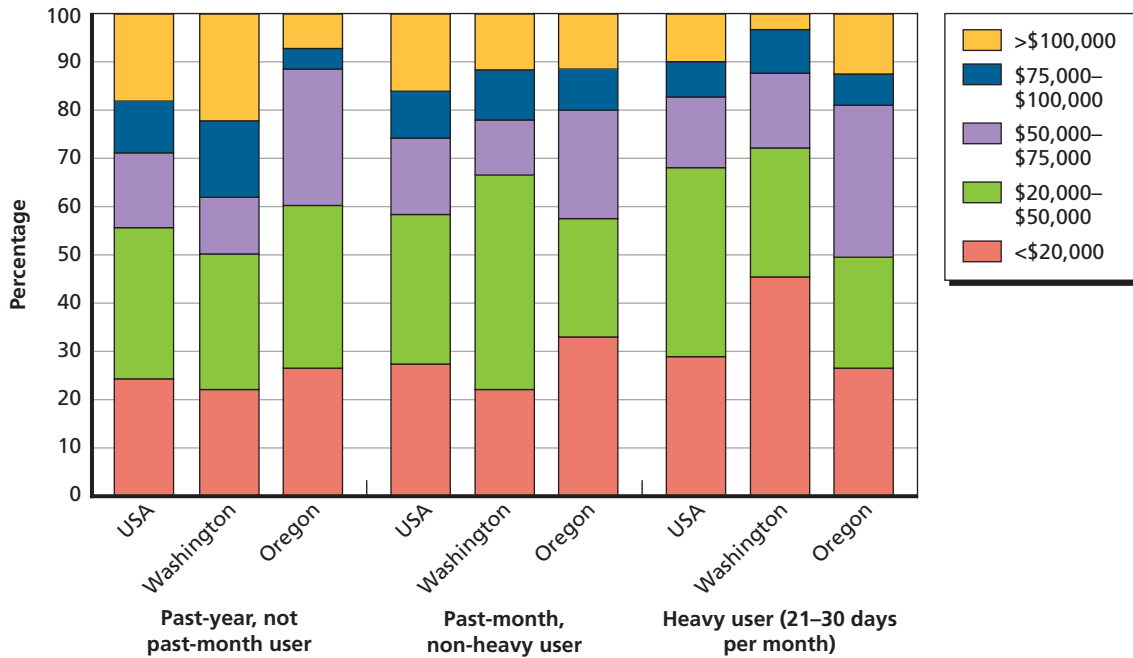
---

[2] Focusing on use days for each of the different substances and rates of polydrug use may be very beneficial for future research.

Figure 4.5
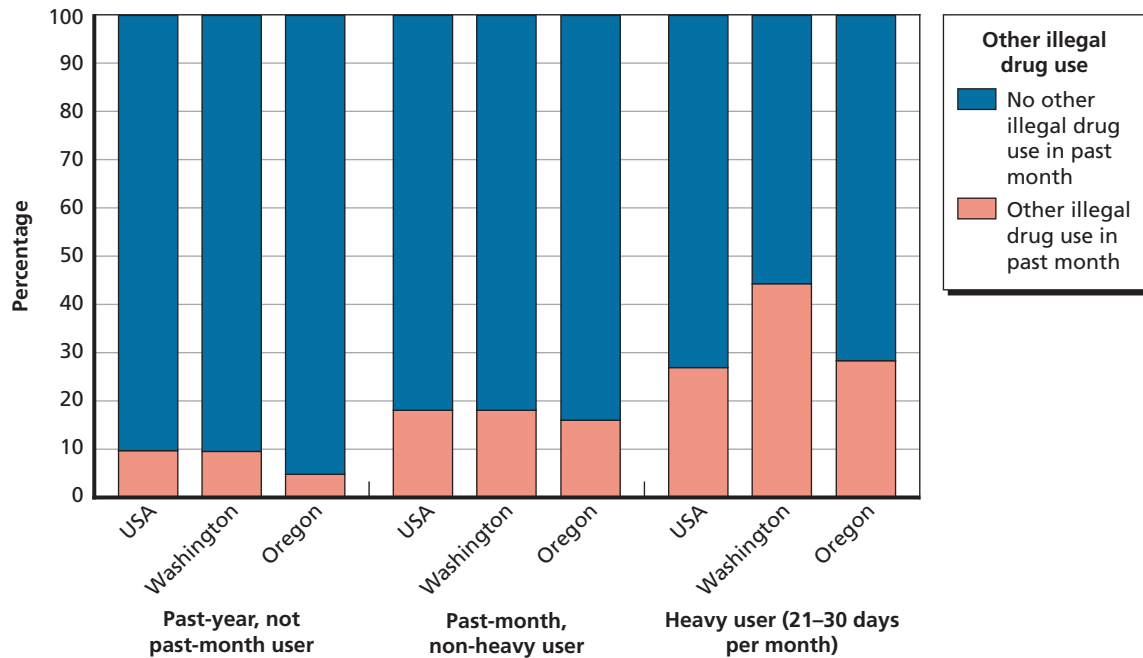**Gender of Marijuana Users, NSDUH 2010/2011**

SOURCE: NSDUH (SAMHSA, n.d.).

RAND *RR466-4.5*

Figure 4.6
Income Distribution of Marijuana Users, NSDUH 2010/2011

SOURCE: NSDUH (SAMHSA, n.d.).

RAND *RR466-4.6*

Figure 4.7
Past-Month Use of Illegal Drugs Other Than Marijuana, NSDUH 2010/2011

SOURCE: NSDUH (SAMHSA, n.d.).

RAND *RR466-4.7*

Past-Month Tobacco Use Among Marijuana Users

Washington's marijuana users appear to use tobacco (i.e., cigarettes, cigars, pipes, and smoke-less tobacco) at a rate about 5–10 percentage points lower than users nationwide. A strong positive correlation between tobacco use and frequency of marijuana use is evident in all three geographies. Among all marijuana users, Washington and Oregon are similar, though infrequent and occasional users in both states seem less likely to use tobacco than similar marijuana users nationwide (see Figure 4.8). While nearly 80 percent of heavy marijuana users reported tobacco use, the rate of tobacco use among the general population ranges between 25 percent and 28 percent in all three geographies.

Past-Month Alcohol Use Among Marijuana Users

Alcohol use is common among most people who claimed to use marijuana in the past year, and appears to increase with frequency of marijuana use. Washington's heavy and "binge" alcohol use rates appear to be similar to those of the nation as a whole, with the exception of heavy marijuana users in Washington, who show a higher rate of heavy alcohol use than the national rate.[3] Heavy drinking appears to be more prevalent among Washington marijuana users than Oregon marijuana users, regardless of frequency of use (see Figure 4.9).[4]

---

[3] Binge use is defined as having five or more drinks in one sitting at least one time in the past month. Heavy use involves "bingeing" five or more times in the past month.

