Exhibit D

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January 2016

» Marijuana Report

Marijuana use, attitudes and health effects in Oregon

Oregon Health Authority
PUBLIC HEALTH DIVISION

Acknowledgments

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Executive summary

In November 2014, Oregon voters passed Measure 91 to legalize non-medical retail marijuana sale in the state. The Oregon Health Authority's Public Health Division created this report to provide current data on marijuana-related public health surveys and other measures. This report summarizes readily available data sources that describe marijuana use, attitudes and health effects. These data shed light on the public health impacts of marijuana use and create a baseline in order to monitor trends over time.

Key findings from this report

Many young people and adults in Oregon currently use marijuana.

- Nearly one in 10 eighth-graders (9%) and approximately one in five 11th-graders (19%) report current marijuana use in 2015; this is comparable to national use patterns. More youth currently use marijuana than smoke cigarettes. Recent trends in youth use have been stable.
- Approximately half (48%) of Oregon adults report they have ever used marijuana. One in 10 (11%) Oregon adults report they currently use marijuana; use is higher among men (14%) than women (8%). Young adults are the highest reported use age group (18% among ages 18–24 years). Oregon's adult marijuana use is higher than the nation's adult use.
- Although multiple methods of marijuana use are practiced (including eating marijuana in food and "vaping" in electronic vaporizers), smoking is the most common method (approximately 90%).

Youth prevention efforts may be needed.

- 62% of 11th-graders report they have easy access to marijuana. Youth report that marijuana is easier to get than cigarettes.
- Nearly half of 11th-graders currently using marijuana that drive a car report that they drove within three hours of using marijuana in the past month.

Many adults report seeing marijuana marketing in communities; gaps exist in public knowledge of marijuana-related health risks and the law.

- Approximately half (51%) of Oregon adults had seen marijuana product or store advertising in their community in the past month; less than one-third (29%) had seen information about health risks of using marijuana.
- More than half of adults (61%) knew that 21 years or older is the legal age to use marijuana in Oregon, and more than half (59%) knew that it is still illegal to use marijuana in public spaces. However, nearly two-thirds (63%) said they didn't know when it is legal to drive after using marijuana.
- Three in four (75%) adults knew that driving under the influence of marijuana increases the risk of a traffic crash, and half (54%) knew that users that start young face greater health risks.

Many adults use marijuana for medical purposes.

- Annual numbers of medical marijuana patients have increased during the last 15 years, and 78,045 medical marijuana patients are currently registered in Oregon. The primary indication for use is severe pain. Few children or youth are registered as medical marijuana users.
- Three percent of adults report current medical marijuana use, making up less than one-third of total adult marijuana use.

Public health impacts have already been observed associated with legalization of marijuana.

- Marijuana-related calls to the Oregon Poison Center were stable from 2013 through mid-2015 and increased in the second half of 2015. From 2013–2015, calls for persons under age 13 increased.
- Marijuana-related arrests decreased from 2012 to 2015.

This is the first installment in a planned series of data reports. New information will be reported as it becomes available from these or other potential sources that provide greater understanding about marijuana and public health.

Purpose

Oregon has had a legal medical marijuana system since 1998, and voters approved legalized retail (non-medical, also known as recreational) marijuana in 2014. As marijuana distribution systems have become more publicly governed, the state and policymakers need information to support decision making about how best to serve public interest.

The Oregon Health Authority Public Health Division serves to protect Oregon's public health. The role of the Public Health Division relevant to marijuana includes:

- Understanding and minimizing the possible negative public health impacts of retail and medical marijuana products;
- Educating the public about health issues related to marijuana use;
- Protecting children and vulnerable populations from marijuana exposure;
- Preventing youth from starting to use marijuana;
- Monitoring marijuana use, attitudes and health effects.

The purpose of this report is to provide a first look at marijuana-related public health metrics for Oregon. This "baseline report" summarizes readily available information about marijuana use, attitudes and health effects. Future reports will describe changes over time in key indicators, and also provide information about some health measures that are not currently available.

This report, and future reports in the series, provide data that can be used by public health and community leaders to identify where action is needed to protect public health, and to monitor progress of those actions.

Note to readers: definitions

The following definitions guide readers in understanding the terms used throughout this document.

Marijuana: Marijuana (sometimes known as cannabis, weed or pot) is derived from the plant *Cannabis sativa.* The main psychoactive compound in marijuana is tetrahydrocannabinol (THC). Unless otherwise specified in this report, the term marijuana refers to any marijuana products, intended for either medical or recreational purposes.

Marijuana use: Unless otherwise specified, this means use of marijuana in any form. Marijuana is most commonly used by smoking dried flowers and leaves; it also can be consumed through ingesting infused foods or liquids, inhaling vapors from concentrates using an electronic device (e.g. "vaping"), inhaling smoke from extracts heated on a hot surface (e.g. "dabbing") or applying infused lotions or oils to skin.

Medical marijuana: This term refers to marijuana used for treatment of a disease or symptoms, as recommended by a physician. Medical marijuana products may not differ from non-medical products.

Substance use: Consumption of alcohol or drugs as a general group is sometimes called "substance use." In this report, the term is used in discussions about marijuana, alcohol and tobacco.

Current use: Current use of marijuana means any use of marijuana products, in any form, within the past 30 days. This is the standard definition on national and state health surveys for both youth and adults.

Confidence interval: Much of this report's data came from surveys. Surveys represent populations but, because surveys used here do not query every member of a population, we don't know the population's "true value." We use 95% confidence intervals in this report. This means we can be 95% sure the "true value" for a population falls within this range. In other words, if the survey sampling was done in the population 100 times, we would expect the "true value" to fall within this range 95 times. The larger the sample, the more confident we are of its value.

Confidence intervals also help to compare whether results from one group are significantly different from another group. In this report, when you see that the ends of gray "barbell" lines (representing the confidence interval) do not overlap between two groups, those measures are significantly different. When the gray "barbell" lines overlap between two populations, we cannot be sure that the populations truly differ without a more formal statistical test. (See Appendix A for more information about confidence intervals.)

Background

In November 2014, Oregon voters passed Measure 91 to legalize a non-medical retail marijuana market in the state; possession of limited amounts of marijuana by people aged 21 and older became legal in Oregon as of July 1, 2015. Possession and use of non-medical marijuana by youth (under age 21), driving under the influence of marijuana and using marijuana in public places remain illegal.

Retail stores that sell non-medical marijuana and marijuana products will not be opened and regulated until late 2016; however, limited early retail sales of marijuana (dried leaves and flowers, immature marijuana plants and seeds) were allowed through medical marijuana dispensaries beginning Oct. 1, 2015. (See "Resources" section at the end of this report for links to additional information about the law and oversight of medical and retail marijuana systems in Oregon.)

Multiple entities play a role in the regulation of marijuana in Oregon. Currently, medical marijuana dispensaries are registered with the Oregon Medical Marijuana Program (OMMP). The Oregon Liquor Control Commission (OLCC) began licensing retail marijuana facilities in 2016. Some cities and counties have passed ordinances that prohibit medical marijuana dispensaries or early retail sales within medical dispensaries, and these policies are monitored by the OMMP and OLCC.

As of Nov. 30, 2015:

- 333 medical marijuana dispensaries were registered with the Oregon Medical Marijuana Program:
  - 42% (139) of medical dispensaries were within Multnomah County.
  - 85% (283) of statewide medical dispensaries were participating in early retail sales of marijuana.
- Multiple Oregon communities have established local ordinances to further regulate marijuana distribution:
  - 11 counties (Crook, Douglas, Harney, Jefferson, Klamath, Malheur, Marion, Morrow, Umatilla, Union and Wheeler) prohibit medical marijuana dispensaries.

- Linn County prohibits early retail sales in its medical marijuana dispensaries.
- 40 Oregon cities have ordinances in place that prohibit medical marijuana dispensaries.
- An additional nine cities (Albany, Gresham, La Pine, Medford, Newberg, Reedsport, Scappoose, Sherwood and Tangent) prohibit early retail sales in their medical marijuana dispensaries.

Figure 1 shows the location of Oregon's medical marijuana dispensaries, including those participating in (dark blue) or not participating in (orange) the limited early retail sales that began Oct. 1, 2015. There are 138 total dispensaries in the city of Portland, 21 in Eugene, 18 in Bend and 17 in Salem. Other cities have fewer than 10 dispensaries.

Figure 2 shows regions that have banned medical dispensaries (shaded orange) and regions that have banned early sales through medical dispensaries (shaded dark blue). County-wide bans may not apply within the limits of some cities, depending on city-county agreements.

Figure 1: Oregon registered medical marijuana dispensaries and status of early retail sales, by city, Nov. 30, 2015

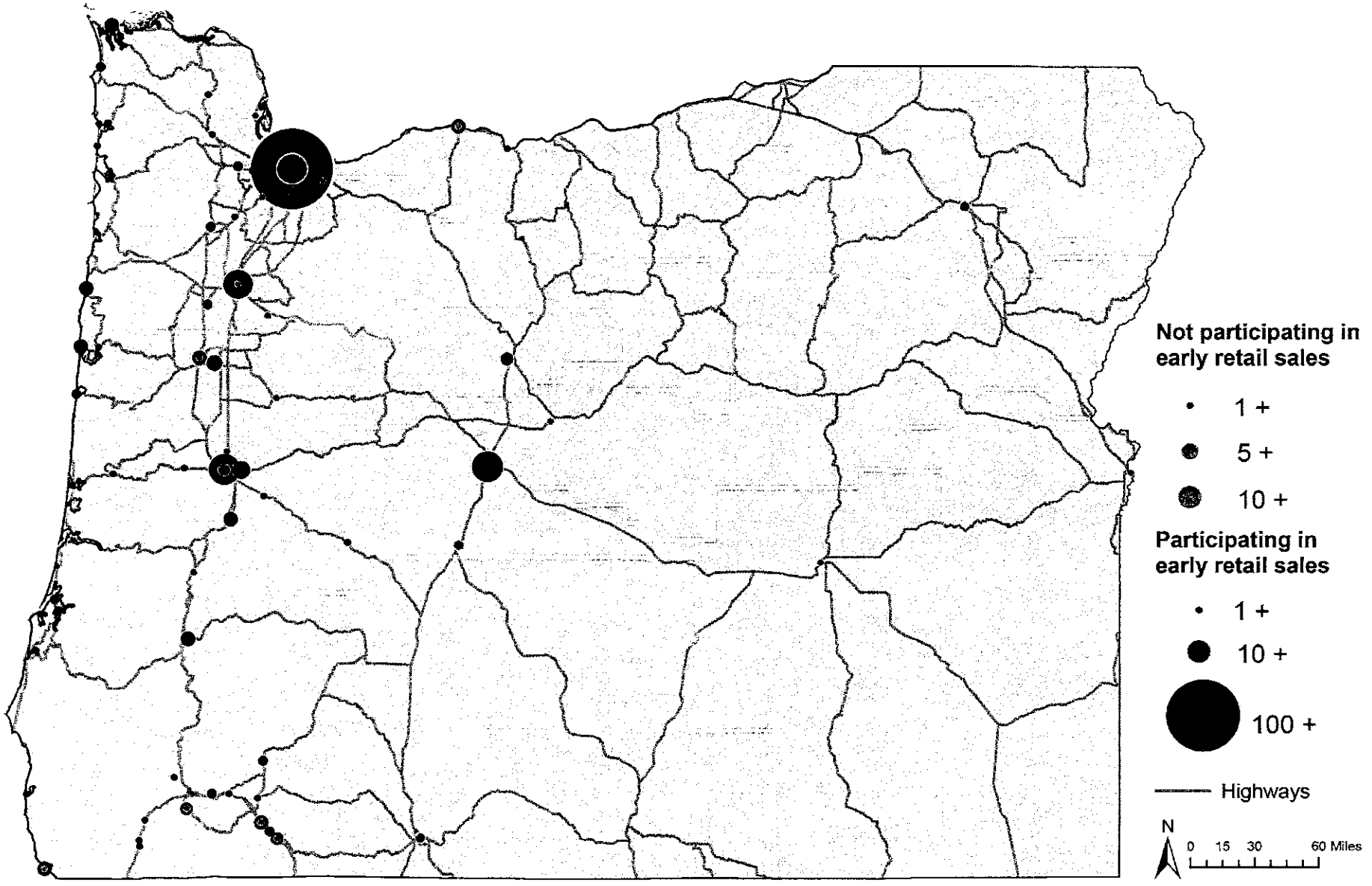
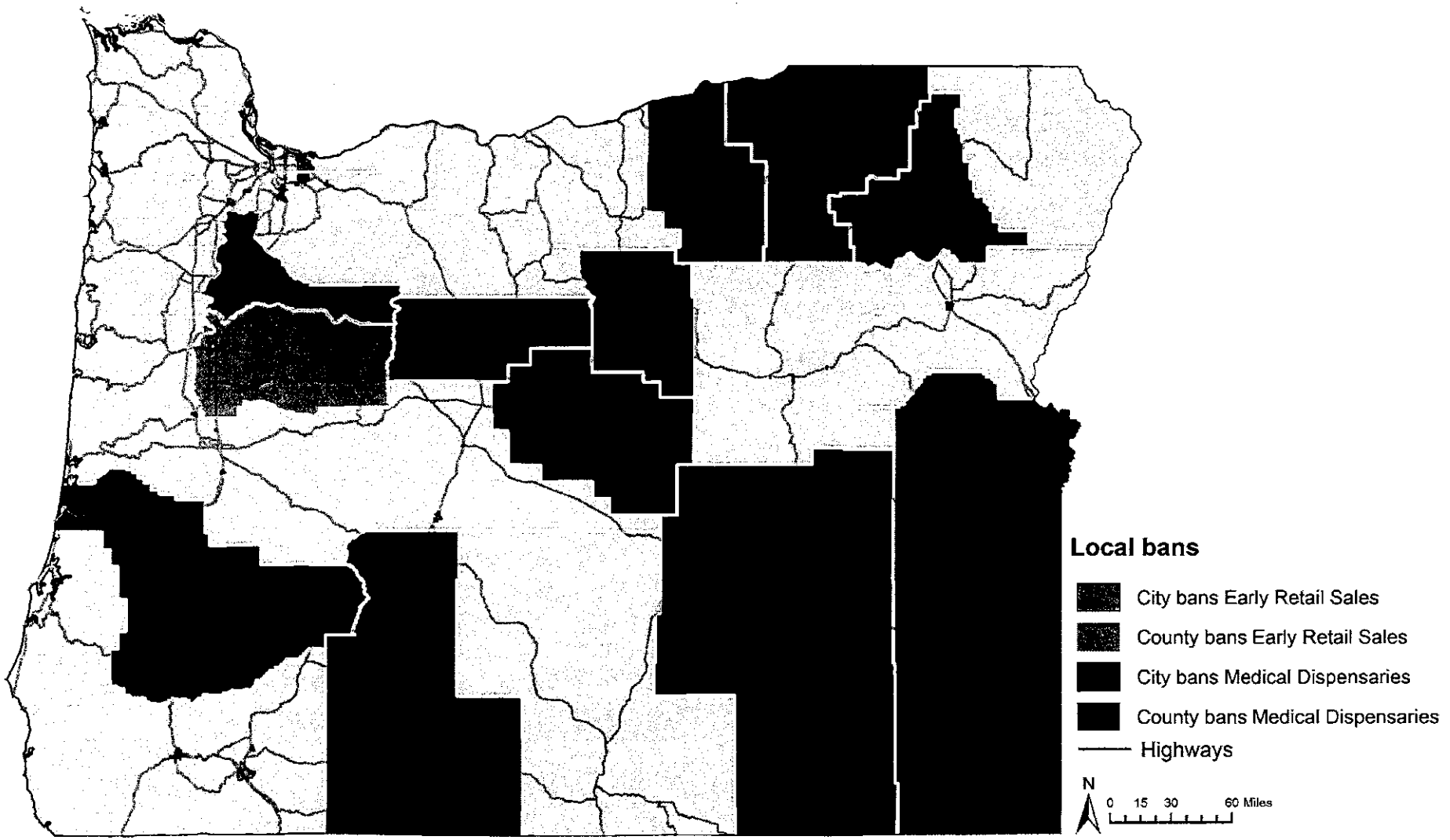


