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Before the Grand Opening

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

Appendixes A, B, and C

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Prepared for the Washington State Liquor Control Board/BOTEC Analysis Corporation
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<tr>
<td>ADAM</td>
<td>Arrestee Drug Abuse Monitoring</td>
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<tr>
<td>CBC</td>
<td>cannabichromene</td>
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<tr>
<td>CBD</td>
<td>cannabidiol</td>
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<td>CBN</td>
<td>cannabinol</td>
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<td>Cannabis Consumption Survey</td>
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<td>DEA</td>
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<td>dwelling unit</td>
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<td>I-502</td>
<td>Initiative 502</td>
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<td>Socioeconomic status</td>
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<tr>
<td>SILJ</td>
<td>Survey of Inmates in Local Jails</td>
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<tr>
<td>THC</td>
<td>tetrahydrocannabinol</td>
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<tr>
<td>UMISS</td>
<td>University of Mississippi</td>
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The Washington state subsample within national surveys such as NSDUH provides some useful information, particularly concerning overall prevalence, but is weak on (1) grams consumed (as opposed to days of use) and (2) details of method of acquisition, forms of use, etc. Hence, for this project we conducted our own survey.

We opted for a web-based survey, which has notable advantages and some disadvantages. Within the time available it would not have been feasible to mount a high-quality random sample of all Washington residents. Furthermore, that approach would have replicated one of the weaknesses of the national surveys, namely few respondents who use marijuana daily/near-daily, and it is those users who dominate total consumption. On the other hand, ethnographic approaches (snowball sampling, respondent-driven sampling, etc.) are more feasible for smaller geographic areas, and would have likely produced smaller samples.

Of course, web-based surveys have their own limitations. As described below, we invested considerable effort in detecting and removing respondents who were not “sincere” (e.g., individuals who sought to game the survey to influence policy decisions that draw on the survey information). In our judgment, the number of such disingenuous respondents (whom we came to refer to as scoundrels) was not large, and we think we flagged most of them.

The larger issue is the non-representativeness of those who choose to complete this web-survey. For example, not surprisingly, relative to the overall population of Washington state marijuana users, survey respondents are disproportionately well-educated and more frequent users (occasional users may not care enough about marijuana-related issues to take the time to complete a survey).

Given this, we only use the survey to make statements conditional on a user’s status. Notably, we use survey responses to inform estimates of amounts used by people who are daily/near-daily users and amounts per day of use. We never use these data directly to draw inferences about state-level aggregates, such as the number of past-month users there are in Washington.

After beta-testing the survey throughout June 2013, RAND and BOTEC launched the final survey for Washington cannabis users on June 24th. The survey was designed to take respondents approximately 15 minutes. We closed the survey on July 3rd with 3,488 responses, which included 2,783 respondents from Washington. (Data from the 705 who reported living in a different state or country are used here only when comparing reported potency, not for estimating quantities consumed.) Among the 2,783 from Washington, 1,687 respondents reported past-month use and 1,133 respondents provided information on both the number of use days and consumption in the preceding month; 721 (63.6 percent) of those 1,133 reported using...
cannabis on at least 21 days in the last month. So the survey did produce data on a large number of high-frequency users.

Randomized Stimulus Questions

Traditionally, surveys have focused on measures of prevalence (e.g., “Have you used in the last week?”) rather than on quantity consumed (“How much did you use in the last week?”), but estimates of quantity (weight) are precisely what was needed for this project.

To help respondents supply valid responses to questions related to their average daily cannabis consumption, we prompted all who reported past-month use with a picture of loose cannabis (randomly selected to be either one gram or one-half gram), stated the amount pictured in grams, and asked about the amount they consumed on their last use day relative to the amount shown. The categorical responses allowed the respondent to indicate whether the amount of marijuana consumed on the typical use day was < 0.5x, 0.5x, 1x, 2x, 4x, 5x or > 5x the amount shown (see Figure A.1). The pictures included a quarter, credit card, and ruler to give respondents a sense of scale. These values were used to generate an alternative estimate of average use-day consumption and to verify that the amounts stated in a similar unprompted (i.e., no picture) question later in the survey are similar. These questions may also help inform research on the accuracy of stated consumption amounts in surveys of this type, and the effect of stimuli on survey responses.

There was a significant positive relationship (R = 0.7) between respondents’ typical consumption imputed from the photo prompt and their unprompted entry, although the picture prompt led to lower average responses than the unprompted answers. This is in part due to the construction of the imputed variable—those consuming more than five times the amount shown in the random picture prompt are unbounded.
Responses to the randomized, picture-based questions showed a typical anchoring effect (Epley and Gilovich, 2006), with lower reported consumption among those shown the 0.5-gram picture (mean = 1.38 grams) than the 1-gram picture (mean = 1.71 grams). But this was compensated for by the benefits of having some anchor; results from the picture prompt suggest that the long right tail on the unprompted responses may have been noisiness produced by the difficulty people had judging these quantities without a point of reference. The fact that the Winsorized responses to the unprompted consumption question closely match the mean of the picture responses is consistent with that interpretation.

Figure A.2 shows the cumulative density functions for reported typical consumption based on the randomized picture prompt. The distributions are quite similar. Roughly half of respondents report consuming 1 gram per day or less, 90 percent consume less than 3 grams, and a long tail of heavy users consume more than 3 grams.
Conversion of Responses to Quantitative Measures

The survey combined multiple choice and free-text responses. A cleaning algorithm was written to remove extraneous characters from all free-text responses. For all questions regarding expenditure, all responses containing text indicating that a value was denominated in something other than U.S. dollars (e.g., answers in grams, joints, or bowls) were excluded from the analysis. Respondents were asked how many grams they consume in a light, typical, and heavy use day and given ten characters of free text to respond. Most responded in whole numbers or fractions. These entries were kept as-is. When a response included a range, we considered its midpoint (e.g. “1-2g” became 1.5 grams). We excluded nine observations where respondents gave an inequality (e.g., “> 1g”, “< 3g”). Those who were not comfortable answering these questions in grams could instead answer in another format. The 67 responses replying in ounces were converted to grams for analysis and did not appear to be statistically different from gram-denominated responses. Another 158 responses were in terms of joints, blunts, pipe bowls, vaporizer bowls, or bong bowls and were not included in this analysis.

Detection of Problematic Responses

The public debate on the legal treatment of cannabis includes willful activists on both sides. In light of this, we developed a set of 32 different risk flags indicating illogical, erratic, or otherwise problematic response behavior. A battery of psychometric approaches to scrutinize the risk flags were employed, including simple correlations, principal components, factor analysis with varimax rotation, factor analysis with promax rotation, several forms of cluster analysis, and
coefficient alpha scaling of potential subscales. The number of target factors the algorithms would look for was also varied.

The results of these steps are mixed. The original hope had been to create one or more composite “scoundrel score scales” that would identify people who appeared to be trying to add noise, add bias, or complete the survey multiple times. This is of course difficult because no independent criterion exists; if one were to know who some of the scoundrels were a priori, a statistical profile of their characteristics could be built and used to impute scores for everyone else. The second-best strategy was to identify plausible risk flags and see whether they “hang together” in psychometric analyses, indicating a common latent factor. There is no compelling evidence that such a factor exists.