[4] The variations for this and other variables may be affected by sampling variation, as noted previously. The 95-percent confidence intervals for Washington data range from 17.7 to 36.5 percentage points. Oregon shows similar uncertainty.

Figure 4.8
Past-Month Tobacco Use Among Marijuana Users, NSDUH 2010/2011
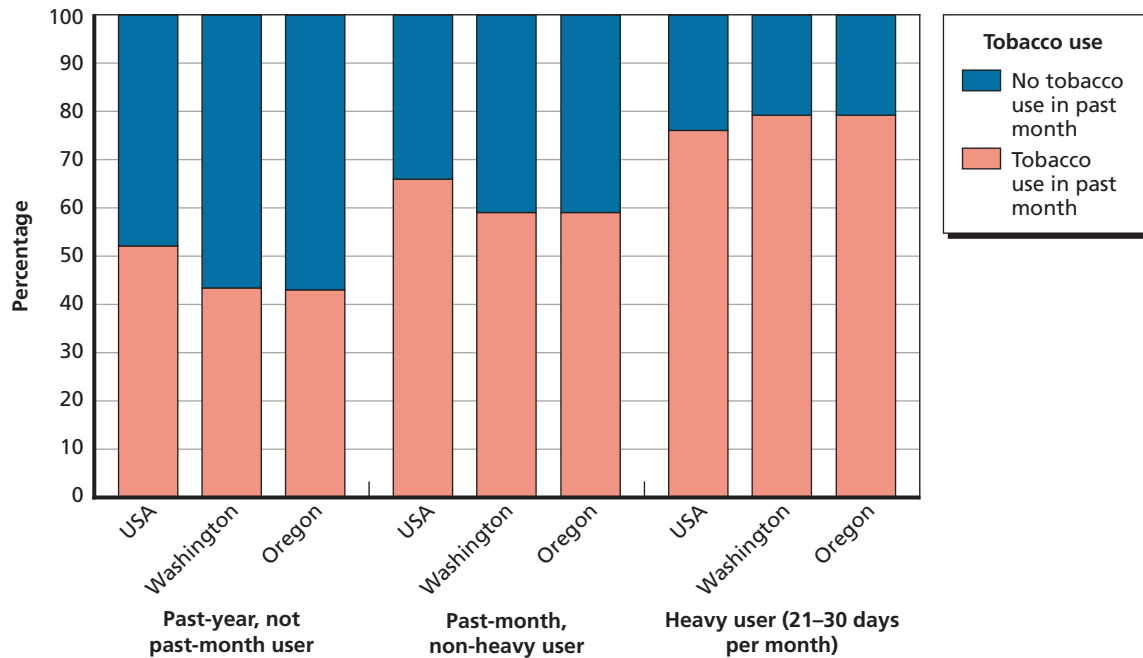
SOURCE: NSDUH (SAMHSA, n.d.).
NOTE: Tobacco use here includes past-month use of cigarettes, cigars, pipes, and smokeless tobacco (NSDUH variable TOBMON).
RAND *RR466-4.8*

Obtaining Marijuana in Washington

This section summarizes the small but growing knowledge base about how users obtain marijuana in Washington. We are optimistic that much more will be learned about these transactions in coming years. First, our CCS includes a number of questions about sources and purchasing patterns (see Appendix A). Second, the 2013 NSDUH added questions about medical marijuana.[5] Third, it is now possible for researchers to analyze the individual-level NSDUH data with state-level identifiers. This should improve our understanding of how marijuana is acquired and sold in Washington and other states.

Insights from NSDUH

Since 2002, NSDUH has asked questions regarding acquisition of marijuana. In this section, we examine these characteristics for respondents in Washington.

How Respondent Last Obtained Marijuana

Among respondents who reported marijuana use, the dominant acquisition methods were buying and receiving for free/sharing. Washington marijuana users report purchases nearly 50 percent of the time, a slightly higher rate than the rest of the nation and a greater rate than

---

[5] Namely, two questions: **MJMM01** Earlier, you reported using marijuana in the past year. Was any of your marijuana use in the past 12 months recommended by a doctor? **MJMM02** Was all of your marijuana use in the past 12 months recommended by a doctor? (Research Triangle Institute, 2012)

Figure 4.9
Past-Month Alcohol Use Among Marijuana Users, NSDUH 2010/2011
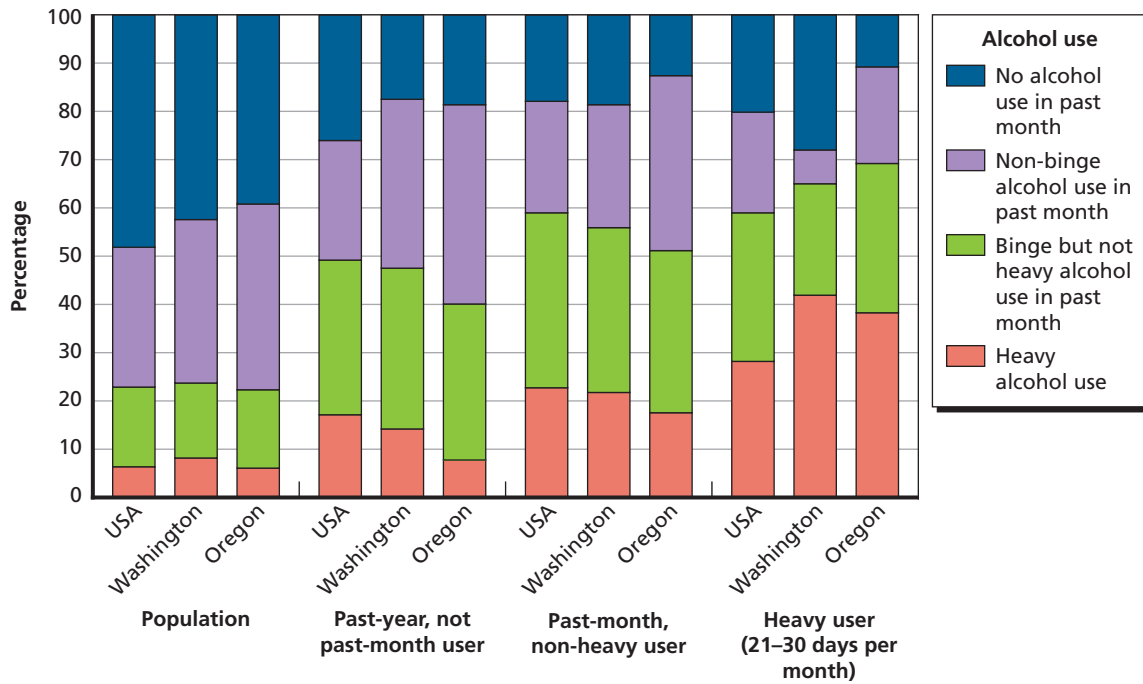
SOURCE: NSDUH (SAMHSA, n.d.).
NOTE: Binge drinking is defined as having five or more drinks in one sitting. Heavy alcohol use is defined as binge drinking five or more times in the past month.
RAND *RR466-4.9*

Oregon's users (see Figure 4.10). However, the 95-percent confidence intervals for state-level statistics are overlapping, so the different numbers may be a mere sampling artifact rather than reflecting actual state-to-state differences.