Figure 2: Local bans on medical marijuana dispensaries



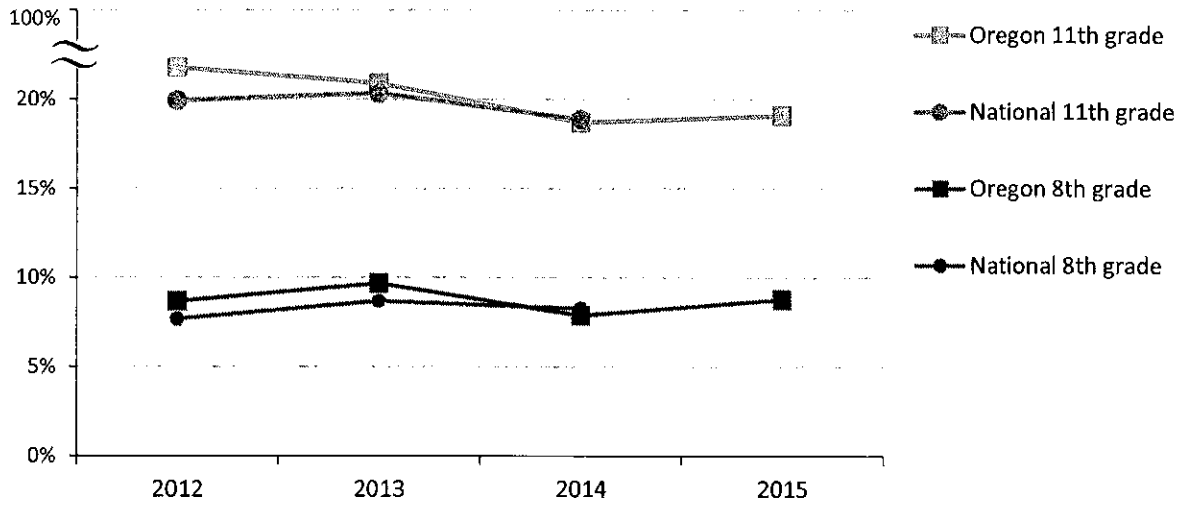
Behaviors

Youth use

Oregon's Student Wellness Survey (SWS) and Oregon Healthy Teens (OHT) are anonymous, school-based surveys conducted by the Oregon Health Authority. Both surveys contain multiple marijuana-related measures, including patterns of use. National youth data were obtained from Monitoring the Future (MTF), a similar school-based survey of U.S. secondary school students. Oregon's surveys collect data among eighth-graders and 11th-graders. MTF results for 10th-graders and 12th-graders were averaged to provide a national comparison for Oregon's 11th-graders.

On all youth surveys "current use" is defined as using marijuana on one or more of the past 30 days.

Figure 3. Current marijuana use among Oregon and U.S. youth, 2012–2015

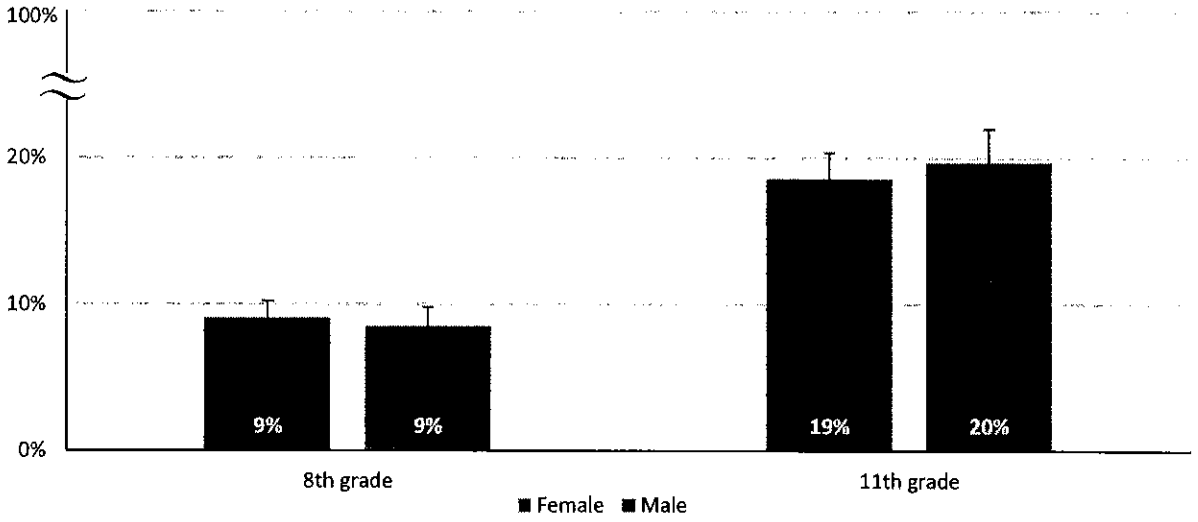


Data sources: Oregon data are from Healthy Teens Survey (2013 and 2015) and Student Wellness Survey (2012 and 2014). National data are from Monitoring the Future Survey (2012–2014)

As shown in Figure 3:

- Current marijuana use among Oregon eighth- and 11th-graders is similar to national estimates.
- From 2012–2015, nearly one in 10 eighth-graders, and approximately one in five 11th-graders, report current marijuana use each year.
- In 2015, 9% of Oregon eighth-graders and 19% of Oregon 11th-graders report current marijuana use.

Figure 4. Current marijuana use among Oregon youth, by grade and gender, 2015



Data source: Oregon Healthy Teens Survey, 2015

Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

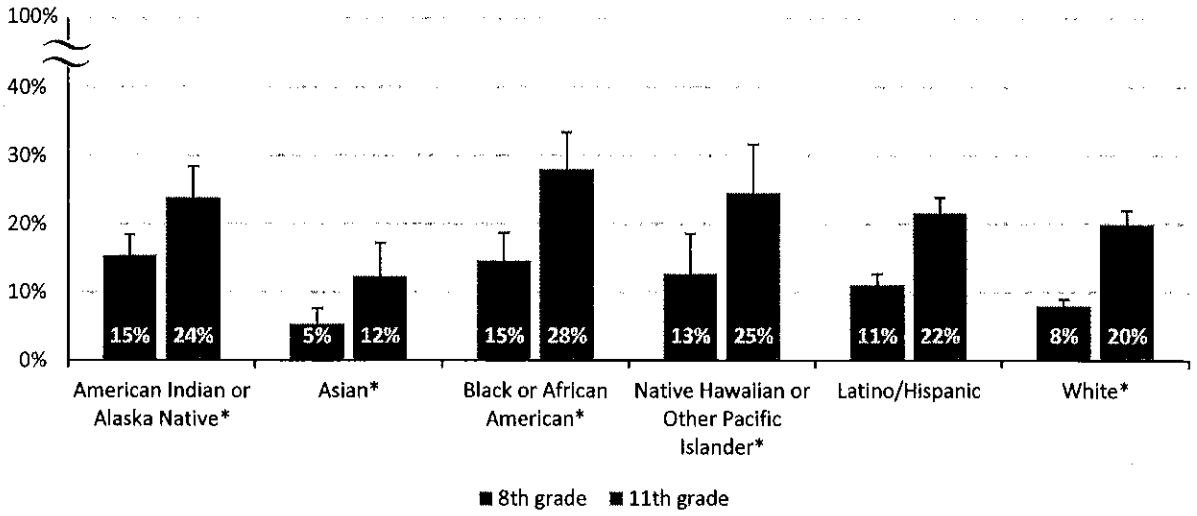
As shown in Figure 4:

- 11th-grade marijuana use was almost double that of eighth-grade student use.
- Marijuana use rates were similar between male and female students in both 8th and 11th grades.

Additionally, (data not shown):

- Among eighth-grade marijuana users, approximately two in five (41%) reported they used between one and two days in the past month; one-third (30%) reported they used on 10 or more days in the past month.
- Among 11th-grade marijuana users, approximately one-third (34%) reported they used between one and two days in the past month; and two in five (40%) reported they used on 10 or more days in the past month.

Figure 5. Current marijuana use among Oregon youth, by race and ethnicity, 2015



*Indicates non-Latino or non-Hispanic ethnicity. Racial groups were defined based on students' self-reported race, either alone or in combination with another race. Latino or Hispanic youth can be of any race.

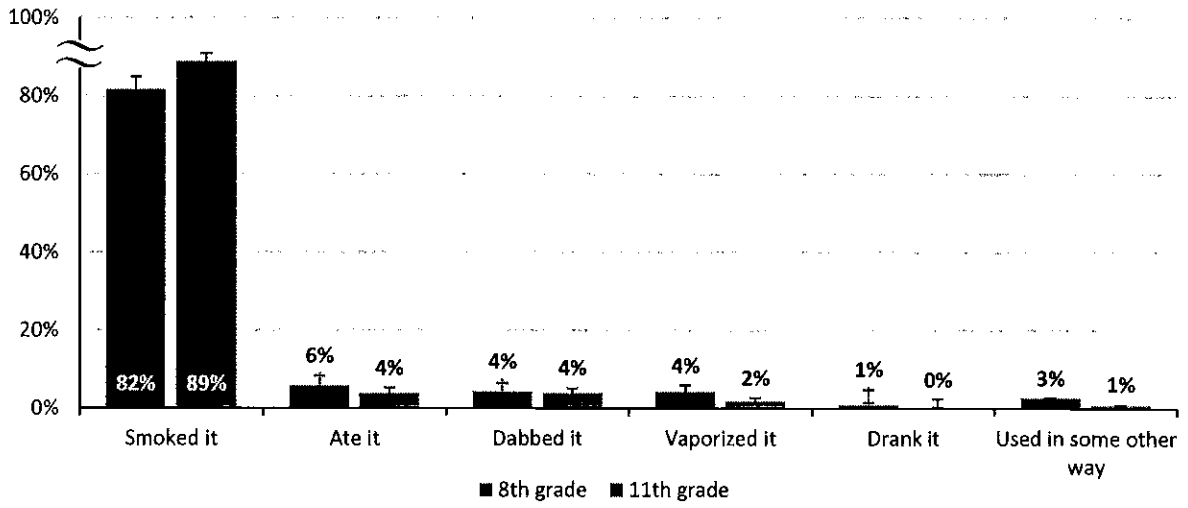
Data source: Oregon Healthy Teens Survey, 2015. Results are unweighted.
Error bars (I) *indicate 95% confidence intervals (see pages 5–6 for definition).*

As shown in Figure 5:

- During the 2015 school year, current marijuana use among Oregon youth varied by race and ethnicity.
- Among eighth-graders, current marijuana use was higher among students that identified as American Indian or Alaska Native, Black or African American, Native Hawaiian/Pacific Islander or Latino when compared to students that only identified as non-Latino White.
- Among 11th-graders, current marijuana use was higher among students that identified as Black or African American when compared to students that only identified as non-Latino White.

Figure 6. Usual mode of marijuana use among Oregon youth that currently use marijuana, 2015

Oregon students were asked, "During the past 30 days, if you used marijuana, how did you usually use it?" Students had to choose a single answer.



Data source: Oregon Healthy Teens Survey, 2015

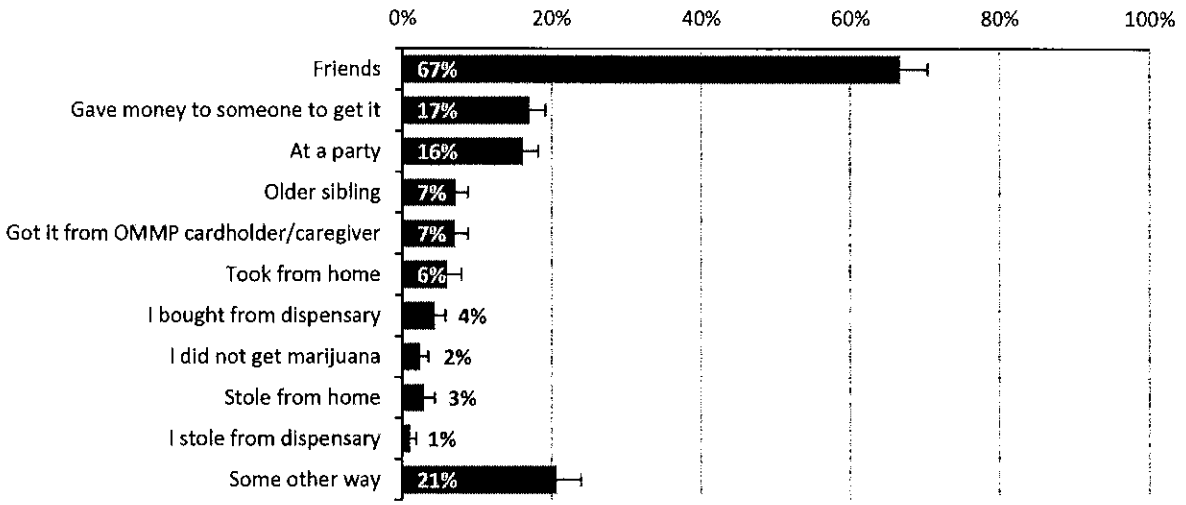
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 6:

- Most students reported smoking as their usual mode of use, followed by eating (edibles), dabbing (inhaling smoke from vaporized marijuana concentrate) and vaping (inhaling vapors from an electronic cigarette-like vaporizer or electronic device).
- A higher proportion of 11th-grade current marijuana users reported smoking marijuana compared to eighth-grade users.

Figure 7. Source of marijuana among 11th-grade current marijuana users in Oregon, 2015

Oregon students that used marijuana were asked, "During the past 30 days, how did you get marijuana?" Students could choose multiple answers.



Data source: 11th-grade Oregon Healthy Teens Survey, 2015

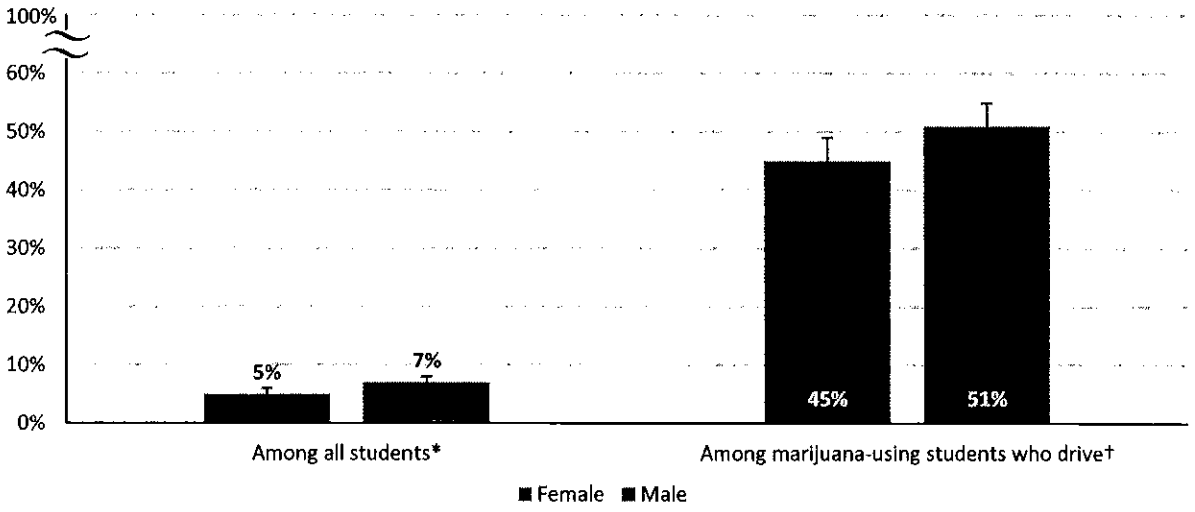
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 7:

- Among Oregon 11th-graders that currently use marijuana, the majority of students that gave a specific answer reported getting their marijuana from friends (67%), giving someone money to buy it (17%) or getting it at a party (16%).