We then looked at the factors to identify possible subscales. A common benchmark for coefficient alpha in field research is 0.65—the standard is much higher than that in the testing industry and in lab experiments. Only one factor of seven considered met that benchmark, but a second came close. The first factor was a composite of responses in the top or bottom 5 percent of the distribution of expenditures on the past three cannabis purchases. The second was a combination of illogical responses for consumption on typical, heavy, and light use days, a missing response to a question asking the respondent to detail their cannabis use in the past week, and completion of the survey in fewer than six minutes given admitted past-month use. The two factors we identified were used to generate an indicator variable flagging 407 potentially problematic observations, 299 of which were Washington residents. All analyses performed on these data were run twice: once with all data and once without. In none of the analyses reported here has including or excluding these observations resulted in significantly different estimates for metrics of interest.
Appendix B. Undercounting/Misreporting in the National Survey on Drug Use and Health

When surveying respondents about sensitive behaviors, undercounting/misreporting is a perennial concern. Hence, estimates of marijuana consumption based on household surveys are commonly adjusted upward. Multiplying by a factor of 1.25 (e.g., Kilmer et al., 2011) or 1.33 (e.g., ONDCP, 2012) is common; others (e.g., Gettman, 2007) have used even larger adjustments.

Sometimes undercounting/misreporting is thought of only in terms of some survey respondents’ denying their use, so that prevalence is underestimated. However, we have in mind the following more general concept: How much do respondents’ self-reports underestimate true consumption by the entire population? That underestimation—a function of both (a) respondents’ personal willingness to respond truthfully to survey questions and (b) representativeness of the surveyed sample to the true population of interest. Both contribute to the size of the multiplier that should be applied to adjust estimates based on the National Survey of Drug Use and Health (NSDUH) when estimating aggregate state or national consumption.

It is useful to distinguish four components of such a multiplier or adjustment:

1. Use by people outside the NSDUH’s sampling frame (e.g., active military, homeless who are not in shelters)
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 take the survey)
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.

We will address each of these issues in turn below.

People Outside NSDUH’s Sampling Frame

The first issue is a major concern for heroin and cocaine, but not for marijuana because the NSDUH-estimated number of past-month users is large compared to typical estimates of the population living outside the NSDUH sampling frame.

Two studies addressed this issue for the National Household Survey on Drug Abuse (NHSDA), the precursor to NSDUH. Bray et al. (1996) combined substance use data obtained from members of households, institutionalized populations, and homeless populations aged 12 or older in the District of Columbia metropolitan statistical area in 1991. They found that “Of the estimated 384,738 past year illicit drug users in the aggregate population, over 95% would have been accounted for by the household estimate (i.e., $370,486 \div 384,738 \times 100 = 96.3\%$),”
implying an adjustment factor of 1.038. The adjustment factor for marijuana in particular was a shade lower, at 1.035.

A ratio estimation study by Wright et al. (1996) used national arrest and treatment data and found that the 1992 NHSDA missed 12 percent of past-year marijuana users (19,461,280 versus 17,400,273).

Use by people outside the survey’s sampling frame is likely even less of an issue now. The above studies are based on the 1991 and 1992 NHSDA surveys, respectively, and tremendous improvements have been made to the survey to help recruit from populations that had previously been neglected (especially those in shelters). Also, since marijuana use was at a nadir circa 1992 (ONDCP, 2013a), the probability a past-month user was in a stigmatized, hard-to-reach population vs. a mainstream population may have been higher than it is today.

Here we revisit the issue with some rough calculations based on the current survey (NSDUH, not NHSDA) and more recent data. The 2011 NSDUH reports that its sampling frame covers “almost 98 percent of the total U.S. population aged 12 or older” (emphasis added)¹ and that the 2011 survey’s target population was 257.6 million. The “almost 98 percent” does not appear to have been defined more precisely. If it were 97.9 percent then that would suggest there are 257.6 million / 0.979 million = 263.1 million Americans who were aged 12 and older and so 263.1 million – 257.6 million = 5.5 million Americans outside the sampling frame.² Similarly, if “almost 98 percent” meant 97.5 percent, then the NSDUH sampling frame could miss up to 6.6 million individuals aged 12 and over.

If those outside the sampling frame used marijuana at rates comparable to those sampled then we might want to multiply the NSDUH estimates of amounts spent by 1 / 0.979 or 1 / 0.975 (i.e., 1.021 – 1.026) to account for consumption by those outside the sampling frame.

However, those outside the sampling frame may not use at the same rates as those who are within the sampling frame. It is common to suppose that they use at higher rates, suggesting a larger multiplier would be appropriate. We can get a sense of whether that common belief is true and, if so, the extent to which it might be true, by examining different subpopulations that are excluded.

The 5.5–6.6 million people outside the sampling frame include those in active military service, those who are homeless and not in a shelter, those in residential drug treatment, and

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¹ SAMHSA: “The estimates of drug use prevalence from the National Survey on Drug Use and Health (NSDUH) are designed to describe the target population of the survey—the civilian, noninstitutionalized population aged 12 or older living in the United States. This population includes almost 98 percent of the total U.S. population aged 12 or older. However, it excludes some small subpopulations may have very different drug use patterns. For example, the survey excludes active military personnel, who have been shown to have significantly lower rates of illicit drug use. The survey also excludes two groups that have been shown to have higher rates of illicit drug use: persons living in institutional group quarters, such as prisons and residential drug use treatment centers, and homeless persons not living in a shelter” (SAMHSA, 2010).

² If it was less than 97.5 percent they probably would not have written “almost 98 percent.” We initially focus on the smallest rate possible, which will give us the biggest possible gap.
those who are in jail or prison, but those groups total only about 4 million, so there are another 1.5–2.6 million others as well.

**Active Members of the Armed Services**

There are about 1.4 million active duty U.S. military personnel. Although drug use among the military was common in the 1970s and early 1980s (e.g., Burt, 1981–1982), it fell sharply thereafter (Bray and Hourani, 2007), and in contemporary times past-month marijuana use among active duty military service members appears to be quite low, presumably since they are subject to frequent testing and significant sanction (including loss of job) if they test positive. The 2011 Department of Defense (DoD) Health Related Behaviors survey (DoD, 2013) reports a past-month marijuana prevalence rate of 0.1 percent. While we expect this self-reported information to be low since marijuana use can have dire consequences for this population, testing is quite frequent: over 27 percent of the respondents reported being drug tested in the past month, and almost 90 percent had been tested in the past year. Of the 3.5 million drug tests administered to active duty personnel, only 0.72 percent came back positive for any drug, with roughly two-thirds of those being for marijuana (DoD, ND). Furthermore, those tests include for-cause as well as random tests, which would tend to inflate the positive rate.

**Those in Jail or Prison**

On a typical day in 2011, there were 735,000 individuals in jail and 1.5 million in prison (Glaze and Parks, 2012). While prisons and jails cannot block all contraband from entering the facility, the vast majority of individuals behind bars are not consuming illegal drugs, especially those with a distinctive smell like marijuana. So use by inmates is likely to be well below use in the general population, even though their use would likely have been substantially higher—not lower—if they were not incarcerated. Data from the Arrestee Drug Abuse Monitoring (ADAM) survey suggest that on the order of 50 percent of booked arrestees in ten large, urban counties tested positive for marijuana use throughout the decade (ONDCP, 2013b).