We also looked at how acquisition methods varied among past-month heavy and non-heavy users (Figure 4.11). Due to small counts for other categories, we include only the two largest categories for Washington, Oregon, and the nation: bought it and got it for free/shared. Results below suggest that, while past-month users bought marijuana at a similar rate to the same group nationwide, a slightly greater proportion of Washington's heavy users bought marijuana than the rest of the nation.

Source of Purchased Marijuana

NSDUH respondents identified three major sources of purchased marijuana: friends, relatives or family members, and strangers. (There was no response choice for dispensaries or access points, and it is unclear whether users who bought there would choose "someone just met/did not know," "friend," or "unspecified.") Friends are the dominant sources in all three jurisdictions, with strangers being the second most common source. The three sources' 95-percent confidence intervals overlap for Washington and Oregon for all methods except "source unspecified," which was more commonly reported in Oregon than in Washington (see Figure 4.12).

Figure 4.10
How Users Acquired Marijuana, NSDUH 2010/2011
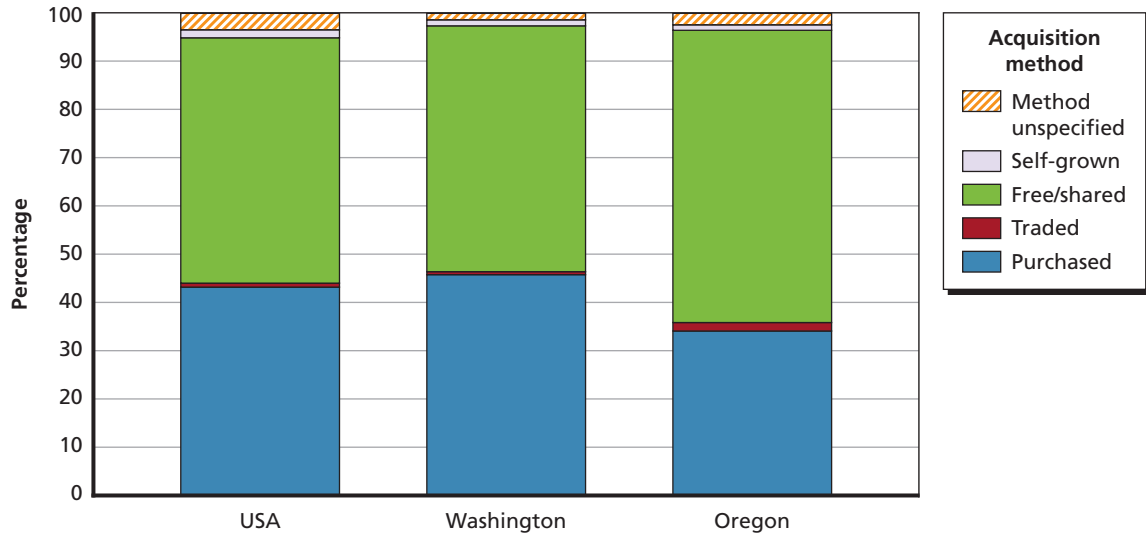
SOURCE: NSDUH (SAMHSA, n.d.).
RAND *RR466-4.10*

Figure 4.11
How Past-Month Users Acquired Marijuana, NSDUH 2010/2011
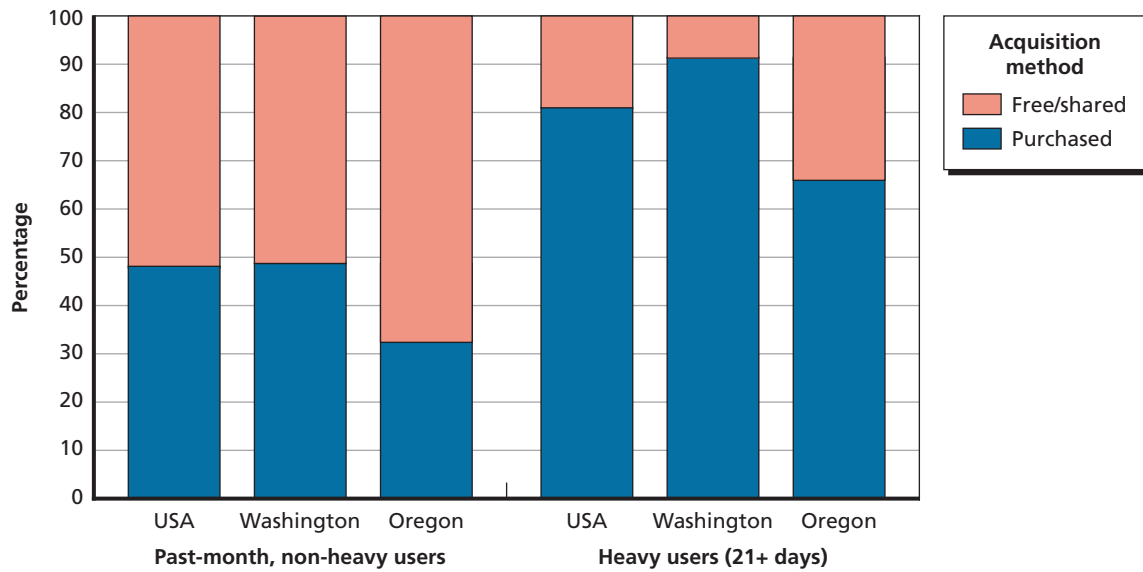
SOURCE: NSDUH (SAMHSA, n.d.).
RAND *RR466-4.11*

Source of Free Marijuana

Friends are also the most common source of free marijuana in all three jurisdictions, and particularly in Washington (see Figure 4.13).

**Figure 4.12
Source of Purchased Marijuana, NSDUH 2010/2011**
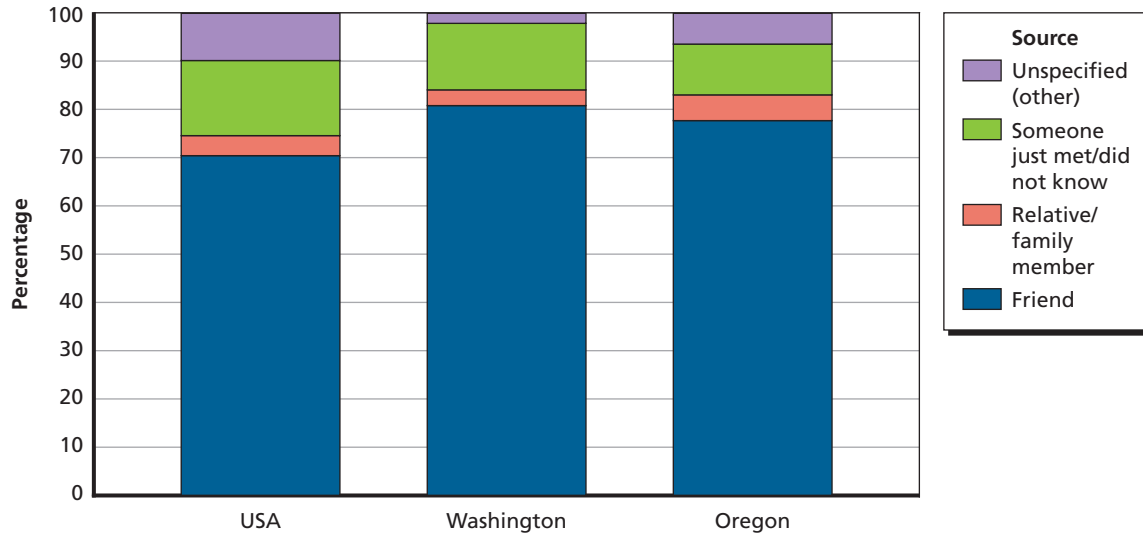
SOURCE: NSDUH (SAMHSA, n.d.).