Figure 8. Driving within three hours of marijuana use in past 30 days among Oregon 11th-graders, by gender, 2015

Oregon students were asked, "During the past 30 days, how many times did you drive a car or other vehicle within three hours after using marijuana?" One response option was, "I did not drive in the past 30 days." Youth that gave any other response besides this one were classified as "students who drive."



*All students includes all 11th-graders, regardless of whether or not they use marijuana.

†Drivers are defined as students that gave any response to question other than "I did not drive in the past 30 days."

Source: Oregon Healthy Teens Survey, 2015

Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 8:

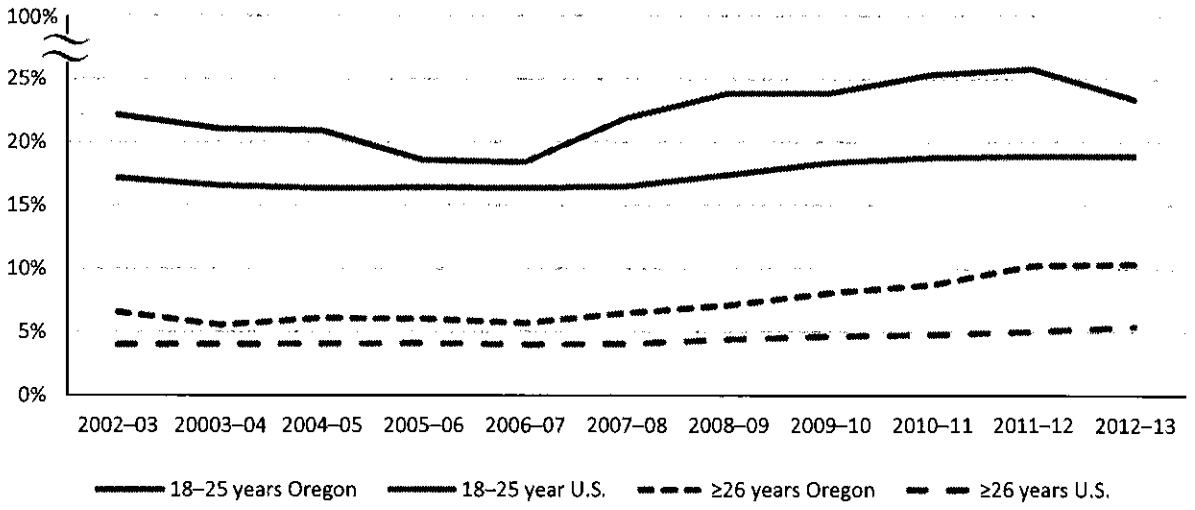
- Of all 11th-grade students, approximately one in 20 girls (5%) and one in 15 boys (7%) had driven within three hours of marijuana use in the past 30 days.
- Approximately one-third of all 11th-graders said they had driven in the past month (data not shown). Among the subgroup of 11th-graders that had both driven a vehicle and used marijuana in the past month (not necessarily at the same time), half of boys (51%) and nearly half of girls (45%) had driven within three hours of marijuana use.

Adult use

The National Survey on Drug Use and Health (NSDUH) is a federally sponsored survey that provides national and state-level data on the use of tobacco, alcohol and illicit drugs and mental health in the United States. This survey has measured adult marijuana use for multiple years.

Adults are classified as "current marijuana users" if they report using on one or more of the past 30 days.

Figure 9. Current marijuana use among Oregon and U.S. adults, by age group, 2002–2013



Data source: National Survey on Drug Use and Health, 2002–2013

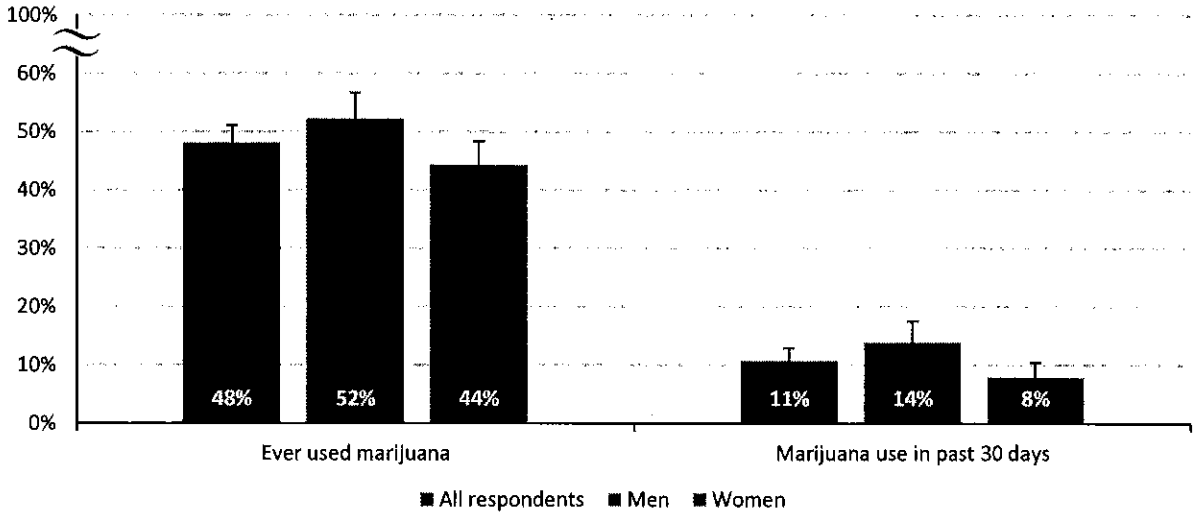
As shown in Figure 9:

- Current marijuana use is consistently higher for young adults (ages 18–25 years) compared to older adults (ages 26+ years) in both Oregon and the United States.
- Oregon marijuana use has been higher than national use among both age groups for the last decade.
- Oregon marijuana use among those 26 years and older has approximately doubled since 2006–2007, while national use has increased only slightly.

The Oregon Behavioral Risk Factor Surveillance System (BRFSS) is an ongoing telephone survey of health behaviors among Oregon adults.

Marijuana use questions were added to Oregon's BRFSS beginning in 2014. Oregon adults were asked, "How old were you the first time you used marijuana in any form, if ever?" and, "During the past 30 days, on how many days did you use marijuana or hashish (grass, hash or pot)?" Adults that provided an age of first marijuana use were classified as "ever using." As with national surveys, adults were defined as "current marijuana users" if they reported using on one or more of the past 30 days.

Figure 10. Marijuana use among Oregon adults, by gender, 2014

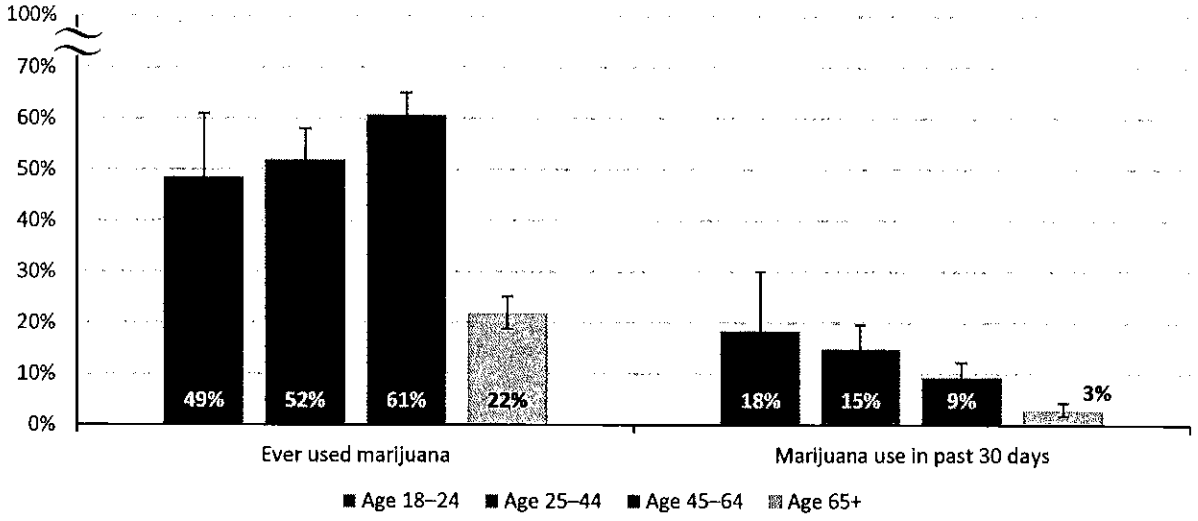


Data source: Oregon Behavioral Risk Factor Surveillance System, 2014
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 10:

- Approximately half (48%) of Oregon adults report they have ever used marijuana.
- One in 10 (11%) Oregon adults report they currently use marijuana.
- Current marijuana use is higher among men (14%) than women (8%).

Figure 11. Marijuana use among Oregon adults, by age, 2014



Data source: Oregon Behavioral Risk Factor Surveillance System, 2014

Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

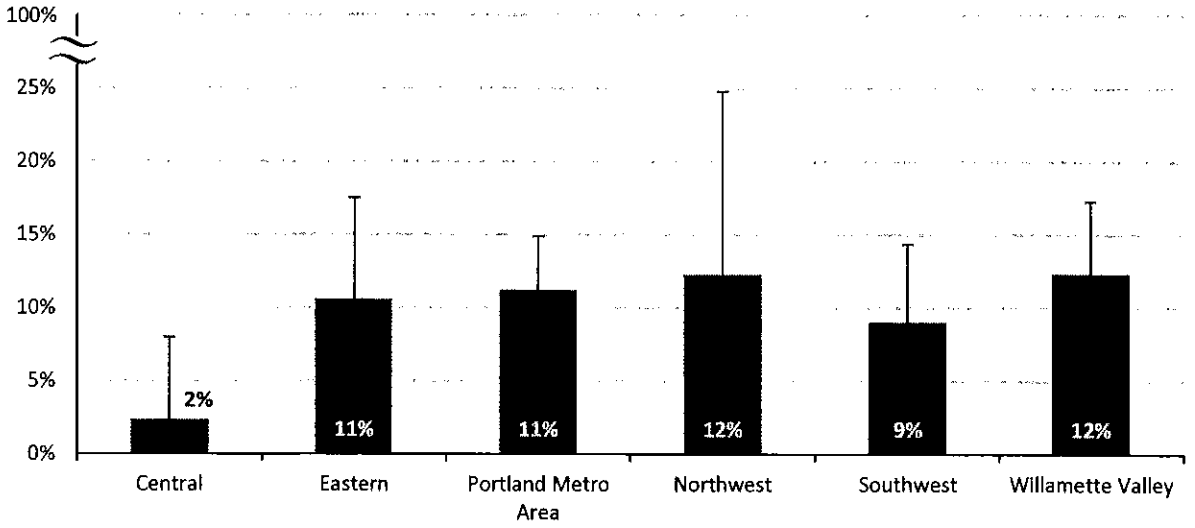
As shown in Figure 11:

- Adults aged 45–64 years were more likely than both younger (ages 18–44 years combined) and older age groups (65+) to have ever tried using marijuana.
- Current marijuana use decreases with age, with adults ages 18–44 years (combined) more likely to use marijuana than older respondents.

Additionally (data not shown):

- One in 10 (11%) adult women of typical childbearing age (18–39 years old) currently use marijuana.
- Among adults that had ever tried marijuana, the median age of first use was 16 years.

Figure 12. Current marijuana use among Oregon adults, by geographic region*, 2014



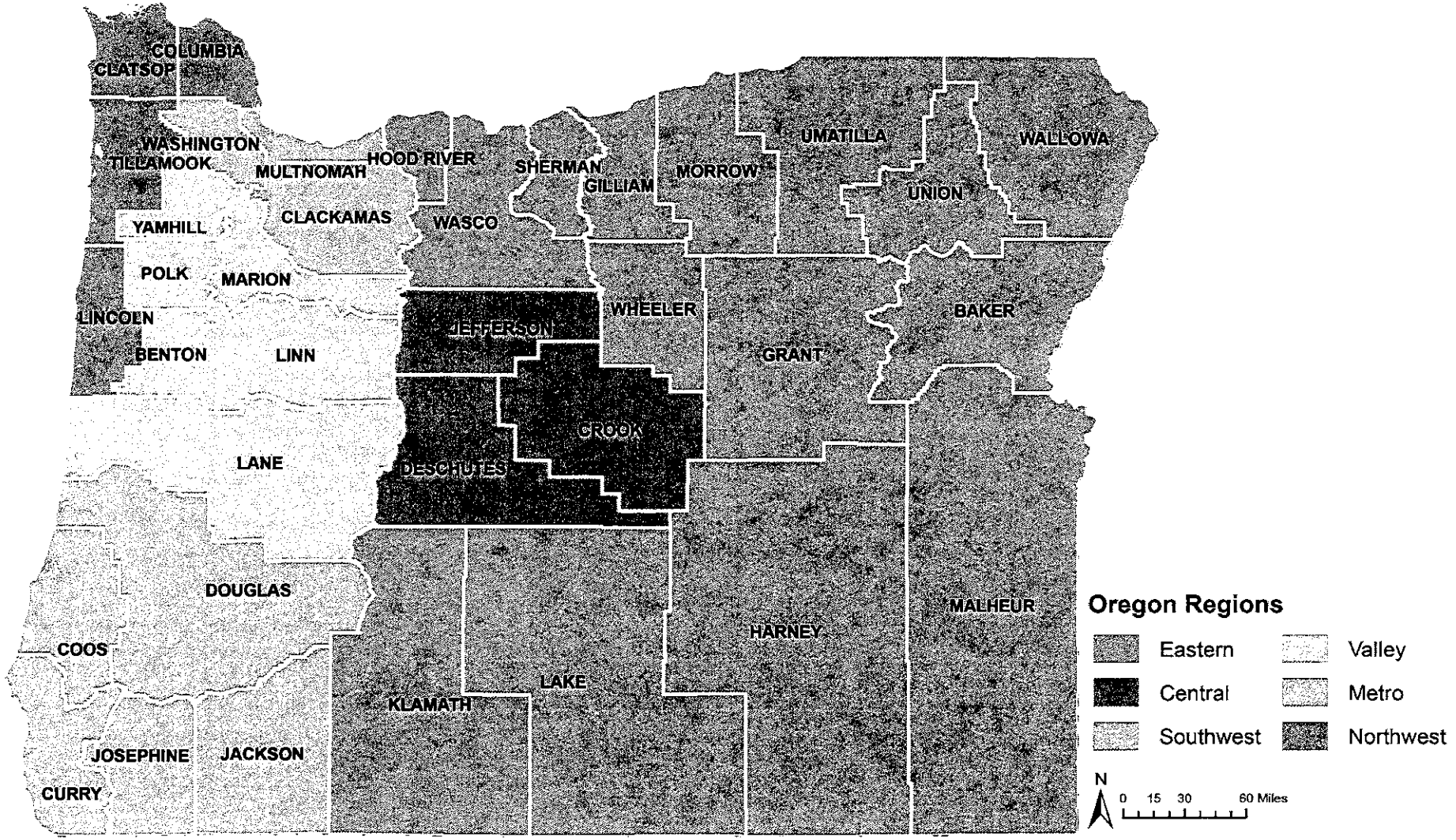
*Regions were defined by county of residence, as shown in Figure 12A.