There is another way, though, that the presence of inmates might make NSDUH-based estimates of national consumption too low, and that is the “churn” of people going in and out of jails or prisons. Consider first the case of prison inmates. Prison admissions and releases in 2011 were 668,000 and 669,000, respectively. That means that at any given time, roughly $669,000 / 12 = 55,750$ people in prison had arrived in the last month. Some just arrived and, hence, spent most of the last 30 days outside prison walls; others would have arrived 29 days before. On average, those 55,750 new arrivals would have spent half of the last 30 days outside of prison. So they represent about $55,750 / 2 = 27,875$ person-months of time spent outside of prison in the last month. If they had all arrived “from the street” one might expect about half (or about 14,000) to have used marijuana in that time. Some, however, arrived from jail, where they probably also were not using at high rates. So one might guess that “prison churn” could lead NSDUH to
underestimate the number of past-month marijuana users by something like 10,000—not a significant number.

Churn could be more important for jail inmates since jails experience about 12 million admissions and releases each year (Solomon et al., 2008). About 35 percent of jail inmates report in the 2002 Survey of Inmates in Local Jails (SILJ) that they have been in jail for less than 30 days (“recently jailed”). Collectively, they report about 130,000 person-months of time spent over the last 30 days before arriving in jail; scaling to the current, higher number of jail inmates would make that 150,000 person months. If 50–60 percent of those individuals used marijuana while free, that would be the equivalent of an additional 75,000 to 90,000 users that are outside the NSDUH sampling frame.

**Unsheltered Homeless**

The NSDUH sampling frame now includes homeless shelters, but the U.S. Department of Housing and Urban Development estimates that on any given night in 2012 there were about 250,000 individuals who were homeless and not living in shelters (Cortes et al., 2012). Obtaining nationally representative samples of the homeless is challenging, and much of the literature focuses on the homeless population in total, not specifically the subset that is outside the NSDUH sampling frame.

There are studies of marijuana use among certain subpopulations of homeless individuals, but they tend to be of subpopulations who one would expect to use at higher than average rates: Those entering a drug treatment program, those engaging in criminal activity, and those who are young.

- Among homeless individuals presenting to public drug treatment in 2010, 26 percent of the admissions (58,054/221,528) reported marijuana as either the primary, secondary, or tertiary substance of abuse, or their reason for treatment.
- Among arrestees in the 2010 ADAM sample who reported that their place of residence for the past 30 days was “SHELTER,” 34 percent tested positive for marijuana. For those who reported “NO FIXED RESIDENCE OR HOMELESS,” the positive rate was 47 percent. For those who reported “SOMEONE ELSE’S HOUSE/MOBILE HOME/APT,” the positive rate was 55 percent.
- Some studies of homeless youth in Los Angeles, including those living in shelters, have found that past-month marijuana use hovers around 60 percent (Rosenthal et al., 2008; Wenzel et al., 2010).

**Residential Drug Treatment Patients**

There were 1.2 million clients enrolled in substance abuse treatment on March 31, 2011, but most were in outpatient treatment and so are within the NSDUH sampling frame. Residential and inpatient-hospital programs accounted for 10 percent of these clients (SAMHSA, 2011). For those admitted to residential facilities (including hospitals) that submitted data to SAMHSA for the Treatment Episode Data Set (TEDS) in 2010, 38.6 percent reported marijuana as a primary,
secondary, or tertiary substance of abuse at admission, but we do not know the rates of substance use for this population while in residential or in treatment programs. Continued drug use while in outpatient treatment is not uncommon, but one would expect such use to be less common for inpatients.

**Others**

The remaining 1.5–2.6 million people who remain outside the NSDUH sampling frame are something of a mystery. The NSDUH screener excludes those without a permanent residence who are residing with family/friends for less than 1.5 months, so this accounts for some of them.

How many of these 5.5–6.6 million individuals used marijuana in the past month? Table B.1 contains some speculations. Since most of the 5.5–6.6 million people outside the sampling frame are precluded from high rates of use by their situation (in prison, jail, residential treatment, or the active duty military), the main source of marijuana use outside the NSDUH sampling frame are the mysterious 1.5–2.6 million “others.” Even if they use at rates no higher than for the household population, they are still the largest line item, with unsheltered homeless being the second most important and jail churn being third.

<table>
<thead>
<tr>
<th>Table B.1. Marijuana Use Among Those Excluded from NSDUH Sampling Frame</th>
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<tr>
<td>Population</td>
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<td></td>
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<tr>
<td>Military</td>
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<tr>
<td>Unsheltered homeless</td>
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<tr>
<td>Residential treatment clients</td>
</tr>
<tr>
<td>Prison inmates</td>
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<tr>
<td>Recently imprisoned</td>
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<tr>
<td>Jail inmates</td>
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<tr>
<td>Recently jailed</td>
</tr>
<tr>
<td>Other</td>
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<tr>
<td>Total</td>
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Sources: DoD, 2013; Cortes et al., 2012; SAMHSA, 2011; Glaze and Parks, 2012.

We do not know the precise size of the “Other” group, let alone what it looks like and what it consumes. A low estimate that assumes the group was 1.5 million and consumed marijuana at the same rate as the general population generates an adjustment factor close to 1.014 \[ = (18 + .2424)/18 \]. Since this group includes those without a permanent residence who are on the move,

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3 NSDUH Screener question: (Including yourself), how many people in this household (lived/will live) here for most of the time during the months of (CURRENT QUARTER)? (Do not include anyone who (lived/will live) at school or somewhere else for most of the time during the months of (CURRENT QUARTER).)
one could argue that some members may have prevalence rates closer to those who are homeless. However, we still do not know what the weighted average would be.

If we consider the previously mentioned research on the 1991/1992 NHSDA and divide the adjustment factors by two to account for improvements to the survey methodology and increased likelihood that a past-month marijuana user will be in the sampling frame, we get a range of 1.018 to 1.06. This low estimate happens to be very close to the low estimate calculated in Table B.1 for the 2011 NSDUH (1.014). The high estimate of 1.06 would be consistent with there being 2.6 million individuals in the “Other” group and their prevalence rate being 30 percent. This does not seem unreasonable since we would expect it to be higher than the national average (7 percent) and lower than what we observed for those who were transient and recently arrested (about 50 percent).

In sum, while it is extremely difficult to pin down how much use there is outside the survey sampling frame, it appears that the associated adjustment is unlikely to be very large.

### People in the Sampling Frame But Not Surveyed

The second of the four issues concerning nonresponse, by contrast, could be much more problematic. Among eligible dwelling units (DUs) for the 2011 NSDUH, SAMHSA obtained some information from 89 percent (i.e., at a minimum, a member of the household completes the screener, which is essentially a household roster). Some reasons for not obtaining information include language barriers, refusals, and denied access (e.g., gated communities). Post-screening, 85,429 individuals were chosen to be interviewed and 80 percent of them completed the survey.