RAND *RR466-4.12*

**Figure 4.13
Source of Free Marijuana, NSDUH 2010/2011**
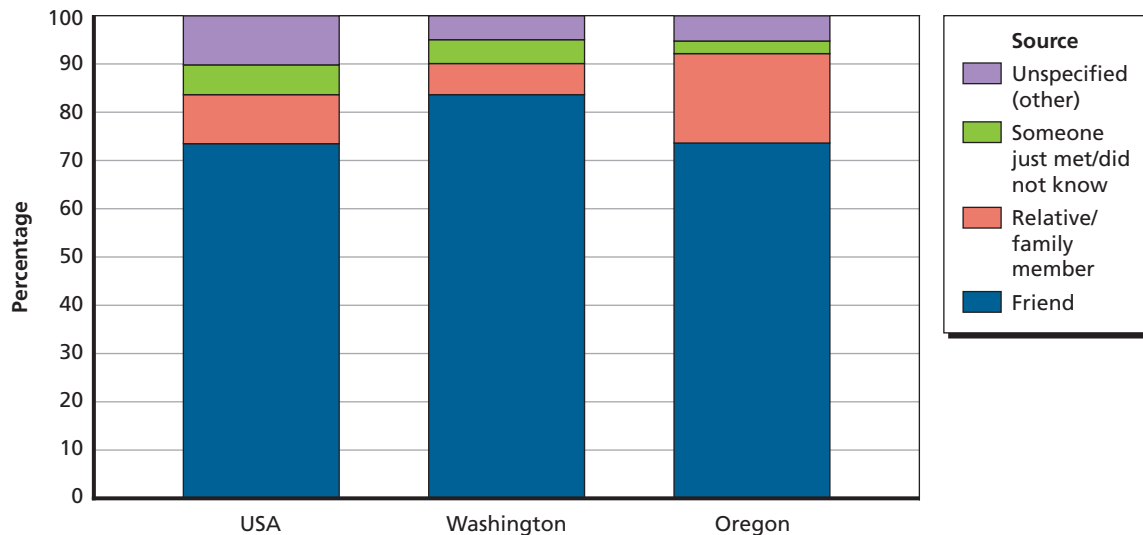
SOURCE: NSDUH (SAMHSA, n.d.).

RAND *RR466-4.13*

Insights from Seattle's Youth Risk Behavior Survey

The YRBS is a national classroom-based survey sponsored by the Centers for Disease Control and Prevention.[6] The survey is administered to a sample of 9th–12th grade classrooms in Seat-

---

[6] From the Seattle Public Schools (n.d.):

> The Youth Risk Behavior Survey (YRBS) is a national survey that is administered to a sample of 9th to 12th grade classrooms throughout our 10 comprehensive high schools. The YRBS focuses on priority health risk behaviors established

tle's ten comprehensive high schools. Local jurisdictions can add questions and Seattle's 2012 survey included some questions about how marijuana was obtained.

Figure 4.14 presents the responses from the question: "During the past 30 days, how did you usually get the marijuana you used?" Again, the vast majority reported obtaining marijuana from a friend. The next-largest response was "Some other way" (21 percent). Only 6 percent of the past-month users reported usually obtaining the marijuana they used from a dispensary. However, since the retail facilities that sell marijuana products to those with a medical recommendation are often referred to as "access points" in Washington instead of dispensaries, this figure could be an underestimate. It also does not reflect those who received it from friends making dispensary purchases.

The Seattle YRBS included an additional question about dispensaries, asking respondents: "During the past month, did you use marijuana that came from a medical marijuana dispensary?" Those responding "Yes" include those who directly purchased from a dispensary as well as those who consumed marijuana that someone else obtained from a dispensary. Unlike the previous question, this question did not include the word "usually." Thus, one cannot use this question to estimate the amount of marijuana consumption by high-school students that is supplied by dispensaries.

The responses were 38 percent "Yes," 39 percent "No," and 23 percent "Not Sure." It is perhaps not surprising that such a large number of marijuana users in Seattle's public high schools report consuming marijuana that came from a dispensary; there are a lot of dispensa-

Figure 4.14
"During the past 30 days, how did you usually get the marijuana you used?"
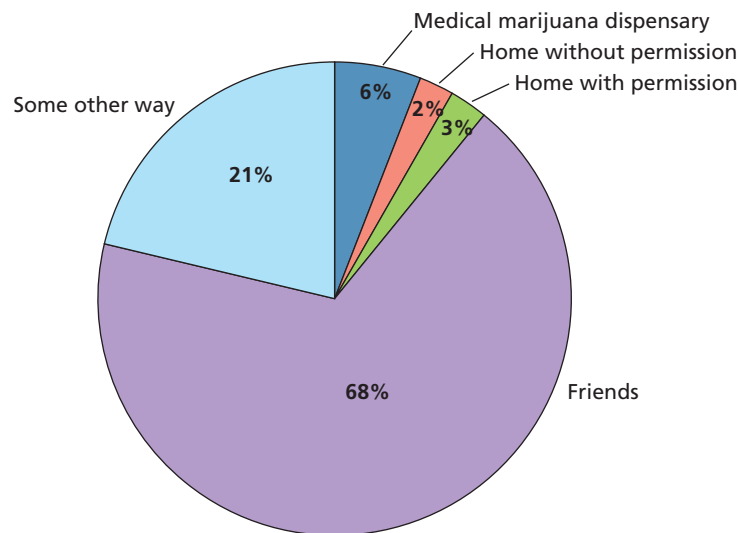
SOURCE: Weighted data from Seattle's 2012 YRBS (Seattle Public Schools, 2012).
RAND *RR466-4.14*

during youth that result in the most significant mortality and morbidity during both youth and adulthood. These include: behaviors that result in unintentional injuries and violence; tobacco use; alcohol and other drug use; sexual behaviors that contribute to HIV infection; other sexually transmitted diseases; unhealthy dietary behaviors; and physical inactivity.

ries in the Seattle Metro Area. One newspaper article reported that in September 2012 there were more dispensaries (145) than Starbucks (139) in Seattle (Martin, 2012).