Data source: Oregon Behavioral Risk Factor Surveillance System, 2014.
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

Figure 12 shows current marijuana use among adults by Oregon geographic regions (see map in Figure 12A for regional reference):

- Adults from the Central region reported lower current marijuana use (2%) than adults from each of the five other regions (9%–12%).
- Other regions' marijuana use was similar to each other.

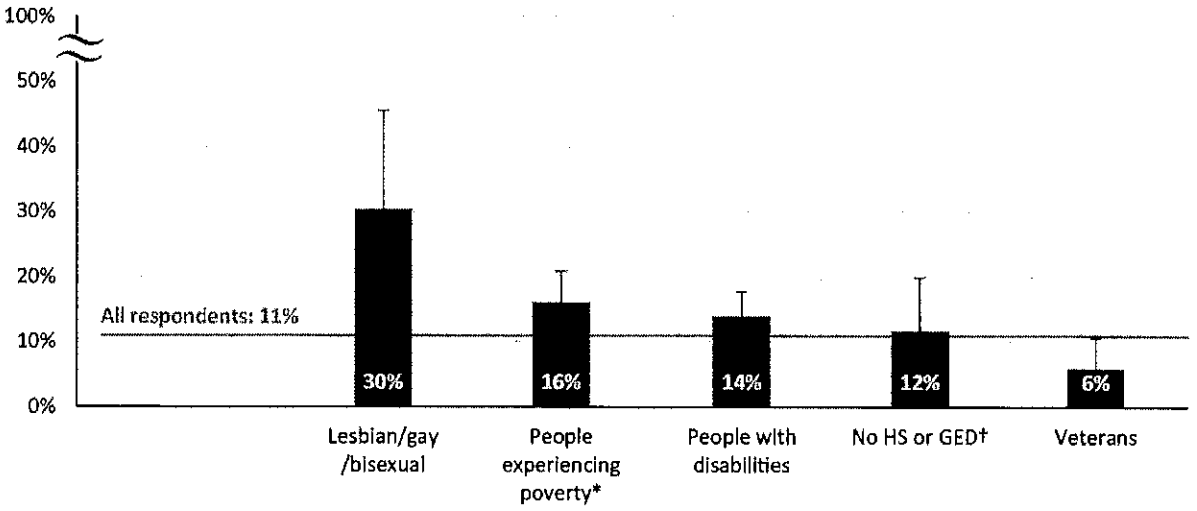
Figure 12A. Oregon geographic regions*



*Oregon regions delineated by county, as defined by Oregon Geospatial Enterprise Office, Spatial Data Library, February 2011.

Some populations that experience health disparities are of particular concern. These include people with low education levels, low income and disabilities as well as veterans and sexual minorities.

Figure 13. Current marijuana use among Oregon adults, by select demographic characteristics, 2014



*Household income less than 185% of 2014 Federal Poverty Guidelines; more information is available at *https://aspe.hhs.gov/2014-poverty-guidelines*.

†HS: high school graduation; GED: General Education Development, a high school equivalency certification.

Data source: Oregon Behavioral Risk Factor Surveillance System, 2014
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

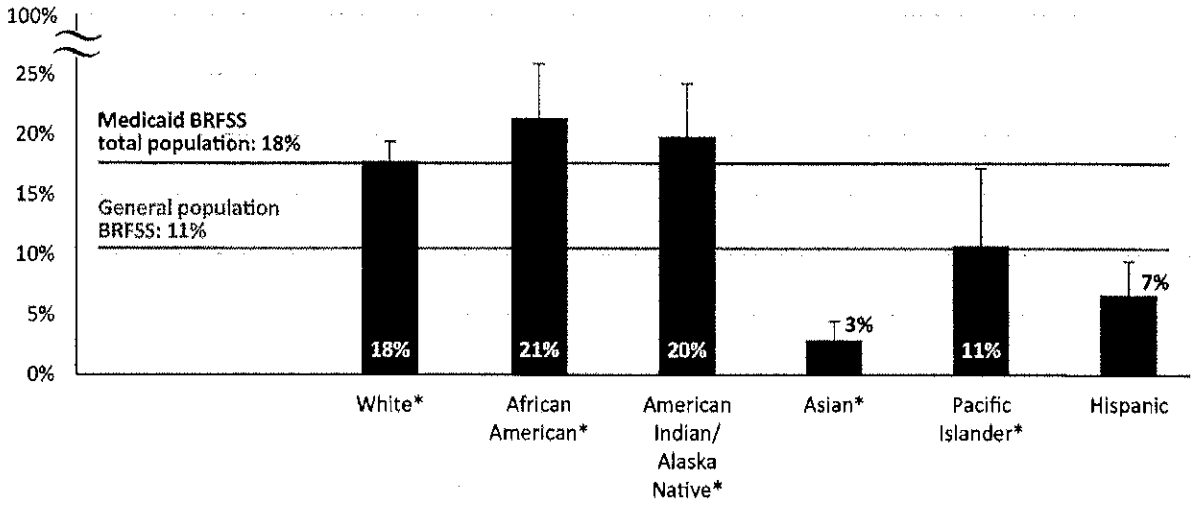
The prevalence of current use for each group is shown in Figure 13. Statistical comparisons to relevant groups were conducted for each group (data not shown) and revealed:

- Marijuana use was higher among:
  - Lesbian/gay/bisexual people, compared to straight, for men and women combined;
  - People with disabilities, compared to people without disabilities;
  - People experiencing poverty, compared to those not in poverty.
- Marijuana use was lower among:
  - Military veterans, compared to non-veterans.

- There was no significant difference in marijuana use:
    - Between people that did not graduate high school (HS) or receive a GED, compared to those with higher levels of education.

In 2014, a special version of the BRFSS Survey was conducted among Oregon adults enrolled in Medicaid, including an oversample of selected racial and ethnic groups. The standard BRFSS did not include sufficient numbers of adults from specific racial and ethnic groups to report marijuana use prevalence, but the Medicaid BRFSS had sufficient participation to do so.

Figure 14. Current marijuana use among Oregon adults enrolled in Medicaid, by race and ethnicity, 2014



*Indicates non-Latino or non-Hispanic ethnicity. Racial groups were defined as respondents that identified with a single race or "preferred race" among multiple races.

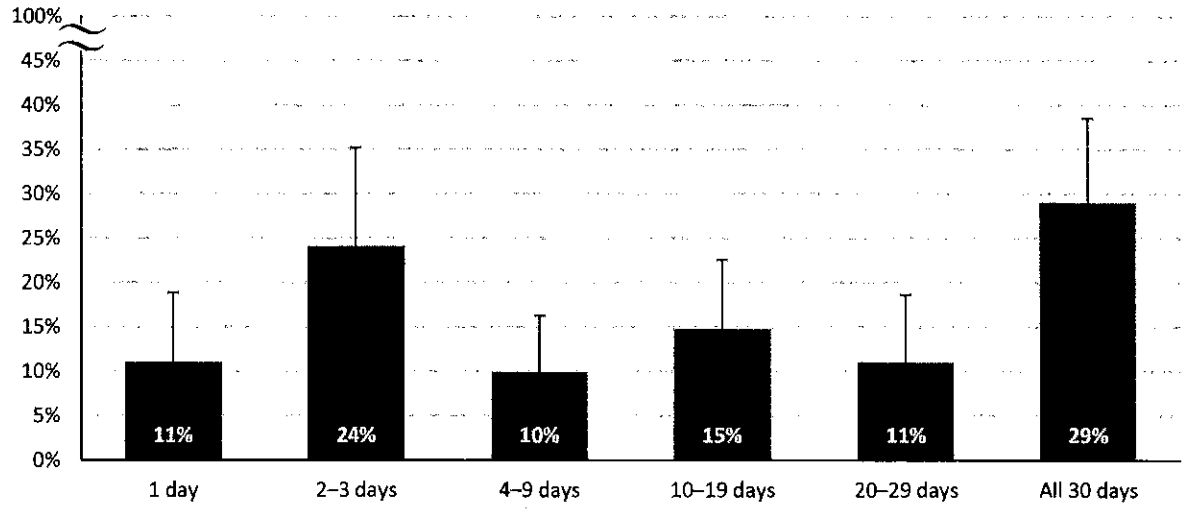
Data sources: Oregon Medicaid Behavioral Risk Factor Surveillance System, 2014, Oregon Behavioral Risk Factor Surveillance System, 2014
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 14:

- Current marijuana use was higher among adults in the Medicaid BRFSS compared to the general population BRFSS.
- Within the Medicaid population, current marijuana use was higher among Black or African American (21%), American Indian or Alaska Native (20% and non-Hispanic White (18%) adults than among the other groups (Asian, Pacific Islander and Hispanic groups).

Figure 15. Frequency of current marijuana use among Oregon adults, 2014

Adults were asked, "During the past 30 days, on how many days did you use marijuana or hashish (grass, hash or pot)?"



Data source: Oregon Behavioral Risk Factor Surveillance System, 2014
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

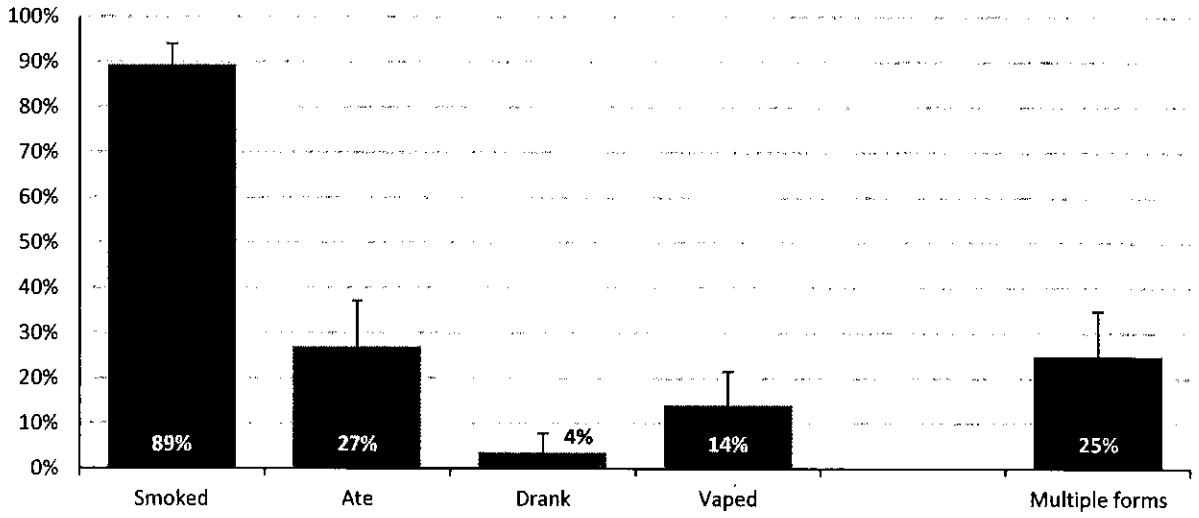
As shown in Figure 15:

- More than one in four (29%) current marijuana users reported using marijuana all 30 days in the past month.
- On average, current users reported every-other-day (14.5 of 30 days) marijuana use (data not shown).

*Although confidence intervals overlap, these groups were found to be significantly different in a separate, formal statistical test.

Figure 16. Modes of marijuana use among Oregon adults that currently use marijuana, 2014

In the 2014 BRFSS, adults that reported using marijuana in the past 30 days were asked, "How did you use marijuana in the past 30 days?" Multiple choices were allowed.



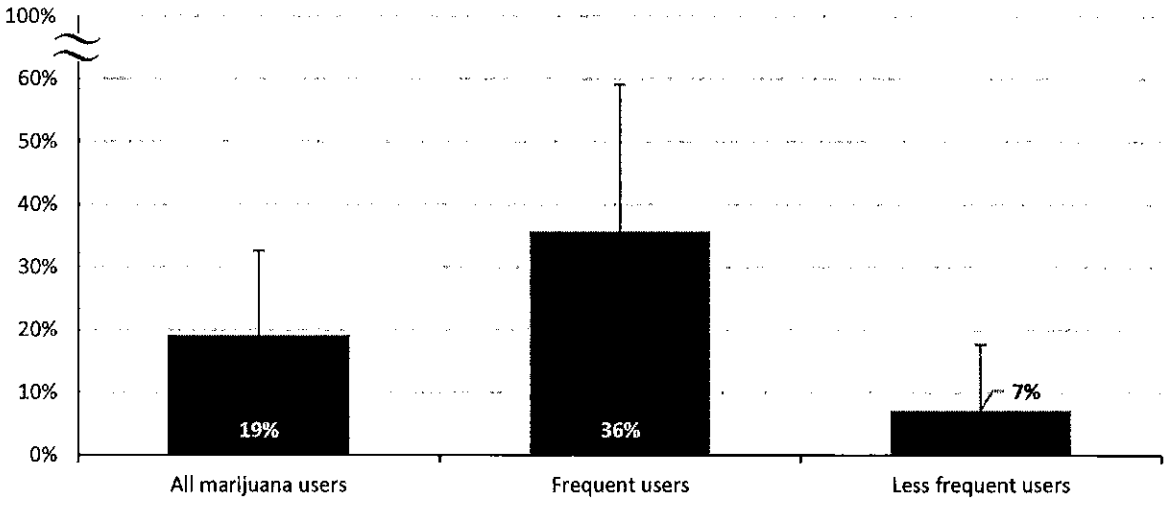
Data source: Oregon Behavioral Risk Factor Surveillance System, 2014
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 16:

- The vast majority (89%) of current marijuana users reported smoking it.
- Approximately one in four (27%) current users ate marijuana (edibles) in the past month.
- One in four (25%) reported using multiple forms of marijuana in the past month.
- Approximately one in ten (14%) reported vaping, which is inhaling vapors from an electronic cigarette-like vaporizer or electronic device.
- Frequent marijuana users (20+ days of use in the past month) were more likely than less frequent users to have used multiple forms and to have vaped marijuana (data not shown).

Figure 17. Driving within three hours of using marijuana among Oregon adults that currently use marijuana, 2014

In the 2014 BRFSS, adults that reported using marijuana in the past 30 days were asked, "Thinking about the last 12 months, did you ever drive within approximately three hours after using marijuana or hashish?"



Data source: Oregon Behavioral Risk Factor Surveillance System, 2014
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 17:

- Approximately one in five (19%) current marijuana users reported driving within three hours of use in the past year.
- Frequent marijuana users (20+ days of last 30) were more likely (36%) than less frequent users (7%) to have driven within three hours of using marijuana.

Marijuana, alcohol and tobacco

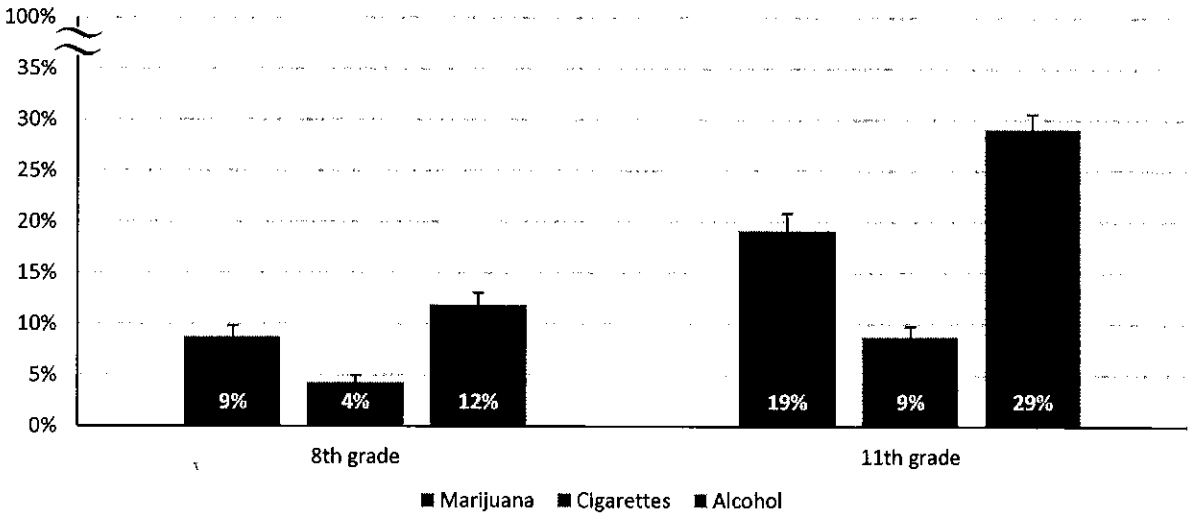
Alcohol and tobacco use patterns are important to consider in monitoring marijuana-related public health data. Changing patterns of marijuana use may lead to substitution for other substance use (e.g., using marijuana rather than binge-drinking alcohol), or combining with other substances to increase their use (e.g., smoking marijuana with tobacco).