There are various reasons why individuals could refuse to take the survey. Not wanting to admit drug use or report illicit behavior are obvious examples, but some could also refuse on the principle that they do not want to give any information like this to the government. Further, some may not have the time or do not like the person who came to the house. Even determining whether the bias is positive or negative is not straightforward.

SAMHSA goes to great lengths to deal with unit nonresponse. Completed responses are weighted based on a number of location-based census variables and interactions among those variables. For those who open the door and report info about those who live there, extra information about age, gender, race/ethnicity is incorporated:

Typical predictors used for the screener dwelling unit (DU) nonresponse adjustment were State, Quarter, Group-Quarters Indicator, Population Density, Percentage Hispanic or Latino in Segment, Percentage Black or African American in Segment, Percentage Owner-Occupied DUs in Segment, and Segment-Combined Median Rent and Housing Value, which is also called the Socioeconomic Status (SES) indicator. The SES indicator was a composite

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4 Recall from above that at least among recent arrestees, those who responded to the past-month residence question “NO FIXED RESIDENCE OR HOMELESS” had a positive rate (47 percent) that was similar to those who reported “SOMEONE ELSE'S HOUSE/MOBILE HOME/APT” (55 percent).
measure based on (standardized) median rent, median housing value, and the percentage of dwellings that are owner occupied. Typical predictors for the person-level nonresponse adjustments were, in addition to those stated previously, Age, Gender, Race, Hispanicity, and Relation to Householder (i.e., the head of the household). For poststratification, predictors typically used were State, Age, Race, Gender, Hispanicity, and Quarter. In all cases, the model consisted of main effects and some interactions of these predictors. For a separate extreme weight adjustment with the generalized exponential model after poststratification, the predictors were the same as those used in the poststratification adjustment. (Chen et al., 2011, p. 9)5

To argue that user estimates should be inflated to account for nonresponse, one has to make the case that nonresponders are more likely to use marijuana than responders and argue that SAMHSA’s nonresponse adjustments do not fully account for this.

Research conducted on NHSDA (the predecessor to NSDUH) nonresponse suggests that nonresponse is not a large concern for marijuana. Gfroerer et al. (1997) linked 1990 NHSDA nonrespondent cases with data from the 1990 Decennial Census and found that “the high screening response rate and the small differences among demographic groups suggest that screening nonresponse is not likely to result in biased drug use estimates in the NHSDA.”6 The issue could be nonresponse by those chosen to be interviewed, but the bias cuts in both directions:

[I]t is not always the case that low response rates occur in conjunction with high drug use prevalence. Some populations with low response rates (e.g., older adults and high-income populations) tend to have low rates of drug use. On the other hand, some populations (e.g., large metro residents and men) have low response rates and high drug use rates. In estimating overall prevalence, many of these potential sources of bias would be in opposite directions and would therefore tend to cancel each other. (Gfroerer et al., 1997, pp. 291–292)

At this point we do not have enough information to quantify this adjustment factor. We are, however, encouraged that screening and recruitment procedures have improved over time.

Misreporting by Those Surveyed

Misreporting by those who do respond to the survey is the most discussed issue in the scientific literature, and it is the exclusive focus of ONDCP’s (2012) adjustment mentioned above. There is a moderately large literature comparing self-reports to biological tests (e.g., urinalysis), but arrestees and treatment populations have been studied more than general

---

5 Note that segments are smaller than census tracts.
6 “The Census Match Study involved linking 1990 NHSDA nonrespondent cases with data from the 1990 Decennial Census. Household and individual data for NHSDA nonrespondents were obtained from the Census and used to characterize NHSDA nonresponse patterns in detail. A multilevel logistic model of response propensity identified the important predictors of nonresponse, including characteristics of the sampled person, the selected household, the neighborhood, and the interviewer.”
populations, and the literature finds that misreporting varies across populations and settings for data collection.

Hence, the Harrison et al. (2007) study comparing self-reports with biological test results for a household sample rightly attracted considerable attention, albeit with two caveats: (1) Harrison et al. (2007) sampled only 12–25 year olds, not all ages, and (2) Harrison et al. (2007) did their study with the old (NHSDA) household survey protocol, not its current form (NSDUH).

More specifically, in 2000–2001 Harrison et al. surveyed 6,000 respondents aged 12–25 in a manner parallel to the NHSDA, but then asked for urine and hair samples. Harrison et al. report that 39.1 percent of those testing positive for marijuana denied using marijuana in the previous month, suggesting substantial underreporting.

ONDCP (2012, p. 9) argues that “Presumably few respondents would say they used marijuana when they had not.” So they assume that past-month users can be found as the union of those who self-report past-month use and those who test positive.7

However, while some people self-report no use but nonetheless test positive, there are even more people who test negative but nonetheless report past-month use. Hence, more people self-report past-month use than tested positive (12.7 percent versus 11.3 percent). It is easy to reconcile past-month use with a negative test; while heavy users may test positive for up to 30 days, the detection window for non-heavy use is only 2–7 days. However, Harrison et al. (2007) also found many people who self-report recent use, within the last seven days or three days, and yet also test negative. In particular:

\[
0.71 = P\{ \text{test positive} | \text{self-report use in last 7 days} \}
\]
\[
0.78 = P\{ \text{test positive} | \text{self-report use in last 3 days} \}.8
\]

Since (1) most of those using within the last 72 hours are frequent users and (2) even light users will often test positive if they used within the last few days, it appears that there is indeed some overreporting. Overreporting is not unheard of. For example, Williams and Nowatzki (2005) report that 40/119 (34 percent) of adolescents reporting cannabis use within its detection window nonetheless tested negative.

**Implications for the Adjustment Factor**

The central finding from Harrison et al. (2007, p. 61) is supported by Table B.2. The oft-quoted 39-percent underreporting rate is the 4.4/(4/4 + 6.9).

---

7 ONDCP (2012) has a variant that counts as users some who both self-report no use and test negative, but they do not do much with that variant.

8 This phenomenon is not unique to the Harrison et al. (2007) sample. In ADAM-2 data, P\{ test positive | self-report use in last 30 days \} = 80.4 percent; P\{ test positive | self-report use in last 7 days \} = 85.8 percent; and P\{ test positive | self-report use in last 3 days \} = 89.4 percent.
Table B.2. Harrison et al. (2007) Findings

<table>
<thead>
<tr>
<th>Urinalysis result</th>
<th></th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-day self-report on core questions</td>
<td>-</td>
<td>82.9%</td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>5.8%</td>
</tr>
<tr>
<td>n</td>
<td>3,342</td>
<td>418</td>
</tr>
</tbody>
</table>

Source: Harrison et al., 2007, Table 5.1, p. 61.

ONDCP’s (2012) main approach assumes that none of the 82.9 percent used, but all of the 5.8 percent did. In that case, the adjustment relative to self-report is \((4.4 + 6.9 + 5.8) / (5.8 + 6.9) = 1.35\), which ONDCP “rounds down” to 1.33.