Insights from the Cannabis Consumption Survey

The web survey asked respondents where they obtained their most recent, second-most recent, and third-most recent purchases, with possible answers including friend/family member, dealer, three different medical options ("Dispensary or access point," "Designated caregiver," and "Medical cannabis delivery service"), and other.[7] As Figure 4.15 shows, respondents in Washington were more likely to buy from a medical provider and less likely to buy from a dealer as compared to respondents who lived outside of Washington.

Our user survey also asked various questions about *how* regular users consume their marijuana. Nearly 98 percent of past-month users in the CCS report consuming cannabis in conventional bud form in the past year, and nearly 95 percent in the past week. Many cannabis users in Washington report also consuming forms other than loose marijuana, and such substances are relatively more common among frequent users (see Table 4.2). The most common form reported in the CCS was edibles, with 78 percent of all respondents and 88 percent of daily/near-daily users reporting past-year use. However, past-week consumption of edibles was reported less than a third as often, suggesting that edibles are common, but perhaps infrequently consumed. Many cannabis users have edibles once in a while, but few have them often.

Unlike edibles, kif, cannabis-infused beverages, hash oil, and hash resin are much more rarely used by infrequent cannabis users than those who use near-daily. For example, the rate of past-year beverage use is more than five times greater among near-daily users (29 percent) than among those using one to three times in the past month (5 perent). Dabbing, a particular

Figure 4.15
Source of the Most, Second-Most, and Third-Most Recent Cannabis Purchases
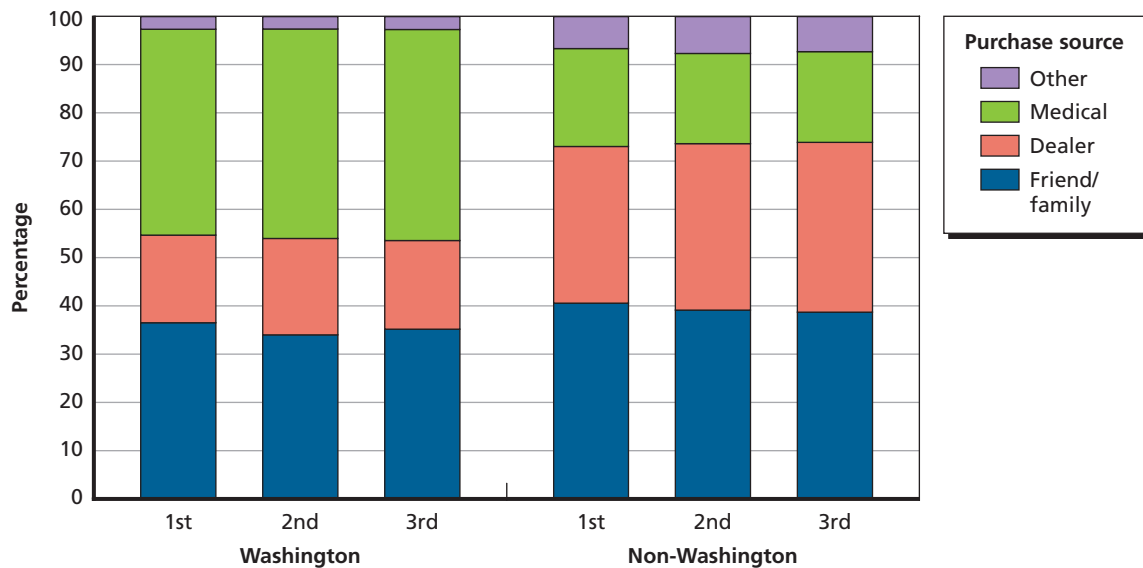
SOURCE: CCS.

RAND *RR466-4.15*

---

[7] Dispensary/medical access point was by far the most common of the three medical options.

Table 4.2
Rates of Reported Use of Cannabis, by Type of Product (Percentage)

	Past-Month Use Days				
	1–3	4–10	11–20	21–30	Total
Used Substance in Past Year					
Bud	96.6	95.2	98.4	98.8	98.0
Hash resin	21.6	28.5	41.8	63.9	50.9
Hash oil	18.2	29.7	38.5	58.2	46.8
Edibles	60.2	72.3	79.9	81.8	77.8
Beverages	5.1	15.7	16.8	28.9	22.6
Lotion	7.4	12.9	19.7	30.0	23.5
Kif	11.4	22.5	24.4	58.7	44.7
Used Substance in Past Week					
Bud	78.8	88.8	96.9	96.8	94.6
Hash resin	1.3	6.7	10.3	21.8	16.8
Hash oil	2.5	8.4	9.2	28.0	20.9
Edibles	22.5	17.4	21.5	27.5	24.9
Beverages	0	5.1	2.1	7.1	5.6
Lotion	0	3.9	5.1	12.2	9.2
Kif	5.0	4.5	7.2	21.6	16.1

NOTES: N = 1,659. Kif, or kief, is a concentrated form of cannabis. From marijuana aficionado site leafly.com: "Kief is a collected amount of trichomes that have been separated from the rest of the marijuana flower. Since trichomes are the sticky crystals that contain the vast majority of the plant's cannabinoids, kief is known to be extremely potent. Kief is sometimes mistakenly referred to as pollen and is the primary ingredient in hashish production." (Leafly, n.d.)

method for consuming hash oil—a concentrate with very high THC levels—was reported by nearly 40 percent of past-month users and 52 percent of daily/near-daily users. Among daily/near-daily users, 20 percent of respondents report dabbing in the past week (see Table 4.3).

Since these figures are based on a voluntary web survey with no sampling frame, readers should not assume that these patterns are representative of all past-month users in Washington state. However, they do suggest that there is a great deal of heterogeneity in *how* Washington residents consume marijuana in the pre-commercial era. There is much more to learn about the public health consequences of these different methods of consumption.

Table 4.3
Dabbing by Past-Month Use Frequency Category (Count and Percentage)

Experience with Dabbing	Past-Month Use Days				Total
	1–3	4–10	11–20	21–30	
Never dabbed	124	145	116	351	736
	83.2%	77.1%	71.2%	48.4%	60.0%
Dabbed in past week	2	9	7	148	166
	1.3%	4.8%	4.3%	20.4%	13.5%
Dabbed in past month, but not past week	2	2	10	50	64
	1.3%	1.1%	6.1%	6.9%	5.2%
Dabbed in the past year, but not in past month	21	29	28	170	248
	14.1%	15.4%	17.2%	23.4%	20.2%
Not sure	0	3	2	7	12
	0%	1.6%	1.2%	1.0%	1.0%
Total	149	188	163	726	1,226
	100%	100%	100%	100%	100%

Conclusion

This report provides information about the Washington marijuana market before the anticipated opening of commercial marijuana stores and their associated supply chain. It presents consumption estimates for the entire state and each of its 39 counties for 2013. It also includes information about the characteristics of recent and heavy consumers, and how they obtained marijuana, as well as how they consumed it.