Both the Oregon school-based youth surveys and BRFSS ask questions about alcohol and tobacco use, which are reported below.

Youth substance use and access

Oregon youth were also asked about alcohol and cigarette use in school-based health surveys. As with marijuana, youth that reported they had used alcohol or cigarettes on one or more of the past 30 days were defined as "current users."

Figure 18. Current use of marijuana, cigarettes and alcohol among Oregon youth, 2015



Data source: Oregon Healthy Teens Survey, 2015

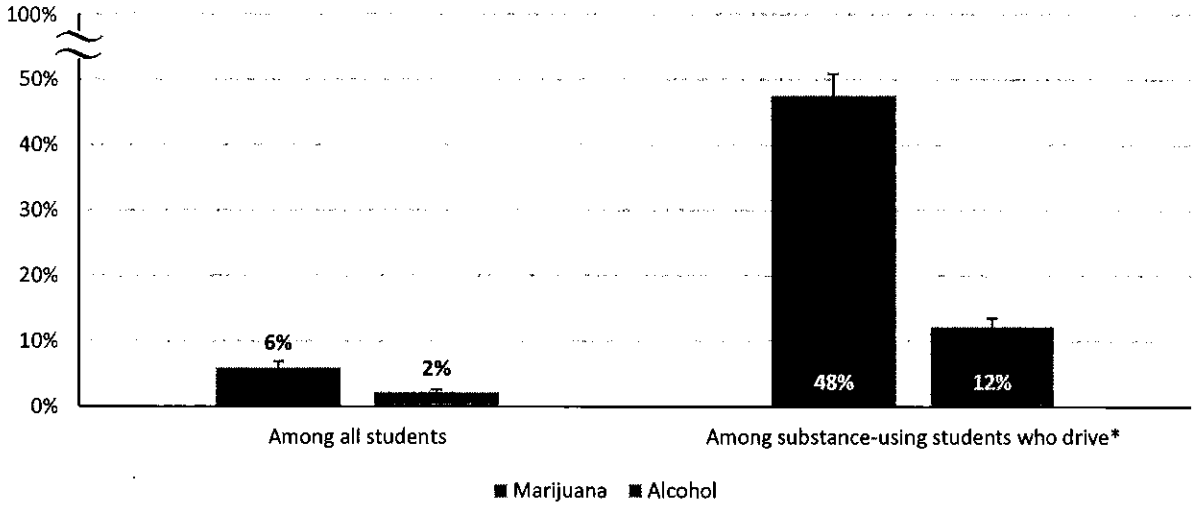
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 18:

- Current marijuana use was higher than current cigarette smoking among both eighth- and 11th-grade students.
- Current marijuana use was lower than alcohol use among both grades.

Figure 19. Driving after use of marijuana or alcohol among Oregon 11th-grade students, 2015

Oregon youth were asked, "During the past 30 days, how many times did you drive a car or other vehicle within three hours after using marijuana?" and "During the past 30 days, how many times did you drive a car or other vehicle when you had been drinking alcohol?" Youth could respond, "I did not drive in the past 30 days." Youth that gave any other response besides this one were classified as "students who drive."



*Drivers defined as students that gave any response to question other than "I did not drive in the past 30 days."

Data source: Oregon Healthy Teens Survey, 2015
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 19:

- In the overall student population, more 11th-grade students drove within three hours of marijuana use than did after drinking alcohol in the past month.
- Approximately one-third of all 11th-graders said they had driven in the past month (data not shown). Among the subgroup of 11th-grade students that drove and that used

substances in the past month, nearly half (48%) of marijuana users had driven after using marijuana in the past month. This is four times higher than the one in 10 (12%) alcohol-using students that drove after using alcohol in the past month.

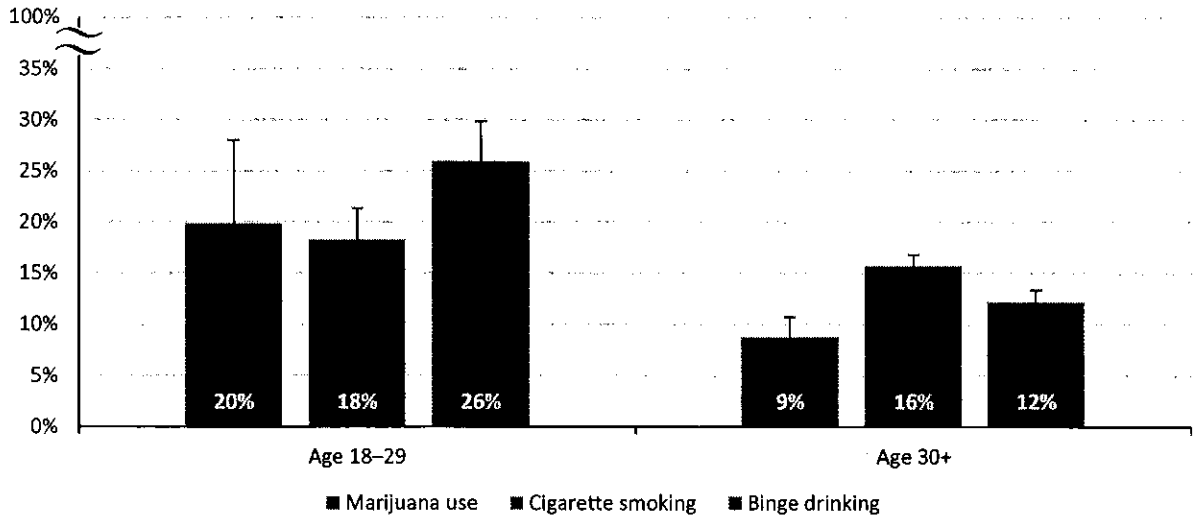
Adult substance use

In the 2014 BRFSS, adults were also asked about the use of other substances, including tobacco and alcohol.

Figure 20. Current marijuana and tobacco use and binge drinking among Oregon young adults (18–29) and age 30+, 2014

Current smokers are people that have smoked at least 100 cigarettes in their lifetime and that now smoke cigarettes "every day" or "some days." One measure of potentially harmful alcohol use among adults is "binge drinking." Binge drinking is defined as five or more drinks on one occasion for men, four or more for women, in the past 30 days.

Data source: Oregon Behavioral Risk Factor Surveillance System, 2014



Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 20:

- Among all adults, 11% currently used marijuana, 16% smoked cigarettes and 15% reported binge drinking (data not shown).

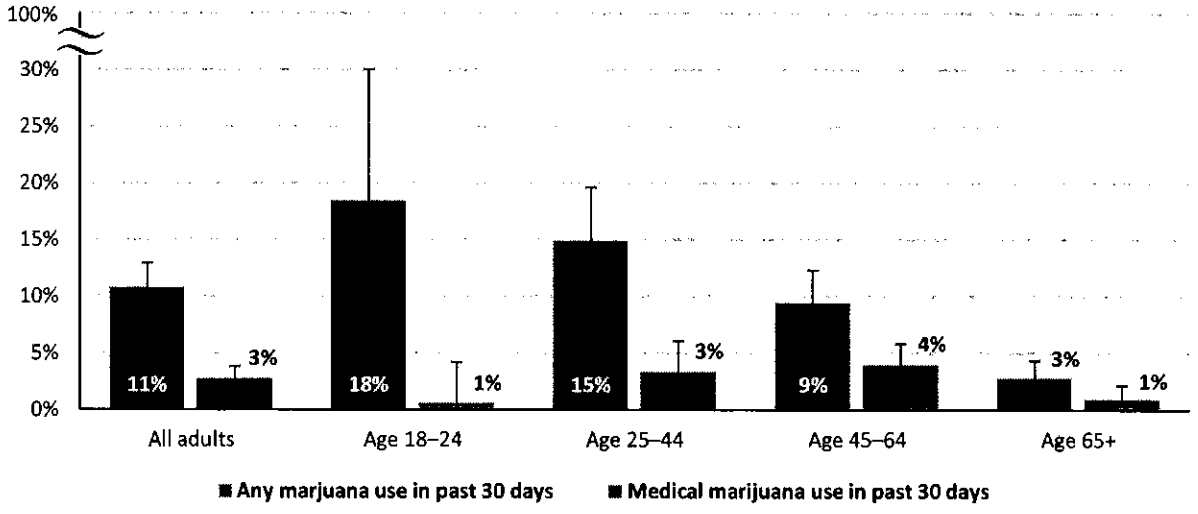
- Among respondents ages 18–29, current marijuana use (20%) was comparable to current tobacco smoking (18%).
- Current marijuana use was less prevalent than smoking and binge drinking among adults ages 30 years and older.
- Among current marijuana users, 42% reported current cigarette smoking and 32% reported binge drinking (data not shown).

Medical marijuana

Medical marijuana use has been legal in Oregon since 1998, when the state's voters passed the Oregon Medical Marijuana Act.

Figure 21. Current any and medical marijuana use among Oregon adults, by age group, 2014

In addition to asking about general marijuana use, the 2014 BRFSS asked respondents that had ever tried marijuana, *"During the past 30 days, on how many days did you use medical marijuana as recommended by a doctor or other health care provider for treatment of a medical condition?"* People that said they had used medical marijuana during the past 30 days were classified as "medical marijuana users."

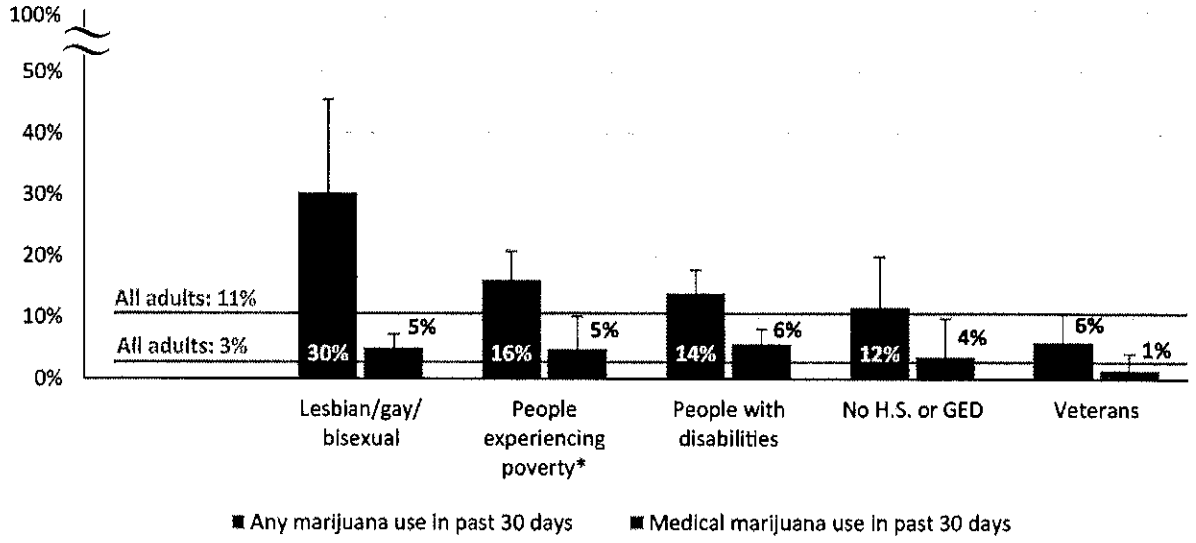


Data source: Oregon Behavioral Risk Factor Surveillance System, 2014
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 21:

- Three percent of adults reported current medical marijuana use, making up less than one-third of the 11% total use percentage.
- Young adults (18–24 years old) that use marijuana are least likely to use marijuana for medical purposes. Medical marijuana use makes up a greater share of any marijuana use among groups older than 25 years of age.
- While any marijuana use decreases with age, medical marijuana use increases with age among those less than 65 years old.

Figure 22. Current marijuana and medical marijuana use among Oregon adults, by select demographic characteristics, 2014



*Household income below 185% of the 2014 Federal Poverty Guidelines. Further information available at *https://aspe.hhs.gov/2014-poverty-guidelines*.

Data source: Oregon Behavioral Risk Factor Surveillance System, 2014
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 22:

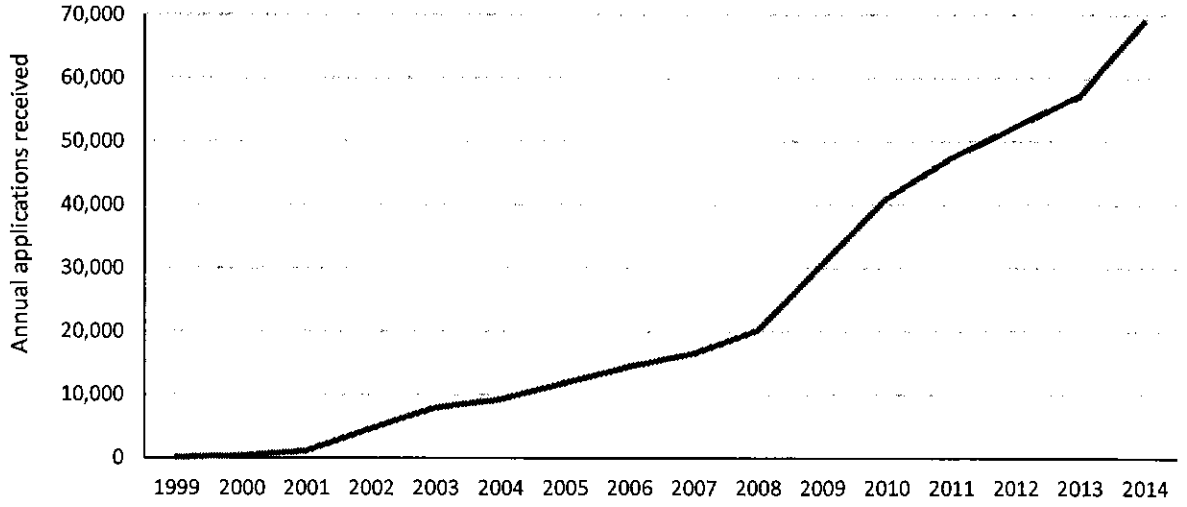
- Medical marijuana use represents between one-sixth and one-third of total marijuana use for all groups.
- Medical marijuana use represents the greatest share of total marijuana use among people with disabilities for the groups shown.

Statistical comparisons between relevant groups were conducted (data not shown), and medical marijuana use was higher among:

- People with disabilities, compared to people without disabilities;
- People experiencing poverty, compared to those not in poverty.

The Oregon Medical Marijuana Program (OMMP) is a state registry program within the Oregon Health Authority Public Health Division. OMMP's role is to administer the Oregon Medical Marijuana Act, including registering patients to use marijuana for medical treatment for specific conditions as confirmed by a physician. Patients must have their condition and medical marijuana treatment recommendation reaffirmed by a physician once per year. The OMMP also registers medical marijuana caregivers (individuals 18 years and older who have significant responsibility for the wellbeing of a patient, including assisting with supply, transportation and administration), growers and grow sites. The OMMP routinely analyzes its registry data.