However, if some respondents were falsely reporting use, they should be deducted from the numerator. In particular, if one-in-ten of the 12.7 percent (5.8 + 6.9) reporting past-month use were lying, then the factor should be \((4.4 + 6.9 + 5.8 – 1.27) / (5.8 + 6.9) = 1.25\), not 1.35. Figure B.1 shows how this adjustment varies with the frequency of overreporting. Adjustments between 1.15 and 1.35 seem plausible.

But the underlying data are more than a decade old. As mentioned in the text, views about marijuana legalization as well as marijuana use have changed. Further, these figures are based on an older version of the survey, which has improved overtime. Thus, respondents may now be more honest about their marijuana use (especially in Washington, which has had a flourishing medical marijuana market for years). If so, this would suggest an adjustment closer to 1.

Figure B.1. Adjustment for Underreporting as a Function of the Overreporting Rate

Source: RAND analysis of data from Harrison et al., 2007.
Misreporting of Quantities Consumed

The fourth issue concerns whether those who admit to past-month use report the correct number of days of use. This final component, like the second, could be greater or less than 1.0. One typically thinks the bias would be toward underreporting frequency—e.g., reporting use on only a handful of days when in reality use was daily. But there is no logical or theoretical reason why the opposite could not occur. For example, Leigh et al. (1998) found that, relative to daily diary records, adolescents’ retrospective statements about the past month underreported their frequency of drinking but overreported their frequency of sexual activity. As far as we can tell, there is essentially no scientific literature on this last component, perhaps because there is no “gold standard” against which self-reports could be compared.

Summary

In sum the four components and their values are:

Component #1: 1.018–1.06
Component #2: Unknown; previous research suggests it could be greater or less than 1.0
Component #3: Perhaps in the range 1.0–1.35
Component #4: Unknown; could be greater or less than 1.0.

A useful way to think about the combined effect of all four components is as the product of four uncertain numbers (i.e., four “random variables”). If the four uncertainties can be considered one at a time (i.e., are “independent”), then the expected value of the combined effect is just the product of each component’s expected value: \((1.018 + 1.06) / 2 \times 1.0 \times (1.0 + 1.35) / 2 \times 1.0\), or 1.22.

But the issue of concern here is not just or mainly the “best guess” but rather what is a plausible range of values. If the second and fourth factors are seen as ranging from 0.9 to 1.1 but with 1.0 being the most likely value, then the combined effect of the four has a standard deviation of 0.13, with about 90-percent chance of falling between 1.02 and 1.43. That is, the second and fourth factors need to be recognized because they contribute to uncertainty in this factor, even if they are not believed to push it higher or lower, in expectation.

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9 More precisely, if they are modeled as following a “triangular” distribution over that range.
Appendix C. Insights About Marijuana Potency in Washington State

The potency of marijuana in Washington is of interest for three reasons: (1) In its own right, as an important characteristic of the market, (2) as a baseline so subsequent evaluations can judge whether the passage of Initiative 502 (I-502) affected potency, and (3) as input to judgments about the average quantity or weight of marijuana consumed per use day in Washington. To the extent that potency is higher in Washington, one might guess that the weight consumed per use day may be somewhat lower than elsewhere, because less weight would need to be consumed to get the same amount of tetrahydrocannabinol (THC).

Multiple datasets provide information about the potency of the marijuana consumed in Washington. None is ideal; there is no way to take a random sample of the universe of marijuana that is sold or consumed. However, this appendix presents potency information from a number of data sources and assesses whether they paint a consistent picture. Broadly speaking, the information suggests that 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. To the extent that is true, it may stem from a larger proportion of Washington users accessing higher-potency forms and varieties, and fewer using relatively low-potency imports. The sources and their key findings are:

1. The University of Mississippi (UMISS) data, which include lab results of 75,485 samples of cannabis and cannabis products seized by federal, state, and local agencies from 1967 to 2011. THC potency is markedly higher in these data in Washington as compared with either Oregon or the rest of the United States. That is primarily because a larger proportion of the observations are sinsemilla,10 but it is also the case that sinsemilla in Washington has higher THC content than sinsemilla elsewhere and, likewise, other marijuana in Washington has higher THC content than does other marijuana from elsewhere.

2. Data downloaded from Analytical 360 (2012), a marijuana testing facility in Seattle, show consistently high potencies comparable to, but slightly higher than, those seen in the UMISS data. The Analytical 360 data are composed solely of medical marijuana samples and thus contain a smaller proportion of low-potency marijuana.

3. The Cannabis Consumption Survey (CCS) respondents from the state of Washington report much higher THC concentrations than is thought to be typical of the U.S. market overall, but so do respondents from other states.

4. Data from the crowdsourcing website PriceOfWeed.com indicate that almost all respondents from Washington rated the marijuana they obtained as being of “high” or

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10 Sinsemilla refers to a particular type of high-potency marijuana product, namely flowering tops from unpollinated female cannabis plants, which produce more THC-rich resin.
“medium” quality, but that was also true of respondents in most other states. That would seem to indicate that the subset of users who participate in such surveys accesses fairly high-end products throughout the country, although it is also possible that what users think of as “high” potency may vary from state to state, with users in Washington reserving the term for marijuana that exceeds a higher potency threshold.

These sources do not provide a single clear and consistent story. Nonetheless they can be reconciled as follows. The national market has at least three categories of products listed in order of increasing potency: imported commercial grade, domestically grown high-grade general marijuana, and high-potency sinsemilla (which is primarily domestically grown, but with some imports, e.g., from British Columbia).11

We find little evidence of low-grade marijuana in Washington state, and law enforcement reports suggest that the Washington market may have much less of the relatively low-potency imported commercial grade than does the country as a whole.12 (Kilmer et al. [2010] estimates that at least as of 2008 Mexican imports probably accounted for 40–67 percent of the national market by weight).

Law enforcement reports also suggest that high potency “BC Bud” is likewise less common than it once was. However, Washington has large-scale domestic production from three sources: semi-legal medical growers, purely illegal indoor growers (stereotypically associated with Asian crime gangs), and purely illegal outdoor growers (stereotypically associated with Mexican organizations growing on public or Native American lands) (Northwest High Intensity Drug Trafficking Area, 2013).

This view is consistent with the UMISS data. Only 33 samples (2.1 percent, 800 kg) are kilobricks. Kilobrick observations are more common along the southwest U.S. border,13 so this may suggest a lack of Mexican-sourced marijuana in the Washington market. By contrast, 22.8 percent of all observations in the United States were kilobrick observations.

An absence of low-potency marijuana can be reconciled with the fact that user self-reports to both the CCS and the PriceOfWeed.com website indicate no meaningful difference between Washington and other states if those who participate in surveys are disproportionately marijuana “connoisseurs” who shun the relatively low-quality commercial grade marijuana. That is, those who participate in voluntary surveys about marijuana use may be using more or less similar products in all states, but they may account for only a subset of the market. And the quality difference between Washington and the rest of the country may be more salient for the general marijuana-using population who are not “connoisseurs,” with such individuals in Washington obtaining higher-potency marijuana than do their counterparts in other states.

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11 Perhaps one could further divide sinsemilla into medical grade and that which is produced by organized crime groups for the purely illegal market.