Key findings include the following:

- The NSDUH reports that for 2010 and 2011 the average number of individuals in Washington who used marijuana or hashish in the past month was 556,000, with a 95-percent confidence interval of 475,000–650,000. NSDUH excludes some populations from its sampling frame and self-report surveys typically underestimate consumption. Further, marijuana use has generally been rising, and these figures represent use in 2010 and 2011, not 2013. Thus, the unadjusted figures from the 2010/2011 NSDUH likely understates the number of past-month users in 2013.

- Three counties account for about 50 percent of marijuana users in Washington. King County accounts for about 30 percent of the marijuana users, while Snohomish and Pierce counties have roughly 11 percent each.

- The literature is surprisingly thin concerning how much marijuana users consume during a typical day of use. That knowledge deficit becomes all the more acute when focusing on a particular jurisdiction and time, such as Washington in 2013. The emphasis has traditionally been on counting users, not counting grams. However, by augmenting that thin literature with data from the web-based consumption survey described above, we estimate that Washington residents who use marijuana 21 or more times per month consume, on average, 1.3–1.9 grams during a typical use day.

- Marijuana consumption in Washington in 2013 is larger than the 85 MT previously projected by Washington's OFM (OFM, 2012a). Even before adjusting for survey undercounting/misreporting, our estimates suggest a 90-percent confidence interval of approximately 120–175 MT. The difference is largely driven by our use of more recent data.

- It is difficult to know by how much surveys understate actual consumption. Many of the relevant studies were published over a decade ago and times have changed; the NSDUH methodology has been improved substantially, and a national increase in marijuana use over the 2000s may have increased willingness to self-report. It is also unclear how applicable national and regional studies are to Washington state. After reviewing the evidence and attempting to adjust for undercounting/misreporting, results from our simulation

suggest consumption likely falls within the interval of 135–225 MT, with a median estimate close to 175 MT.

- Multiple datasets provide information about the potency of the marijuana consumed in Washington. None is ideal, and there is no way to take a random sample of the universe of marijuana that is sold or consumed. But the available information suggests that lower-potency forms account for a modest share of the Washington market and probably a smaller share than they do nationwide.

Reflecting on this list of key findings in aggregate, a meta-conclusion is that it is feasible at present to learn a fair amount about marijuana consumption at the state level in the United States. Inasmuch as more than a few states may be considering legalizing marijuana in the near future, there will be cause to replicate this analysis in other states, and comparisons across states are likely to be insightful.

That said, estimating the size of a marijuana market remains a complex task that requires understanding the nuances of the data and making several assumptions. Our goal is to be transparent about the methods and open about the uncertainty surrounding the inputs and outputs. This should not only help readers interpret these findings, but also highlight areas deserving of further research in the future.

One of the largest sources of uncertainty is the lack of information about the reliability of self-report surveys in the 2010s. Much of the research published on this topic is based on pre-NSDUH general-population surveys from more than a decade ago. Further, acceptance of marijuana has shifted dramatically since 2000,[1] and so has use. If marijuana is less stigmatized, users may now be more honest about their consumption.

Another important source of uncertainty comes from not knowing how much marijuana users consume during a typical day of use. While our CCS generated useful insights about this variable, there is more to be done.

Our analysis focused on quantity of *marijuana* consumed, as distinct from the quantity of THC consumed, which would also be useful to know. Ideally, those evaluating I-502's effects would like to estimate changes in consumption of the intoxicant (i.e., THC) as well as changes in the weight of plant material consumed, for both individual users and in the aggregate. This information would be especially useful for decisionmakers who wanted to regulate THC or make the excise tax a function of THC. Our analysis of the available datasets with potency information in Appendix C suggests it is probable that marijuana found in Washington is, on average, of higher potency than elsewhere in the United States, perhaps even higher than its neighboring states; however, data limitations make it difficult to draw precise, quantitative conclusions. Much more can be done to systematically collect this information from users and law enforcement agencies (e.g., testing random samples seized from those under 21).

Aside from the quantities involved, Chapter Four makes it clear that there is a great deal of heterogeneity in how Washington residents consume marijuana. Because the health and behavioral consequences of smoking versus eating versus dabbing are not well understood, it seems advisable to track the "how" of use as well as the "how much."

---

[1] The share of Americans indicating that marijuana should be legal increased from about 30 percent in 2000 to more than 50 percent in 2013 (Pew Research, 2013).

Bibliography

Abt Associates. (2001). *What America's users spend on illegal drugs*. Washington, D.C.: Executive Office of the President, Office of National Drug Control Policy.

Abt Associates. (2012). *What America's users spend on illegal drugs, 2000–2006*. Washington, D.C.: Executive Office of the President, Office of National Drug Control Policy.

Bouchard, M. (2008). Towards a realistic method to estimate cannabis production in industrialized countries. *Contemporary Drug Problems*, *35*, 291–320.

Bramley-Harker, E. (2001). Sizing the UK market for illicit drugs. RDS Occasional Paper No. 74. London: Home Office, Research Development and Statistics Directorate.

Casey, J., Hay, G., Godfrey, C., & Parrott, S. (2009). Assessing the scale and impact of illicit drug markets in Scotland. Edinburgh: Scottish Government Social Research.

Caulkins, J. P., Andrzejewski, S., & Dahlkemper, L. (2013). *How much revenue could the cannabis tax generate under different scenarios?* Olympia, WA: Washington State Liquor Control Board. Retrieved November 18, 2013, from http://liq.wa.gov/publications/Marijuana/BOTEC%20reports/8b_Tax_revenue_under_different_scenarios-%20Final.pdf

Caulkins, J. P., Hawken, A., Kilmer, B., & Kleiman, M. A. R. (2012). *Marijuana legalization: What everyone needs to know*. New York: Oxford University Press.

Caulkins, J. P., & Kilmer, B. (with Graf, M.). (2013). Estimating the size of the EU cannabis market. In Trautman, F., Kilmer, B., & Turnbull, P. (Eds.), *Further insights into aspects of the illicit EU drugs market* (pp. 289–322). Luxembourg: Publications Office of the European Union.

Cohen, P. (1999). Shifting the main purposes of drug control: From suppression to regulation of use. *International Journal of Drug Policy*, *10*(3), 223–234.

Cole, J. M. (2013, August 29). Memorandum for all United States attorneys. Washington, D.C.: U.S. Department of Justice, Office of the Deputy Attorney General. Retrieved November 18, 2013, from http://www.justice.gov/iso/opa/resources/3052013829132756857467.pdf

Cook, P. J. (2007). *Paying the tab: The costs and benefits of alcohol control*. Princeton University Press.

Cortes, A., Henry, M., de la Cruz, R. J., & Brown, S. (2012). *The 2012 point-in-time estimates of homelessness*. Washington, D.C.: U.S. Department of Housing and Urban Development. Retrieved August 20, 2013, from https://www.onecpd.info/resources/documents/2012AHAR_PITestimates.pdf

EMCDDA—*See* European Monitoring Centre for Drugs and Drug Addiction.