Figure 23. Annual numbers of Oregon medical marijuana card patient applications, 1999–2014



Data source: Oregon Medical Marijuana Program (OMMP)

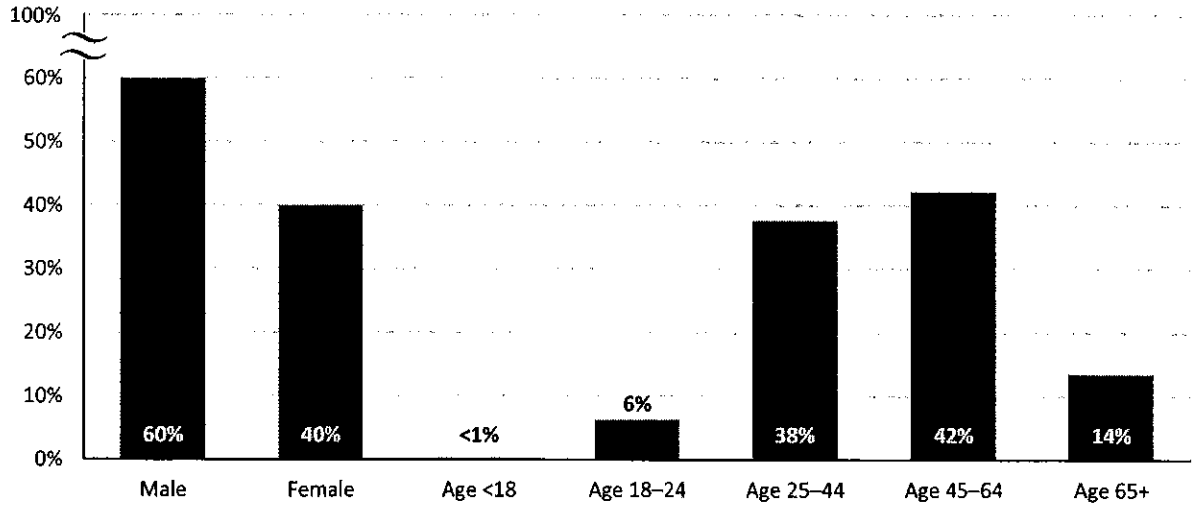
As shown in Figure 23:

- The OMMP has experienced a steady growth in medical marijuana card applications for patients, from 118 in 1999 to 69,062 in 2014.
- Most applications received are approved. Since 2001, an average of 4% of applications were not approved due to lack of documentation or compliance with OMMP.

According to OMMP, as of Oct. 30, 2015, there were:

- 78,045 medical marijuana patients registered in Oregon;
- 37,017 caregivers registered in Oregon;
- 48,699 medical marijuana growers registered in Oregon;
- 33,194 medical marijuana grow sites registered in Oregon;
- 1,705 physicians that provided treatment recommendations for medical marijuana patients.

Figure 24. Demographic characteristics of Oregon medical marijuana patients, 2015



Data source: Oregon Medical Marijuana Program (OMMP)

As shown in Figure 24:

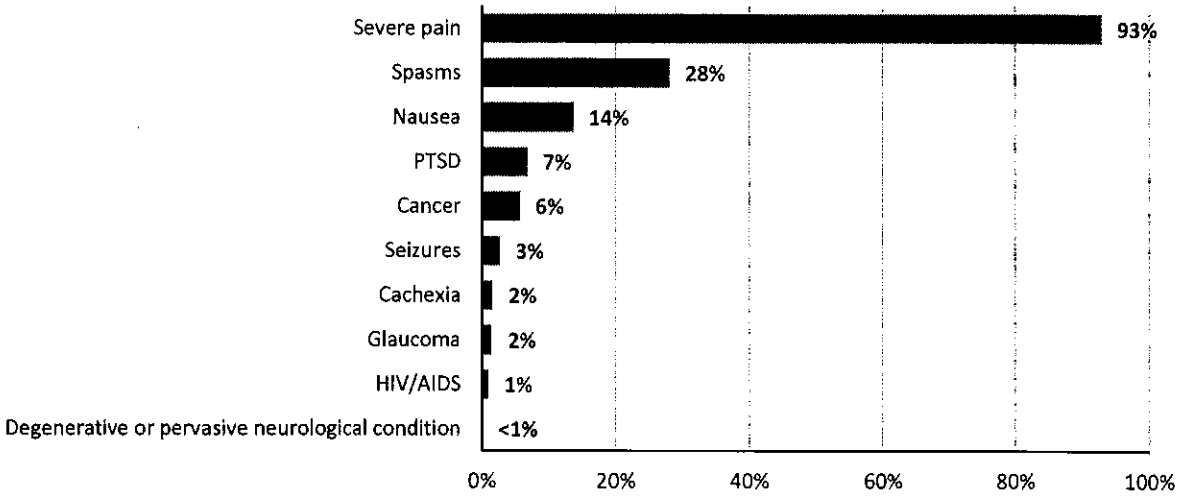
- Men make up a larger proportion of medical marijuana patients than women (60% vs. 40%).
- Most medical marijuana patients are between the ages of 25 and 64.
- Relatively few minors are medical marijuana patients; 257 (less than 0.5%) of currently registered patients are less than 18 years old.

Medical conditions that qualify a patient for the OMMP are:

- Cancer;
- Glaucoma;
- Agitation due to Alzheimer's disease;
- Positive status for human immunodeficiency virus (HIV) or acquired immune deficiency syndrome (AIDS);
- Post-traumatic stress disorder (PTSD); or
- A medical treatment or condition that produces cachexia, severe pain, severe nausea, seizures (including, but not limited to, seizures caused by epilepsy) or persistent muscle spasms (including, but not limited to, spasms caused by multiple sclerosis).

These conditions are not mutually exclusive. A patient may have one or more conditions.

Figure 25. Oregon medical marijuana patient conditions, 2015



Data source: Oregon Medical Marijuana Program (OMMP), October 2015 Statistical Snapshot

As shown in Figure 25:

- Severe pain is the most common condition for which patients apply to receive medical marijuana, and is reported by nearly all applicants (93%).
- Approximately one in four (28%) medical marijuana patient applications indicated treatment of spasms as a qualifying condition.
- Approximately one in 10 (14%) medical marijuana patient applications indicated nausea as a qualifying condition.
- Other qualifying conditions besides severe pain, spasms and nausea were mentioned in fewer than 10% of patient applications.

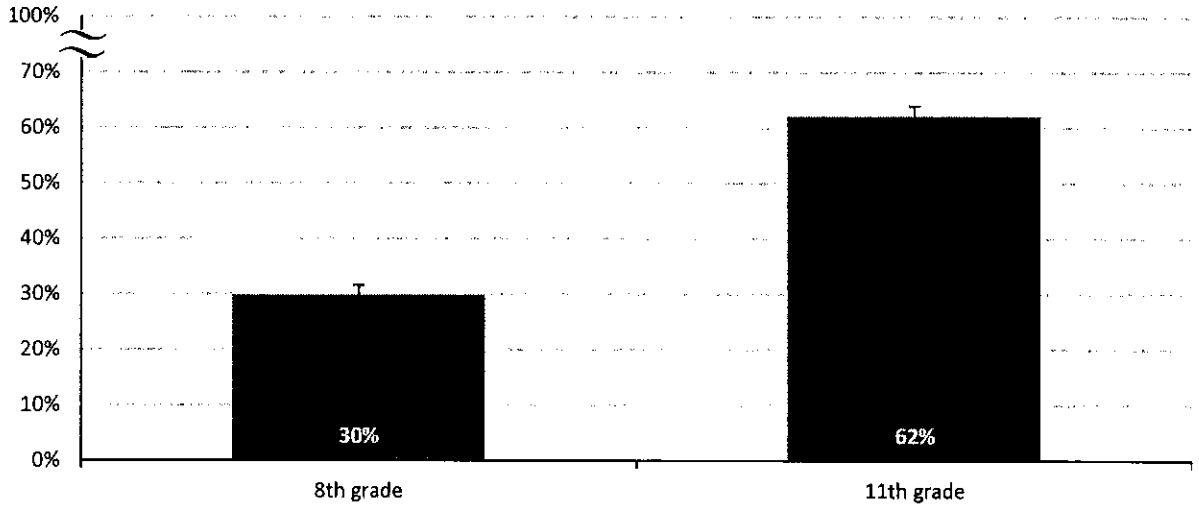
Knowledge and attitudes

Youth attitudes

The Oregon Healthy Teens Survey asks a limited number of questions about marijuana-related attitudes.

Figure 26. Oregon youth that think marijuana is easy to get, 2015

Oregon youth were asked, "If you wanted to get ... some marijuana, how easy would it be for you to get some?" Responses of "sort of easy" and "very easy" were combined and reported as "easy" in this figure.



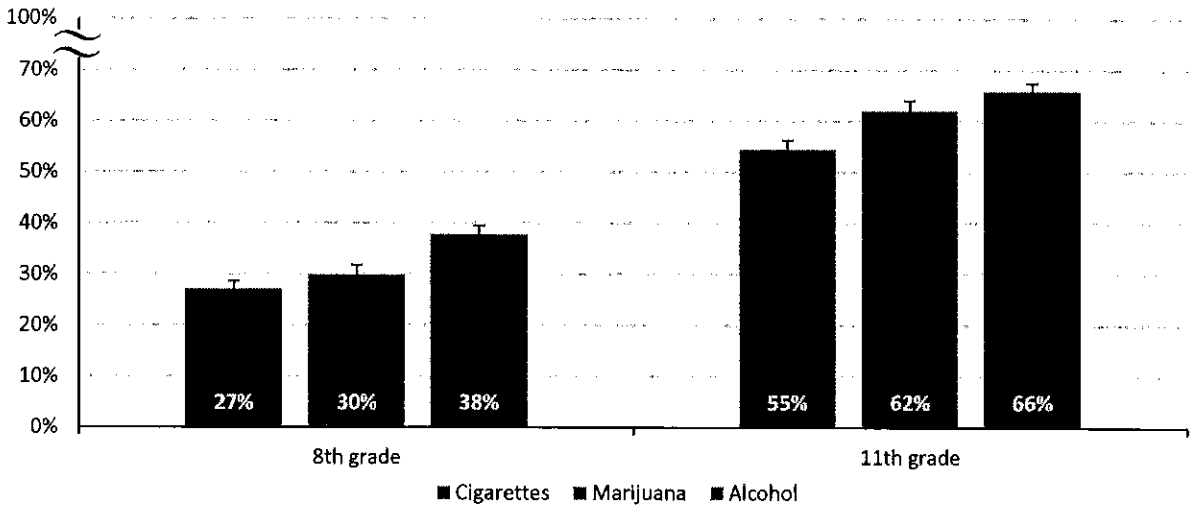
Data source: Oregon Healthy Teens Survey, 2015
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 26:

- Approximately three in five (62%) 11th-graders reported it would be easy to get marijuana.
- Eleventh graders were more likely than eighth-graders to report it would be easy to get marijuana.

Figure 27. Oregon youth that think selected substances are easy to get, 2015

Oregon youth were asked, "If you wanted to get ... [cigarettes/marijuana/alcohol], how easy would it be for you to get some?" Responses of "sort of easy" and "very easy" were combined and reported as "easy" in this figure.



Data source: Oregon Healthy Teens Survey, 2015

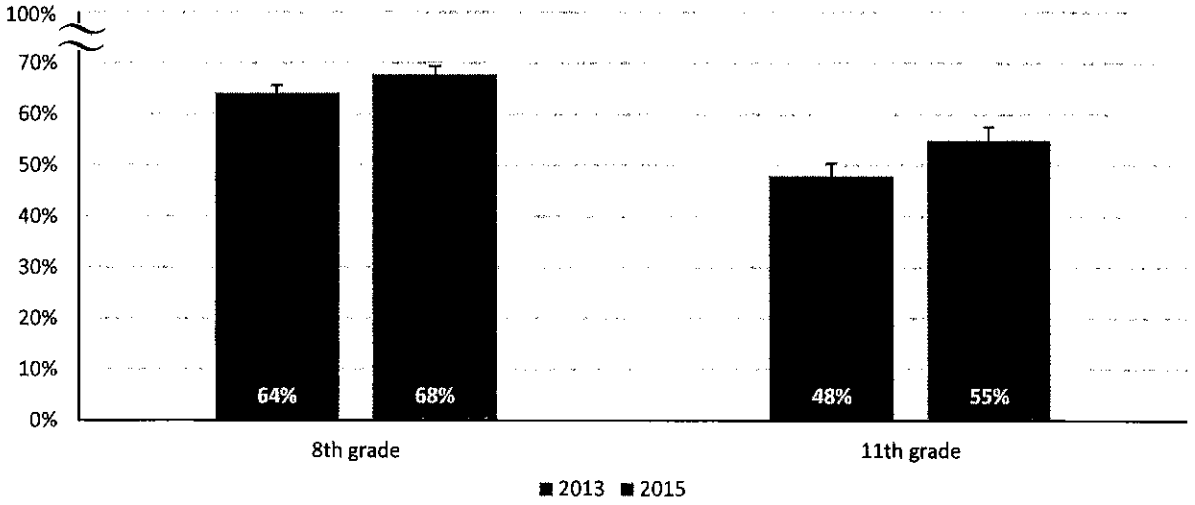
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 27:

- Among eighth-graders, perceived easy access to marijuana was comparable to that of cigarettes, while alcohol is reported as easier to get.
- Among 11th-graders, access to marijuana was reported as being easier than cigarettes, while alcohol is the easiest to get of the three substances.

Figure 28. Oregon youth that think weekly marijuana use* is harmful, 2013–2015

Oregon youth were asked, "How much do you think people risk harming themselves (physically or in other ways) if they....smoke marijuana once or twice a week (asked in 2013) / use marijuana regularly (at least once or twice a week) (asked in 2015)?" The percent of youth that said "great risk" and "moderate risk" was combined and reported as a perception of "harmful."



*Survey language was "smoke marijuana" in 2013, "use marijuana" in 2015.

Data source: Oregon Healthy Teens Survey, 2013 and 2015
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

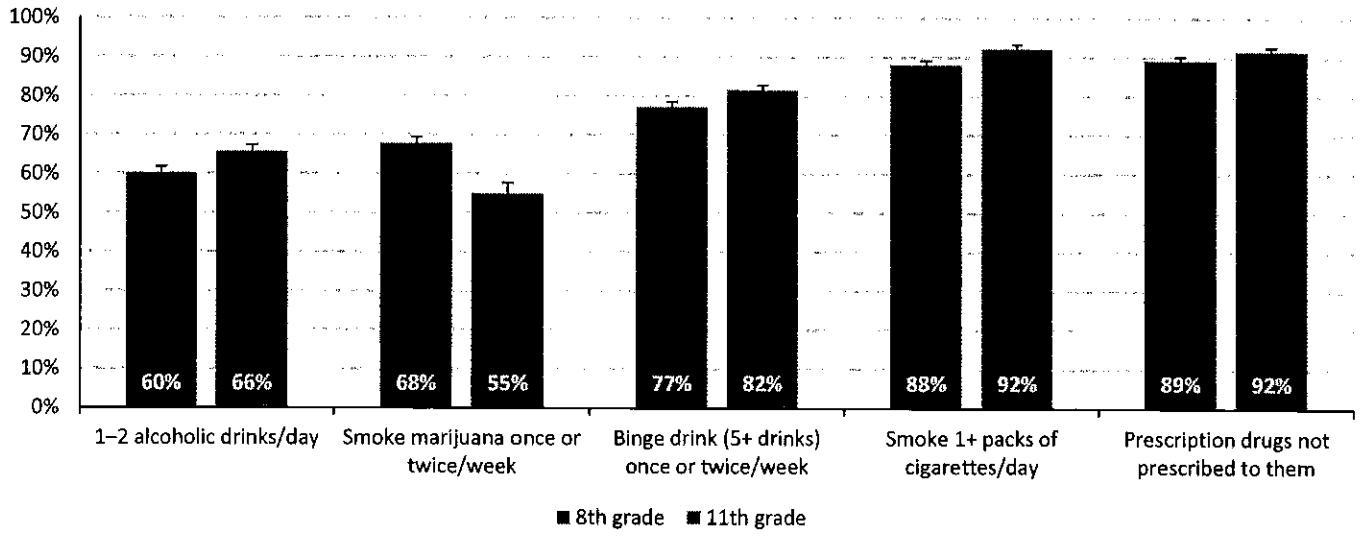
As shown in Figure 28:

- In 2015, more than two-thirds (68%) of eighth-graders and more than half (55%) of 11th-graders thought people were at moderate-to-great risk from weekly marijuana use.
- Risk perception of weekly marijuana use increased in both grades between 2013 and 2015.