12 David Rodriguez, Director Northwest High Intensity Drug Trafficking Area, personal communication, June 7, 2013.

13 More than 70 percent of kilobrick observations come from California, Arizona, New Mexico, or Texas, whereas fewer than 30 percent of all the other major types come from those four states.
UMISS Data

Summary of Results

The marijuana potency data used here include observations through June 2011, with particular emphasis on the 1,671 observations from the state of Washington.

Cannabis observations in the UMISS dataset in Washington state tend to have higher THC potency than those from Oregon and elsewhere in the country. This appears to be mainly due to the composition of the observations. The UMISS dataset distinguishes between a number of types of marijuana, but “sinsemilla” and “marijuana” (not otherwise specified) are the most common, with sinsemilla generally being of higher potency. In this section, “marijuana” refers to the designation given to non-sinsemilla marijuana in this dataset. The (higher-potency) sinsemilla category constitutes a majority of the Washington data, while other forms of marijuana dominate the country as a whole. While sinsemilla and marijuana in Washington both appear to have higher THC levels than do those categories in the country as a whole, the composition effect seems to account for the majority of the difference in THC content overall.

Washington also shows a higher THC to cannabidiol (CBD) ratio than the rest of the country, even though CBD levels are, on average, the same as elsewhere. This is also likely explained by difference in composition. This ratio appears to have increased over time for all samples, but may be decreasing in Washington state sinsemilla over the past decade.

Data Description

Data in this section come from the UMISS’s Marijuana Potency Project lab. ElSohly et al. (2000) and Mehmedic et al. (2010) describe the data in more detail, but briefly: The dataset consists of the lab results of 75,485 samples of cannabis and cannabis products seized by federal, state, and local agencies from 1967 to 2011. Of these, 1,671 samples are from Washington state. Data fields include 45 descriptor or measurement variables, including the lab identifier. Variables include measurements for six cannabinoids, dates of seizure and testing, location seized, type of product (cannabis, hashish, hash oil), description (marijuana, sinsemilla, ditchweed, unknown), maturity, weight seized, and plant size measurements, if applicable. Location is typically available down to the state and/or county level.

All 1,109 observations labeled as coming from outside the United States or its territories were dropped. Additionally, any samples with zero values for all four main cannabinoid measurements (THC, CBD, cannabinol [CBN], cannabichromene [CBC]) were deleted, to not taint averages with null values. These observations typically have a NUM_ANAL = 0, indicating that the sample was not assayed quantitatively. Thus, zero values may indicate untested samples

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14 While samples interdicted on the high seas may have been bound for U.S. markets, there is no way in these data to identify those that were U.S.-bound; thus, they were dropped. Samples with no indication of origin were assumed to be part of the U.S. market.
or products damaged (such as by water). Lastly, an “N” or “NC” for the “MATURE” variable indicates “not cannabis”; thus, those samples were also deleted. The final dataset analyzed here included 72,029 samples, with 1,597 from Washington state and 2,993 samples from Oregon.

Among these remaining samples from Washington, 79.1 percent had variable CLASS = “PM,” indicating they were Drug Enforcement Administration (DEA) lab samples and 20.9 percent had CLASS = “ST,” indicating they were state eradication program samples. Only 4.2 percent of samples were of hashish or hash oil, while the rest were classified as cannabis. The majority of samples were sinsemilla or marijuana (DESC variable = “SM” or “MH,” respectively), but there were small numbers of samples of ditchweed, hash and hash oil, and Thai sticks.15

Table C.1 Distribution of UMISS Observations, by Type of Cannabis Product for Washington, Oregon, and the United States

<table>
<thead>
<tr>
<th></th>
<th>Sinsemilla</th>
<th>Marijuana</th>
<th>Ditchweed</th>
<th>Hash/Hash Oil</th>
<th>Thai Stick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington</td>
<td>54.4%</td>
<td>40.9%</td>
<td>0.5%</td>
<td>4.2%</td>
<td>&lt; 0.1%</td>
</tr>
<tr>
<td>Oregon</td>
<td>27.7%</td>
<td>67.8%</td>
<td>3.5%</td>
<td>0.9%</td>
<td>&lt; 0.1%</td>
</tr>
<tr>
<td>United States</td>
<td>15.8%</td>
<td>78.6%</td>
<td>3.7%</td>
<td>1.8%</td>
<td>&lt; 0.1%</td>
</tr>
</tbody>
</table>

For the entire United States, 68.0 percent of samples had variable CLASS = “PM,” indicating DEA lab samples, and 32.0 percent had CLASS = “ST,” indicating state eradication samples. The U.S. samples were overwhelmingly commercial-grade marijuana, with a smaller percentage of sinsemilla than the Washington samples.

A larger majority of Oregon samples resulted from state eradication (79.0 percent) than federal sources (21.0 percent). Oregonian cannabis types more closely mirrored the composition of national samples than those in Washington.

When calculating THC averages, ditchweed samples and those with a zero value for THC were omitted. Ditchweed is assumed not to be part of the cannabis market. Thus, in the rest of this section “all cannabis” refers to all samples except ditchweed.

Samples with “unknown” or blank fields in the “MATURE” variable were included with mature samples, since they were assumed to be on the market for use.16

Small sample sizes limit certain analyses, particularly in years prior to 1998 and for certain variables, such as Thai stick–type cannabis.17

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15 A Thai stick is a particular type of processed marijuana, of which only one observation is found in the Washington data.

16 If maturity is unknown, it is likely that the product of the sample has been processed in some way and thus likely harvested at maturity for distribution.

17 From 1998 on, each year has at least 20 observations with THC measurements in Washington state. Earlier observations vary from 1 in early years of observations to 56. Graphs start generally from 1975, the first year with
Samples that did not include an indicator for year seized numbered 5,487. They were assigned the year seized as indicated in the “dat.corr” variable. The last year with both a “YR_SZ” indicator and cannabinoid measurements for Washington samples is 2010, making more recent analysis on potency impossible.

**Recent Washington Data**

Figure C.1 shows histograms of the frequencies of all THC levels in samples from the state of Washington and the United States for 2008–2010, the three most recent years represented in the data. While Washington’s average and median THC content is 12.6 percent, the range is from less than one to more than 30 percent, with three-quarters of the observations’ potency falling between 4.7 percent and 19.3 percent. Note that commercial-grade marijuana tends to dominate the lower range of potencies, thus lowering the overall average and median of THC content.

While the average THC content of sinsemilla in the United States is 12.8 percent during this period, the average falls to 8.9 percent when other types of marijuana are included. Even though Washington’s sinsemilla average is still higher than that of sinsemilla nationwide (at 13.4 percent), these histograms reinforce the fact that composition matters when looking at THC potency overall.

**Figure C.1. Frequency of THC Content in Washington (Left) and USA (Right), 2008–2010**

Source: Author’s analysis of UMISS (2013) data.
Note: X-axes are samples’ THC content (percentage), and the y-axes indicate the number of observations.
Figure C.2 shows that CBD potencies were consistently low in the Washington sample from 2008–2010, including 40 samples with a listed potency of zero. The average CBD content is 0.11, while the median is only 0.05. The range is from zero to 3.9 with three-quarters of the observations’ potencies falling between zero and 0.1.