ElSohly, M. A., Ross, S. A., Mehmedic, Z., Arafat, R., Yi, B., & Banahan, B. F. (2000). Potency trends of Δ9-THC and other cannabinoids in confiscated marijuana from 1980–1997. *Journal of Forensic Sciences*, *45*(1), 24–30.

Epley, N., & Gilovich, T. (2006). The anchoring-and-adjustment heuristic: Why the adjustments are often insufficient. *Psychological Science*, *17*, 311–318.

European Monitoring Centre for Drugs and Drug Addiction. (2013, April 26). Table GPS-10: Frequency of use of cannabis amongst users in the last 30 days in national general population surveys. Retrieved November 18, 2013, from http://www.emcdda.europa.eu/stats13/gpstab10a

Fendrich, M., Johnson, T. P., Wislar, J. S., Hubbell, A., & Spiehler, V. (2004). The utility of drug testing in epidemiological research: Results from a general population survey. *Addiction*, *99*, 197–208.

Fendrich, M., & Rosenbaum, D. P. (2003). Recanting of substance use reports in a longitudinal prevention study. *Drug and Alcohol Dependence*, *70*(3), 241–253.

Gettman, J. (2007). Lost taxes and other costs of marijuana laws. *Bulletin of Cannabis Reform*, *4*. Retrieved August 20, 2013, from http://www.drugscience.org/Archive/bcr4/bcr4_index.html

Hakkarainen, P., Kainulainen, H., & Perälä, J. (2008). Measuring the cannabis market in Finland: A consumption-based estimate. *Contemporary Drug Problems*, *35*(2/3), 321–345.

Harrison, L. S., Martin, S. S., Enev, T., & Harrington, D. (2007). Comparing drug testing and self-report of drug use among youths and young adults in the general population. (SMA)07-4249. Rockville, MD: Department of Health and Human Services, Substance Abuse and Mental Health Services Administration, Office of Applied Studies.

Hser, Y.-I., Maglione, M., & Boyle, K. (1999). Validity of self-report of drug use among STD patients, ER patients, and arrestees. *American Journal of Drug and Alcohol Abuse, 25*(1), 81–91.

Johnston, L. D., Bachman, J. G., & O'Malley, P. M. (Annual). Monitoring the future: Questionnaire responses from the nation's high school seniors. Ann Arbor, MI: Institute for Social Research.

Kaminsky, J. (2013, July 11). Washington state marijuana regulators want more federal clarity on rules. *Reuters*. Retrieved August 10, 2013, from http://www.reuters.com/article/2013/07/11/us-usa-marijuana-washingtonstate-idUSBRE96A13B20130711

Kilmer, B., Caulkins, J., Bond, B., & Reuter, P. (2010). *Reducing drug trafficking revenues and violence in Mexico: Would legalizing marijuana in California help?* OP-325-RC. Santa Monica, CA: RAND Corporation. Retrieved November 18, 2013, from http://www.rand.org/pubs/occasional_papers/OP325.html

Kilmer, B., Caulkins, J., Pacula, R., MacCoun, R., & Reuter, P. (2010). *Altered state? Assessing how marijuana legalization in California could influence marijuana consumption and public budgets*. OP-315-RC. Santa Monica, CA: RAND Corporation. Retrieved November 18, 2013, from http://www.rand.org/pubs/occasional_papers/OP315.html

Kilmer, B., Caulkins, J., Pacula, R., & Reuter, P. (2011). Bringing perspective to illicit markets: Estimating the size of the U.S. marijuana market. *Drug and Alcohol Dependence*, *119*, 153–160.

Kilmer, B., Everingham, S., Caulkins, J., Midgette, G., Pacula, R., Reuter, P., Burns, R., Han, B., & Lundberg, R. (in press). *What America's users spend on illegal drugs: 2000–2010*. Washington, D.C.: Executive Office of the President, Office of National Drug Control Policy.

Kilmer, B., & Pacula, R. (2009). *Estimating the size of the global drug market: A demand-side approach*. TR-711-EC. Santa Monica, CA: RAND Corporation. Retrieved November 18, 2013, from http://www.rand.org/pubs/technical_reports/TR711.html

Korf, D., Benschop, A., & Wouters, M. (2007). Differential responses to cannabis potency: A typology of users based on self-reported consumption behavior. *International Journal of Drug Policy*, *18*, 168–176.

Leafly (n.d.). Leafly glossary of cannabis terms. Retrieved November 25, 2013, from http://www.leafly.com/knowledge-center/cannabis-101/glossary-of-cannabis-terms

Lee, J. M., & Rawls, A. (2010). *The college completion agenda: 2010 progress report*. College Board. Retrieved June 27, 2013, from http://completionagenda.collegeboard.org/sites/default/files/reports_pdf/Progress_Report_2010.pdf

Legleye, S., Ben Lakhdar, C., & Spilka, S. (2008) Two ways of estimating the euro value of the illicit market for cannabis in France. *Drug and Alcohol Review*, *27*(5), 466–472.

Martin, J. (2012, September 5). Seattle pot dispensaries finding business climate no longer sunny. *Seattle Times*. Retrieved June 30, 2013, from http://seattletimes.com/html/localnews/2019077879_dispensaries06m.html

Mehmedic, Z., Chandra, S., Slade, D., Denham, H., Foster, S., Patel, A. S., Ross, S. A., Khan, I. A., & ElSohly, M. A. (2010). Potency trends of Δ9-THC and other cannabinoids in confiscated cannabis preparations from 1993 to 2008. *Journal of Forensic Sciences, 55*(5), 1209–1217.

National Institute on Alcohol Abuse and Alcoholism. (2006). National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). Washington, D.C.

Northwest High Intensity Drug Trafficking Area (HIDTA). (2013). *Washington state 2012 marijuana situation report.* Seattle, WA: Washington Association for Abuse and Violence Prevention. Retrieved August 20, 2013, from http://wasavp.org/wp-content/uploads/2012/06/HIDTA-NW-Marijuana-Situation-Report-2012-Unclassified.pdf

Office of Financial Management. (2012a). I-502–fiscal impact statement. Retrieved November 18, 2013, from http://vote.wa.gov/guides/2012/I-502-Fiscal-Impact.html

Office of Financial Management. (2012b). Washington state growth population projections for counties: 2000 to 2030. Retrieved November 18, 2013, from http://www.ofm.wa.gov/pop/gma/projections07.asp

Office of National Drug Control Policy. (2009). *ADAM II: 2008 annual report.* Washington, D.C. Retrieved September 20, 2011, from http://www.whitehouse.gov/sites/default/files/ondcp/policy-and-research/adam2008.pdf

OFM—*See* Office of Financial Management.

ONDCP—*See* Office of National Drug Control Policy.