Oregon students that participated in the Oregon Healthy Teens Survey were also asked about perceived harm from other substance use. Their responses provide insights about the relative perception of harm from marijuana use.

Figure 29. Oregon youth that think select substance use is harmful, by grade, 2015

Oregon youth were asked, "How much do you think people risk harming themselves (physically or in other ways) if they..." (see response options below chart in this figure). The percent of youth that said "great risk" and "moderate risk" was combined and reported as a perception of "harmful."



Data source: Oregon Healthy Teens Survey, 2015

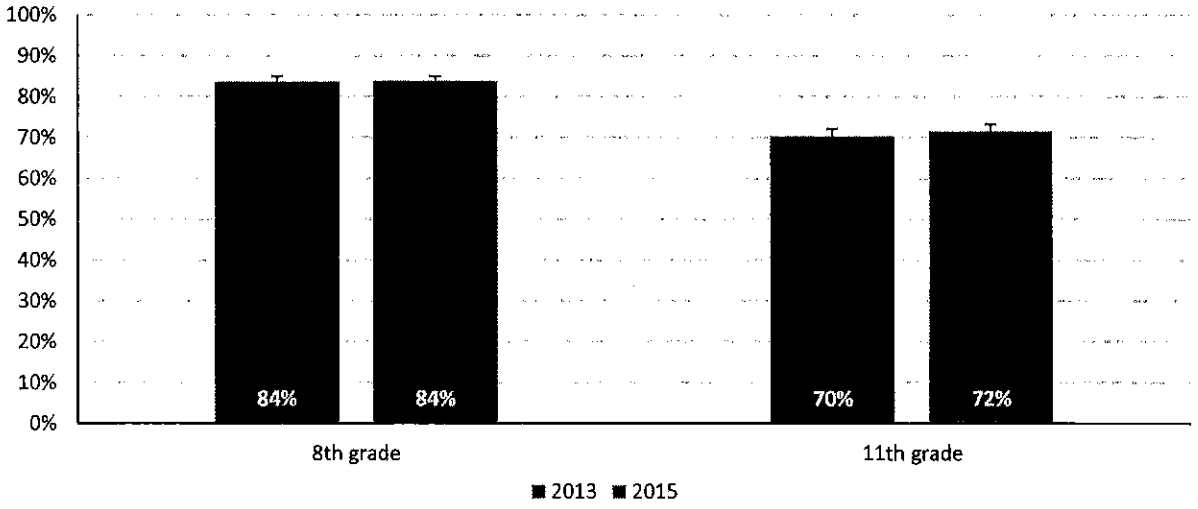
Error bars (ī) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 29:

- In general, both eighth- and 11th-grade Oregon students reported thinking that using marijuana weekly is less harmful than smoking a pack of cigarettes a day, binge drinking or using prescription drugs that do not belong to them.
- Eleventh-graders reported that using marijuana weekly is less harmful than drinking between one and two alcoholic drinks a day; however, eighth-graders believed that using marijuana weekly is more harmful than daily alcohol drinking.
- Eleventh-graders were less likely than eighth-graders to believe that using marijuana is harmful; for all other substances, eleventh-graders were more likely to perceive harm.

Figure 30. Oregon youths' perception that parents feel it would be very wrong for respondents to use* marijuana, by grade, 2013–2015

Oregon youth were asked, "How wrong do your parents feel it would be for you to...smoke marijuana (2013) / use marijuana (2015)?" Response options include "very wrong," "wrong," "a little bit wrong" and "not wrong at all." Responses of "very wrong" are reported in this figure.



*Survey language was "smoke marijuana" in 2013, changed to "use marijuana" in 2015.

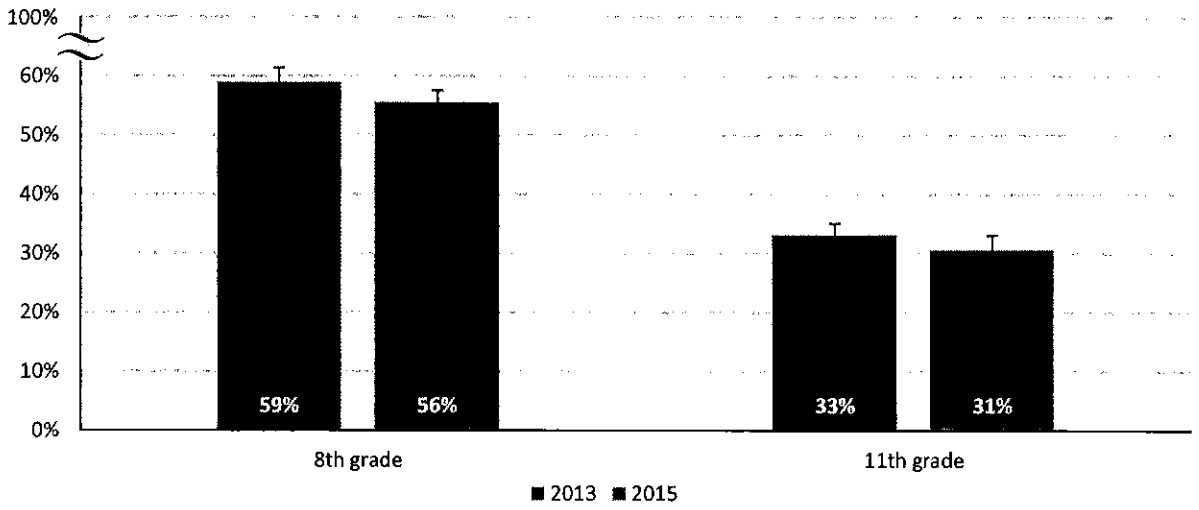
Data source: Oregon Healthy Teens Survey, 2013 and 2015
Error bars (I) Indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 30:

- Eighth-grade students are more likely to report that their parents feel it would be "very wrong" for them to use marijuana than 11th-grade students.
- Youth perception of parents' feelings were similar between 2013 and 2015.

Figure 31. Oregon youths' perception that friends feel it would be very wrong for respondents to use* marijuana, by grade, 2013–2015

Oregon youth were asked, "How wrong do your friends feel it would be for you to...smoke marijuana (2013) / use marijuana (2015)?" Response options include "very wrong," "wrong," "a little bit wrong," and "not wrong at all." Responses of "very wrong" are reported in this figure.



*Survey language was "smoke marijuana" in 2013, changed to "use marijuana" in 2015.

Data source: Oregon Healthy Teens Survey, 2013 and 2015
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 31:

- Eighth-grade students are more likely to report that friends feel it would be "very wrong" for them to use marijuana than 11th-grade students.
- The percentage of eighth-graders reporting friends' "very wrong" feelings regarding marijuana decreased from 2013 to 2015. †

†Although confidence intervals overlap, these groups were found to be significantly different in a separate, formal statistical test.

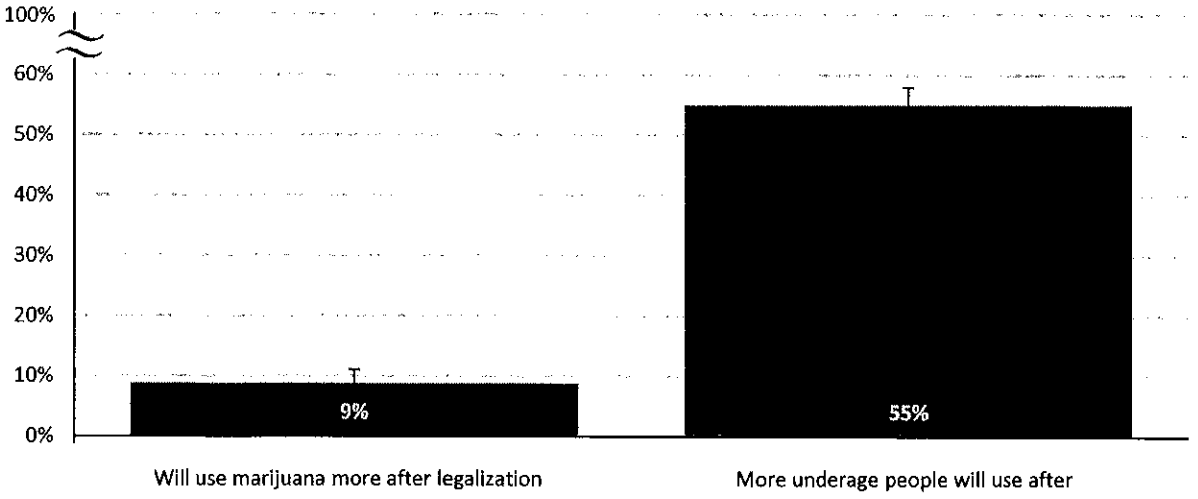
Adult attitudes

The Oregon Public Health Division conducted an online survey of approximately 2,000 Oregon adults in November 2015. This survey included multiple measures of marijuana-related attitudes, beliefs and knowledge about Oregon's new marijuana laws.

Respondents were asked, "How much do you agree with the following statements?" Paraphrased statements are listed within figures 32-34. Respondents could select strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree or strongly disagree.

Figure 32. Oregon adults' perceptions of how legalization has changed marijuana use, 2015

The percent of adults that said "strongly agree" or "somewhat agree" were combined and reported as "agree" in this figure.



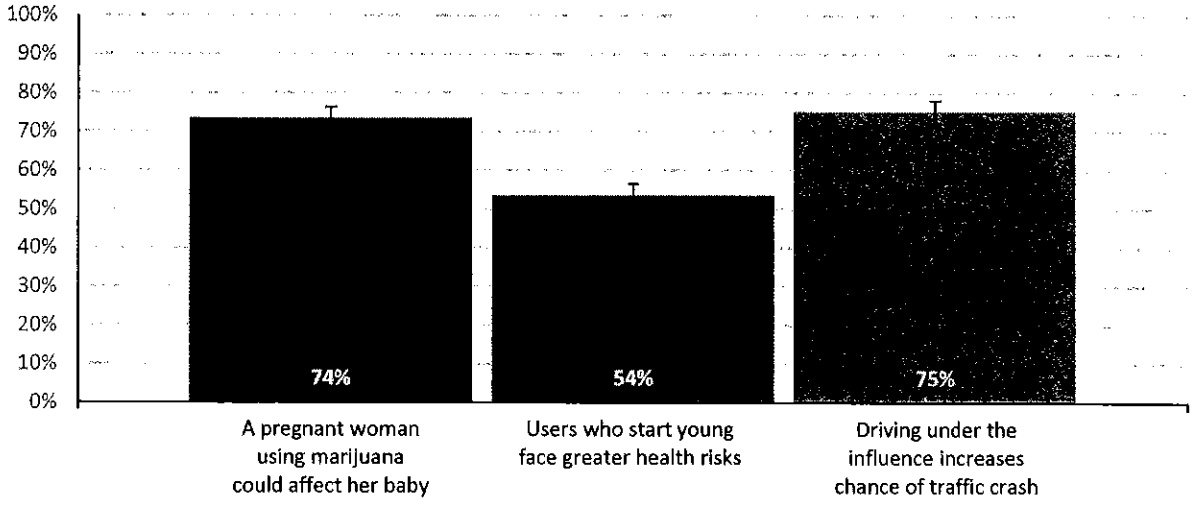
Data source: Tobacco Panel Survey, Health Promotion & Chronic Disease Prevention Program, Oregon Public Health Division, November 2015 (unpublished)
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 32:

- Nine percent of all Oregon adults agreed that they use marijuana more often now that it has been legalized in Oregon.
- A higher proportion of younger adults (ages 18–34 years) reported using more marijuana after legalization compared to adults 35 years and older (15% vs. 6%) (data not shown).
- Approximately half (55%) of adults agreed that more underage people will be trying marijuana now that it has been legalized in Oregon.
- Belief about increased underage use was higher among people that had never personally used marijuana. 72% of adults that never used marijuana agreed with this statement compared to 46% among those that had ever used marijuana (data not shown).

Figure 33. Oregon adults' beliefs about harms from marijuana use, 2015

Respondents were asked, "How much do you agree with the following statements?" Paraphrased statements are listed within this figure. Respondents could select strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree or strongly disagree. The percent of adults that said "strongly agree" or "somewhat agree" were combined and reported as belief in harms about marijuana use as reported in this figure.



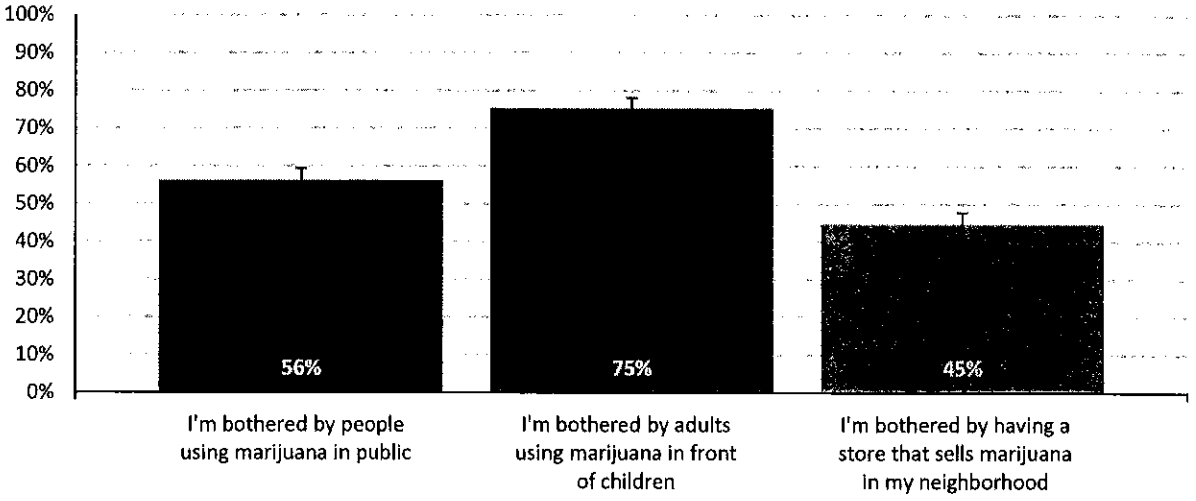
Data source: Tobacco Panel Survey, Health Promotion & Chronic Disease Prevention Program, Oregon Public Health Division, November 2015 (unpublished)
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 33:

- Approximately three of four adults agreed that driving under the influence of marijuana increases the chance of a traffic crash (75%) and that if a pregnant woman uses marijuana it could hurt her baby (74%).
- Fewer adults – approximately half (54%) – agreed that people that start using marijuana when they are younger face more long-term health and addiction risks than people that start using marijuana when they are older.

Figure 34. Oregon adults' attitudes about marijuana use, 2015

Respondents were asked, "How much do you agree with the following statements?" Paraphrased statements are listed within this figure. Respondents could select strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree or strongly disagree. The percent of adults that said "strongly agree" or "somewhat agree" were combined and reported as agreement with statements that indicate negative attitudes about marijuana use in this figure.