![Figure C.2. Frequency of CBD Content in Washington, 2008–2010](image)

CBD levels nationwide average a little higher at 0.33, but the median is comparable over these years at 0.06. CBD does not seem to vary greatly when comparing Washington to the country as a whole; both areas show generally low levels with a long right tail of higher CBD levels.

**THC Potency Trends**

Washington state average THC over all types has increased over time. Figure C.3 plots the average THC potency, along with dashed lines showing two standard deviations on either side of the mean, all smoothed with three-period smoothing.

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18 Ten samples had blank CBD levels and were not included in this graph or the summary statistics.

19 Averages and standard deviations were first calculated for each year, after which each year’s average and average +/- 2 standard deviations were averaged with the prior and next years’ values.
Figure C.3. Washington THC Potency (Percentage) Over Time

![Graph showing THC potency over time in Washington, with data points indicating a trend of increase over the years.](image)

**Source:** Author’s analysis of UMISS (2013) data.

Not only has THC potency increased over time in the state of Washington, but it increased sooner than in the rest of the United States and Oregon, as shown in the three-period smoothing of THC potency information for those three areas (Figure C.4).

Figure C.4. Average THC Potency (Percentage) Over Time

![Graph showing average THC potency over time for Washington, Oregon, and the USA.](image)

**Source:** Author’s analysis of UMISS (2013) data.

A major reason is that sinsemilla continues to compose a greater proportion of the market in Washington than elsewhere. Over time, and particularly since 2001, sinsemilla samples increased
in this dataset both in number and as a proportion of all samples. Figure C.5 illustrates the number of samples with THC measurements of mature and immature marijuana and mature sinsemilla.

**Figure C.5. Washington State Sample Counts, by Type**

![Graph showing sample counts](image)

Source: Author’s analysis of UMISS (2013) data.

Note: SM = sinsemilla; MH = marijuana.

While the proportion of sinsemilla observations nationwide is also increasing (Figure C.6), nearly half of the observations continue to be marijuana, as compared to 28 percent of the Oregon samples and 10 percent of Washington samples in 2009. All three locations show a spike in immature samples from 1995–2001; one guess is that this may result from increased eradication efforts during that time and possible reallocation of resources after September 11, 2001.

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20 These data only include marijuana and sinsemilla, excluding hashish, hash oil, and other samples.
The composition of Oregon samples follows the pattern of increased sinsemilla and fairly steady sample counts of commercial-grade marijuana (Figure C.7).
Both the marijuana and sinsemilla cannabis categories exhibited greater THC potency in Washington than in Oregon and the United States as a whole, as seen in Figure C.8.

**Figure C.8. Average THC, by Type**

![Average THC by Type](image)

Source: Author’s analysis of UMISS (2013) data.  
Note: SM = sinsemilla; MH = marijuana.

Even when using the most uniform group of samples—only DEA-sourced (CLASS= “PM”) sinsemilla since 2000—the average THC content in the state of Washington still appears to be higher than the average THC content nationwide. Conversely, average CBD content in Washington remains lower than CBD levels nationwide. The net result is a higher THC to CBD ratio in Washington sinsemilla than that among sinsemilla nationwide. That is not a new situation. Indeed, a combination of stabilized THC levels and slightly rising CBD levels in the UMISS samples from the last decade show a decreasing average THC to CBD ratio in the state of Washington.

**Analysis of Analytical 360 Testing Data**

Analytical 360 tests useable marijuana and other cannabis products in Seattle for the medical marijuana market. We downloaded the 751 samples of “flowers” (useable marijuana) from their website on June 12, 2013, and examined the recorded THC content. The samples ranged in date of tests from April to June 2013.

This analysis finds a significantly higher THC content than indicated by the most recent UMISS data. The average THC content was 14.7 percent and the median was 15.1 percent, with
a range from 0.3 percent to 25.9 percent. The distribution of potencies was fairly uniform from zero to 8 percent, and followed an approximately normal distribution above that threshold, as shown in Figure C.9. It is possible that the low THC samples represent a part of the medical market that favors high CBD over THC for particular ailments. However, of the 696 samples with content higher than 8 percent, the average THC content was only slightly higher, at 15.4 percent, with a standard deviation of 3 percent.

Figure C.9. THC Potencies of Flower Samples from Analytical 360

![Figure C.9. THC Potencies of Flower Samples from Analytical 360]

Source: Author’s analysis of Analytical 360 data.
Note: X-axis is samples’ THC content (percentage), and the y-axis indicates the number of observations.

Self-Report Data from the Cannabis Consumption Survey

The CCS is described in Appendix A of this report. The survey asked respondents to report the THC potency in the cannabis they use. There are two obvious and significant limitations of these data. First, the data come from self-reports, which may be unreliable. They may also overrepresent purchases from sources (such as medical access points) that test and label their products. Second, the respondents are not a random or representative sample of the overall cannabis market.
The analysis here focuses on four questions:

1. **Know_thc**: “THC is the abbreviated name for the main psychoactive ingredient in marijuana. Now we want to talk about the type of marijuana you most recently purchased. Do you know the amount of THC that was in the amount you last purchased?”
   (Answers included “Yes, I’m confident I know the % THC,” “Maybe. I’m somewhat confident I know about how much % THC,” “No, I do not know,” and Not Applicable.)

2. **Thc_pct**: “What is your best estimate of the % THC of your most recent marijuana purchase? (Answers included all integers up to 30 percent, and then ten-percentage point ranges for 31–40 percent, 41–50 percent, etc.)

3. **Thc_str**: “If you had to guess about the potency (amount of THC) that was in the marijuana you most recently purchased, would you say it was?” (Possible responses being “Very strong,” “Strong,” “Medium strength,” and “Low strength [e.g., Ditchweed]”).

4. **Thc_typ**: “Is this THC-level more than, about the same as, or less than what you typically purchase?” (Possible responses were “More,” “About the same,” or “Less”)

The basic conclusion is that survey respondents in Washington state reported quite high THC potencies, but so did their counterparts from other states. So it is not clear whether Washington has much higher potency overall; that depends in part on the proportion of users in each state who have similar characteristics to those responding to the survey, and on the accuracy of these survey reports.

**THC Content Reported by Marijuana Users in Washington**

We examined responses for the 485 marijuana users (variable init_MJ not equal to 1) in Washington state (wa_state = 1) who were confident or somewhat confident they knew the amount of THC in their last purchase (know_thc = 1 or 2), 418 of whom answered the question thc_pct.\(^{21}\) The respondents clearly believe that they are purchasing high-potency marijuana, as shown in Table C.2.