Pew Research Center for the People and the Press. (2013, April 4). Majority now supports legalizing marijuana. Retrieved November 18, 2013 from http://www.people-press.org/2013/04/04/majority-now-supports-legalizing-marijuana/

PriceOfWeed.com. (2013*). Washington weed prices.* web page. Retreived May 29, 2013, from http://www.priceofweed.com/prices/United-States/Washington.html

Pudney, S., Badillo, C., Bryan, M., Burton, J., Conti, G., & Iacovou, M. (2006) Estimating the size of the UK illicit drug market. In Singleton, N., Murray, R., & Tinsley, L. (eds.). *Measuring different aspects of problem drug use: methodological developments.* 2nd edition (pp. 46–85). Research Development and Statistics Directorate, Home Office. Retrieved November 25, 2013, from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/116642/hoor1606.pdf

Research Triangle Institute. (2012, October). 2013 National Survey on Drug Use and Health: CAI specifications for programming, English version. Rockville, MD: Substance Abuse and Mental Health Services Administration. Retrieved November 19, 2013, from http://www.samhsa.gov/data/2k12/NSDUH2013MRB/NSDUHmrbCAIquex2013.pdf

Robbins, M. S., Briones, E., Schwartz, S. J., Dillon, F. R., & Mitrani, V. B. (2006). Differences in family functioning in grandparent and parent-headed households in a clinical sample of drug-using African American adolescents. *Cultural Diversity and Ethnic Minority Psychology, 12*(1), 84.

SAMHSA—*See* Substance Abuse and Mental Health Services Administration.

Seattle Public Schools. (2012). 2012 Youth Risk Behavior Survey results: Seattle high school survey. Retrieved December 5, 2013, from http://www.seattleschools.org/modules/groups/homepagefiles/cms/1583136/File/Departmental%20Content/health%20and%20safety/healthsurveys/2012%20YRBS%20Detail%20Tables%20with%20Med%20MJREV%281%29.pdf?sessionid=8258fc3c9befacc2a765dec77ed0348a

Seattle Public Schools. (n.d.). Frequently asked questions regarding the Healthy Youth Survey and the Youth Risk Behavior Survey. Retrieved November 25, 2013, from http://district.seattleschools.org/modules/groups/homepagefiles/cms/1583136/File/Departmental%20Content/health%20and%20safety/healthsurveys/surveyfaqs.pdf

Substance Abuse and Mental Health Services Administration. (2008, June 3). Appendix C: NSDUH changes and their impact on trend measurement. Retrieved November 18, 2013, from http://www.samhsa.gov/data/nhsda/2k2nsduh/results/appC.htm

Substance Abuse and Mental Health Services Administration. (2002–2011). Substance Abuse and Mental Health Data Archive. Retrieved November 18, 2013, from http://www.icpsr.umich.edu/icpsrweb/SAMHDA/studies/34482

Substance Abuse and Mental Health Services Administration. (2011). 2010-2011 National Survey on Drug Use and Health: Guide to state tables and summary of small area estimation methodology, Section A: Overview of NSDUH and model-based state estimates. Retrieved November 25, 2013, from http://www.samhsa.gov/data/NSDUH/2k11State/NSDUHsaeMethodology2011.htm

Substance Abuse and Mental Health Services Administration. (n.d.). Restricted-use Data Analysis System. Retrieved November 18, 2013, from http://www.icpsr.umich.edu/icpsrweb/content/SAMHDA/rdas.html

United Nations Office on Drugs and Crime. (2006). Review of the world cannabis situation. *Bulletin on Narcotics, 58*(1 & 2).

United Nations Office on Drugs and Crime. (2009) *World drug report*. Vienna, United Nations Office on Drugs and Crime, 2009.

University of Mississippi (UMISS). (2013). The National Institute on Drug Abuse Potency Monitoring program data. University, MS: National Center for Natural Products Research.

U.S. Department of Defense. (n.d.). *Status of drug use in the Department of Defense personnel: Fiscal year 2011 drug testing statistical report*. Washington, D.C.: Office of the Under Secretary of Defense for Personnel and Readiness. Retrieved August 17, 2013, from http://prhome.defense.gov/Portals/52/Documents/RFM/ Readiness/DDRP/docs/6b%20FY%202011%20Annual%20Drug%20Use%20Status%20Report.pdf

van der Pol, P., Liebregts, N., de Graaf, R., Korf, D. J., van den Brink, W., & van Laar, M. (2013). Validation of self-reported cannabis dose and potency: An ecological study. *Addiction*, *108*(10), 1801–1808.

van Laar, M., Frijns, T., Trautmann, F., & Lombi, L. (2013). Cannabis market: User types, availability and consumption estimates. In Trautmann, F., Kilmer, B., & Turnbull, P. (Eds.), *Further insights into aspects of the illicit EU drugs market* (pp. 73–182). Luxembourg: Publications Office of the European Union.

Vopravil, J. (2013, May 16). Estimation of drug trade from demand side. Paper for the 7th ISSDP Conference in Bogota. Retrieved December 4, 2013, from economia.uniandes.edu.co/content/download/47114/.../Jiri_ Vopravil.pdf

Washington State Department of Health. (2003–2013). Healthy Youth Survey 2002–2012 analytic reports. Washington State Department of Health, Office of the Superintendent of Public Instruction, Department of Social and Health Services, Department of Commerce, Family Policy Council, and Liquor Control Board.

Washington State Division of Behavioral Health and Recovery. (2013). System for Communicating Outcomes, Performance and Evaluation (SCOPE) program. Retrieved August 20, 2013, from http://www.scopewa.net (login required)

Washington State Liquor Control Board. (2013, September 4). Frequently asked questions about the I-502 proposed rules. Retrieved November 15, 2013, from http://www.liq.wa.gov/publications/Marijuana/I-502/proposed_rules/I-502_Proposed_Rules_FAQ2_9-18-13. pdf

Werb, D., Nosyk, B., Kerr, T., Fischer, B., Montaner, J., & Wood, E. (2012, November). Estimating the economic value of British Columbia's domestic cannabis market: Implications for provincial cannabis policy. *International Journal of Drug Policy, 23*(6), 436–441.

Wilkins, C., Reilly, J., Pledger, M., & Casswell, S. (2005). Estimating the dollar value of the illicit market for cannabis in New Zealand. *Drug and Alcohol Review*, 24(3), 227–234.

Wilkins, C., & Sweetur, P. (2007). Individual dollar expenditure and earnings from cannabis in New Zealand. *International Journal of Drug Policy*, *18*(3), 187–193.

Zeisser, C., Thompson, K., Stockwell, T., Duff, C., Chow, C., Vallance, K., Ivsins, A., Michelow, W., Marsh, D., & Lucas, P. (2011). A 'standard joint'? The role of quantity in predicting cannabis-related problems. *Addiction Research & Theory*, *20*(1), 82–92.

Zhang, Z., Friedmann, P. D., & Gerstein, D. R. (2003). Does retention matter? Treatment duration and improvement in drug use. *Addiction*, *98*(5), 673–684.