\(^{21}\) Aside: Most (429 out of 485) described the THC of that purchase as being about the same (thc_typ = 2) as what they typically purchase, with the others roughly equally split between those who said it was more (27) or less (22) potent (with seven blank responses).
Table C.2. THC Content Responses to CCS

<table>
<thead>
<tr>
<th></th>
<th>Very Strong</th>
<th>Strong</th>
<th>Medium</th>
<th>Low Strength</th>
<th>(blank)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>102</td>
<td>236</td>
<td>77</td>
<td>1</td>
<td>2</td>
<td>418</td>
</tr>
<tr>
<td>Percentage below 10% THC</td>
<td>3%</td>
<td>3%</td>
<td>12%</td>
<td>100%</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>Average THC reported</td>
<td>30.4</td>
<td>19.6</td>
<td>17.0</td>
<td>9.0</td>
<td>16.5</td>
<td>21.7</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>22.1</td>
<td>11.3</td>
<td>9.5</td>
<td></td>
<td></td>
<td>15.3</td>
</tr>
<tr>
<td>Mode</td>
<td>20.0</td>
<td>18.0</td>
<td>15.0</td>
<td></td>
<td></td>
<td>18.0</td>
</tr>
<tr>
<td>Average if maximum capped at 35%</td>
<td>23.0</td>
<td>18.2</td>
<td>16.3</td>
<td>9.0</td>
<td>16.5</td>
<td>19.0</td>
</tr>
</tbody>
</table>

The 30.4 percent average THC reported by the 102 respondents describing the marijuana as “very strong” merits caveat, because it is heavily influenced by 14 people reporting the potency was over 70 percent; such reports are either false or pertained to butane hash oil or some other extract, not to basic usable marijuana.

Only 182 described their most recent purchase as “bud” or “flower” or some variant thereof, with 153 of them answering the thc_pct question. (Many described buying bud and something else; they are not included in the 182.) The results for those 182 are shown in Table C.3.

Table C.3. THC Content of Buds or Flowers

<table>
<thead>
<tr>
<th></th>
<th>Very Strong</th>
<th>Strong</th>
<th>Medium</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>29</td>
<td>90</td>
<td>34</td>
<td>153</td>
</tr>
<tr>
<td>Percentage below 10% THC</td>
<td>3%</td>
<td>2%</td>
<td>6%</td>
<td>3%</td>
</tr>
<tr>
<td>Average THC reported</td>
<td>23.7</td>
<td>19.0</td>
<td>16.9</td>
<td>19.4</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>14.6</td>
<td>9.8</td>
<td>9.6</td>
<td>11.0</td>
</tr>
<tr>
<td>Mode</td>
<td>20.0</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
</tr>
</tbody>
</table>

It is not particularly interesting to break these down by type of user because 115 of the 153 were daily/near-daily users, leaving insufficient sample sizes for the less frequent users. Reported THC for those with a medical access card is less variable (fewer very low and fewer very high values) than for those who do not have an access card, which makes sense as access points generally label their products. Likewise, 95 percent of those saying they purchased most recently from a medical access point reported a potency of 12–25 percent, whereas only 79 percent of those buying from a friend or family member and just 69 percent of those buying from a dealer described the potency as falling within that range.

These results indicate that respondents report that their purchases have very high THC as compared to typical values reported for the country as a whole. That does not show that potency is in fact unusually high in Washington, because those who respond to the survey may differ
from users who do not and/or because everyone may inflate reports of the quality of their purchases. It is worth contrasting responses of those in Washington state with those outside of the state (see Table C.4). Doing so reveals that there are no substantial differences.

Table C.4. Comparison of THC-Content Responses in Washington and Elsewhere

<table>
<thead>
<tr>
<th></th>
<th>Washington</th>
<th>Elsewhere</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>153</td>
<td>50</td>
<td>203</td>
</tr>
<tr>
<td>Percentage below 10% THC</td>
<td>3%</td>
<td>6%</td>
<td>3%</td>
</tr>
<tr>
<td>Average THC reported</td>
<td>19.4</td>
<td>20.5</td>
<td>19.7</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>11.0</td>
<td>11.0</td>
<td>11.1</td>
</tr>
</tbody>
</table>

PriceOfWeed.com Data

PriceOfWeed.com is a crowdsourcing website that allows the public to enter the price, quantity, quality, and location of their marijuana purchases. We downloaded a year’s worth of observations (May 2012–May 2013) from the site for Washington state.

Each observation includes the location of the purchase, price, weight (1 gram, 10 grams, half an ounce, etc.), quality (low, medium, high), and date. Thirty-six of Washington state’s 39 counties are represented, with the greatest number of observations in King County (location of Seattle), Pierce County (just south of King County), and Snohomish County (just north of King County). Just over half (52 percent) of the 2,116 purchases were of an ounce of marijuana. Almost all observations were described as being of medium quality (50.5 percent of the observations) or high quality (46.9 percent); only a relative handful are described as being of low quality (54 observations or 2.6 percent of the data).

The paucity of low-quality observations is not unique to Washington state. As Figure C.10 shows, none of the western states had many observations described as “low quality,” and the greatest numbers seemed to come from states along the southwest U.S. border. For example, Oregon and California have a comparably small number of low-quality observations, at 3.2 percent and 2.2 percent, respectively.

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22 We thank Susan Andrzejewski for important contributions to this section.
There is a modest but fairly consistent difference in prices reported in Washington based on the reported quality of the marijuana, with the price for high quality being on average only 7 percent more than for medium quality.

There were no obvious differences in price or quality before I-502 passed compared with after. Before I-502 the average price was $123 per ounce, while the average price after was $129. High-quality observations made up 50.9 percent of the observations before I-502, and 49.9 percent after I-502.

There are major differences in socio-demographics and marijuana use between the eastern and western parts of the state. Each side of the state also has a different U.S. Attorney, with the eastern one seen as stricter with respect to marijuana enforcement (Kaminsky, 2013). Nonetheless, there appear to be at most rather modest differences between the two sides of the state in terms of price and quality, as reflected in PriceOfWeed.com data.

Table C.5 shows prices based on location as well as quality. High-quality marijuana costs more in the east, but only $6 more on average for all quantities, whereas medium-quality marijuana is less expensive in the east. One possible explanation—assuming the medium-quality marijuana is outdoor grown—is that marijuana is cheaper closer to where it is grown, since outdoor growing is concentrated in the east, whereas the west typically grows indoor, higher-quality marijuana. However, the prices are highly variable, and by a Student’s t-Test, the differences are not statistically significant.

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23 Data from May 25, 2012, to November 6, 2012, are considered “before” and data from November 7, 2012, to May 24, 2013, are considered “after.”

24 This sentiment was also repeated throughout conversations with medical marijuana industry members and law enforcement personnel.
Table C.5. Price of Marijuana in Washington, by Location and Quality

<table>
<thead>
<tr>
<th></th>
<th>East (n = 315)</th>
<th>West (n = 1,379)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High quality</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st quartile</td>
<td>$98</td>
<td>$55</td>
</tr>
<tr>
<td>Median</td>
<td>$156</td>
<td>$150</td>
</tr>
<tr>
<td>3rd quartile</td>
<td>$200</td>
<td>$200</td>
</tr>
<tr>
<td><strong>Medium quality</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st quartile</td>
<td>$40</td>
<td>$50</td>
</tr>
<tr>
<td>Median</td>
<td>$70</td>
<td>$100</td>
</tr>
<tr>
<td>3rd quartile</td>
<td>$160</td>
<td>$181</td>
</tr>
</tbody>
</table>


ONDCP—See Office of National Drug Control Policy.


SAMHSA—See Substance Abuse and Mental Health Services Administration.