Data source: Tobacco Panel Survey, Health Promotion & Chronic Disease Prevention Program, Oregon Public Health Division, November 2015 (unpublished)
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

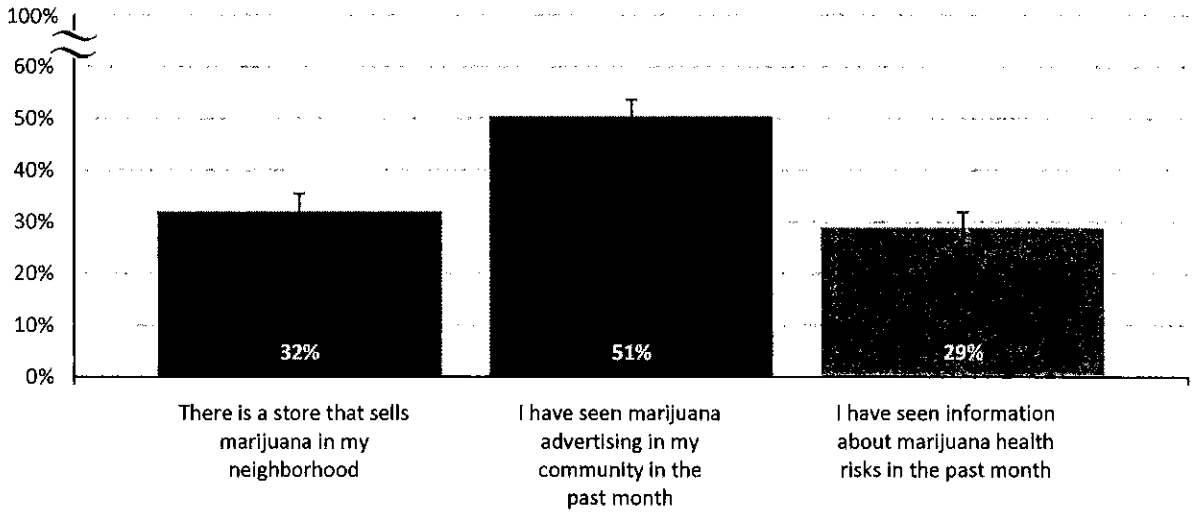
As shown in Figure 34:

- Approximately three of four (75%) adults agreed they would be bothered by adults using marijuana in front of children.
- Slightly more than half of adults (56%) agreed they would be bothered by people using marijuana in public.
- Slightly fewer than half of adults (45%) agreed they would be bothered by having a store that sells marijuana in their neighborhood.
- Younger adults (ages 18–34 years) were less likely than older adults to agree that they were bothered by marijuana use in public, use by adults in front of children, and the presence of a store that sells marijuana in their neighborhood (data not shown).

- Adults that had never used marijuana were more likely to agree they were bothered by having a store that sold marijuana in their neighborhood (72%) compared to current marijuana users (16%) (data not shown).

Figure 35. Awareness of marijuana business activity and related messaging in communities among Oregon adults, 2015

Respondents were asked if they had seen marijuana-related business activity or messages in their community during the past 30 days.



Data source: Tobacco Panel Survey, Health Promotion & Chronic Disease Prevention Program, Oregon Public Health Division, November 2015 (unpublished)
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

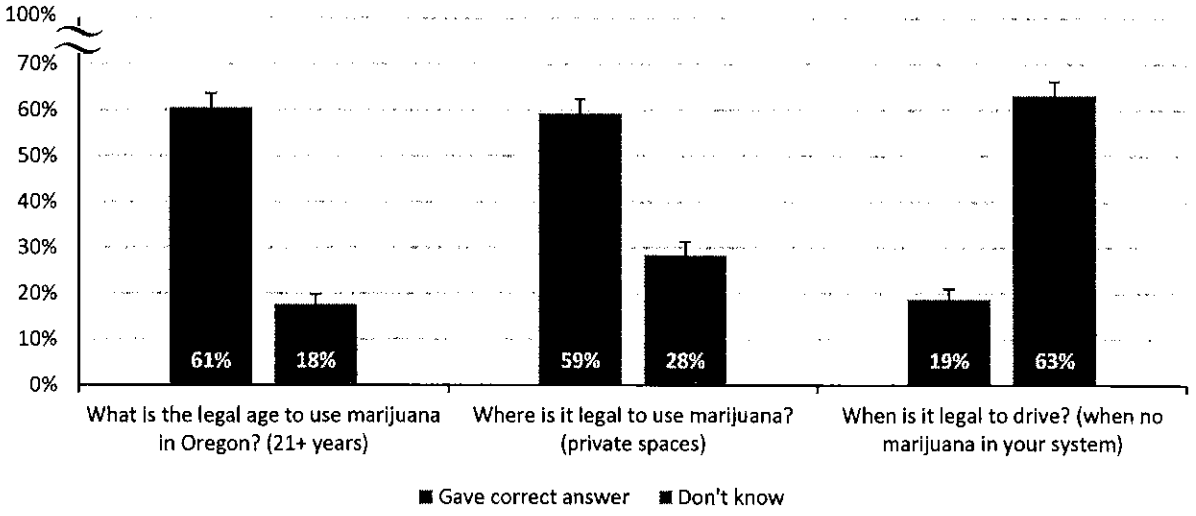
As shown in Figure 35:

- Approximately one-third of adults (32%) said there is a marijuana dispensary or store that sells marijuana in their neighborhood.
- Half of adults (51%) said they had seen or heard advertising for marijuana products or stores in their community (in TV, radio, signs, billboards, newspapers, pamphlets, street side marketing) in the past month.
- Fewer adults (29%) said they had heard anything about the health risks of marijuana in their communities through similar information channels in the past month.
- Although there were not differences in awareness of community marijuana advertising between current marijuana users and non-users, current marijuana users were more likely

to report seeing marijuana health risk information in the past month (40%) than former or non-marijuana users (23% and 27%, respectively) (data not shown).

Figure 36. Oregon adults' knowledge of new Oregon marijuana law's components, 2015

Respondents were asked about several specific components of Oregon's marijuana laws. The percent of adults that chose the correct answer from among multiple choices is reported in Figure 36. Each question also had "I don't know" as a response option, and the percent of adults that selected this answer is also reported in this figure.



Data source: Tobacco Panel Survey, Health Promotion & Chronic Disease Prevention Program, Oregon Public Health Division, November 2015 (unpublished)
Error bars (I) indicate 95% confidence intervals (see pages 5–6 for definition).

As shown in Figure 36:

- More than half of adults (61%) correctly knew that 21 years or older is the legal age to use marijuana in Oregon, but approximately one in five (18%) said they didn't know.
- More than half of adults (59%) correctly knew that it is legal to use marijuana in private spaces rather than in public, but approximately one in four (28%) said they didn't know where it was legal to use marijuana.
- Nearly two-thirds of adults (63%) said they didn't know when it is legal to drive after using marijuana according to Oregon law. Approximately one in five (19%) gave the best response from among the options offered, which was "when there is no measurable marijuana in your system" (other answer options were "2 hours after you have used

marijuana" and "2 hours after you have used marijuana, as long as you didn't combine it with alcohol or other drugs"). However, Oregon has not yet established specific criteria for measuring marijuana-impaired driving (such as the .08% blood alcohol content that is a threshold for alcohol-related driving under the influence [DUI] conviction).

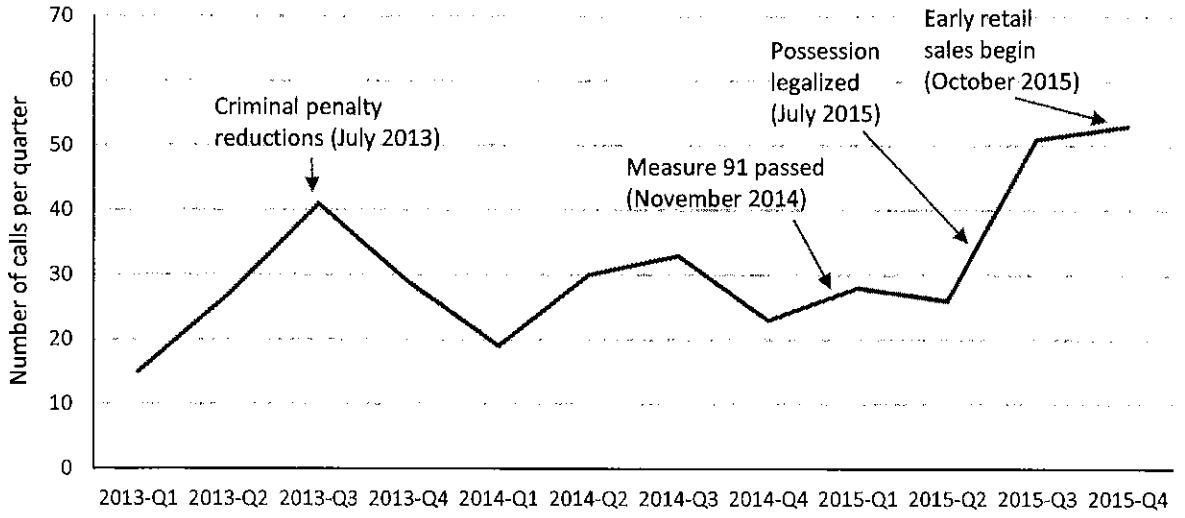
Public health and social consequences

Poison Center calls

The Oregon Poison Center is a 24-hour health care information and treatment resource staffed by doctors and nurses trained in toxicology. For more then 30 years, the Poison Center has provided emergency treatment information for patients experiencing a poisoning or toxic exposure.

Marijuana exposure calls to the Oregon Poison Center are an important measure of acute adverse reactions and accidental poisonings from marijuana. People may call the Poison Center when someone (especially children) accidentally ingests marijuana, or if they are concerned about having overdosed.

Figure 37. Marijuana-related calls to the Oregon Poison Center, quarterly, 2013–2015

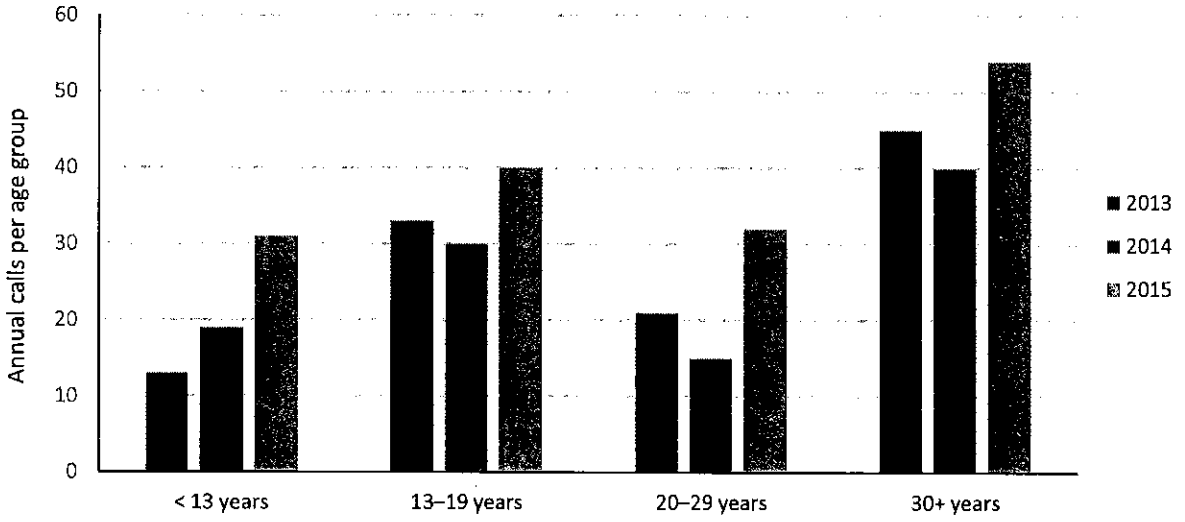


Data source: Toxic Exposure Surveillance System. Oregon Poison Center, Oregon Health & Science University, 2013–2015

As shown in Figure 37:

- Marijuana-related calls to the Poison Control Center increased in the second half of 2015.
- There were 112 total calls about marijuana to the Oregon Poison Center in 2013, 105 total calls in 2014 and 158 in 2015.
- Longer-term monitoring will be necessary to determine whether there has been a sustained increase in call frequencies following changes in Oregon's marijuana laws.

Figure 38. Annual marijuana-related calls to Oregon Poison Center, by age group, 2013–2015



Data source: Toxic Exposure Surveillance System. Oregon Poison Center, Oregon Health & Science University, 2013–2015

As shown in Figure 38:

- There were more calls in 2015 than in prior years, among all age groups.
- The number of annual exposure calls for children younger than age 13 has increased modestly since 2013. The percentage of all marijuana exposure calls for children younger than age 13 affected by marijuana has increased from 12% in 2013 to 20% in 2015.

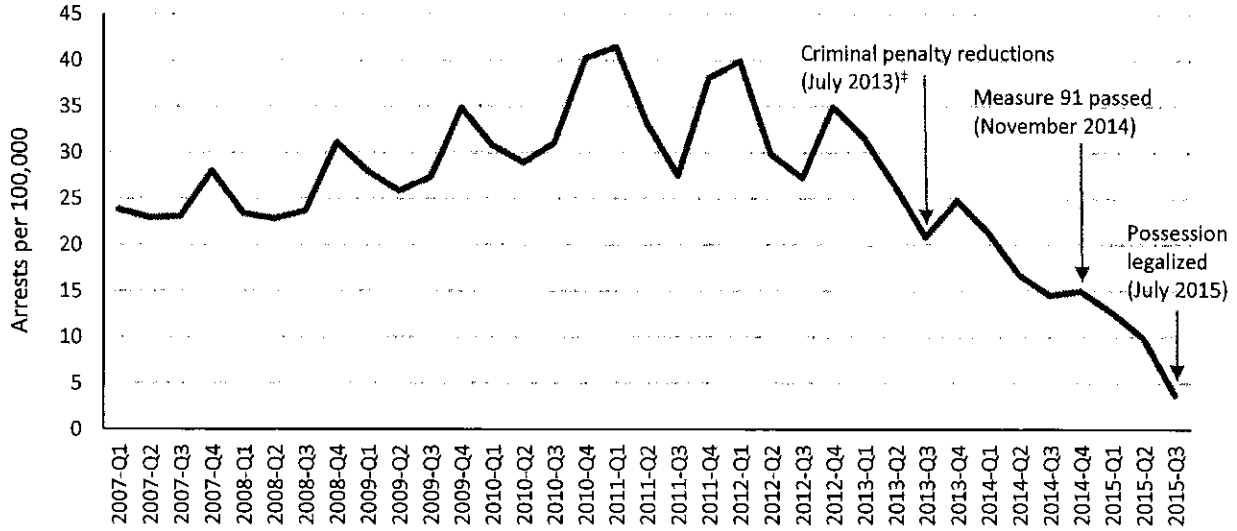
Marijuana-related crimes

Arrests and convictions can have long-lasting consequences such as decreased employment opportunities for individuals. In addition, people with incarceration histories are more likely to have mental illness, chronic conditions and communicable diseases. Furthermore, children can be negatively affected because incarceration of a household member is considered an adverse childhood experience; it can act as a risk factor for poor subsequent adult health.*

Oregon State Police routinely collect information about drug-related adult arrests. Data in this section reflect marijuana-related arrests where the subject is taken into custody (booked and fingerprinted). Juveniles that are prosecuted as adults are also included in these arrest reports. Citations (such as for possessing less than an ounce of marijuana) are not included.

*For more discussion about effects of incarceration on health, see https://public.health.oregon.gov/DiseasesConditions/CommunicableDisease/CDSummaryNewsletter/Documents/2012/ohd6101.pdf.

Figure 39. Quarterly marijuana arrest rates among Oregon adults, January 2007–September 2015



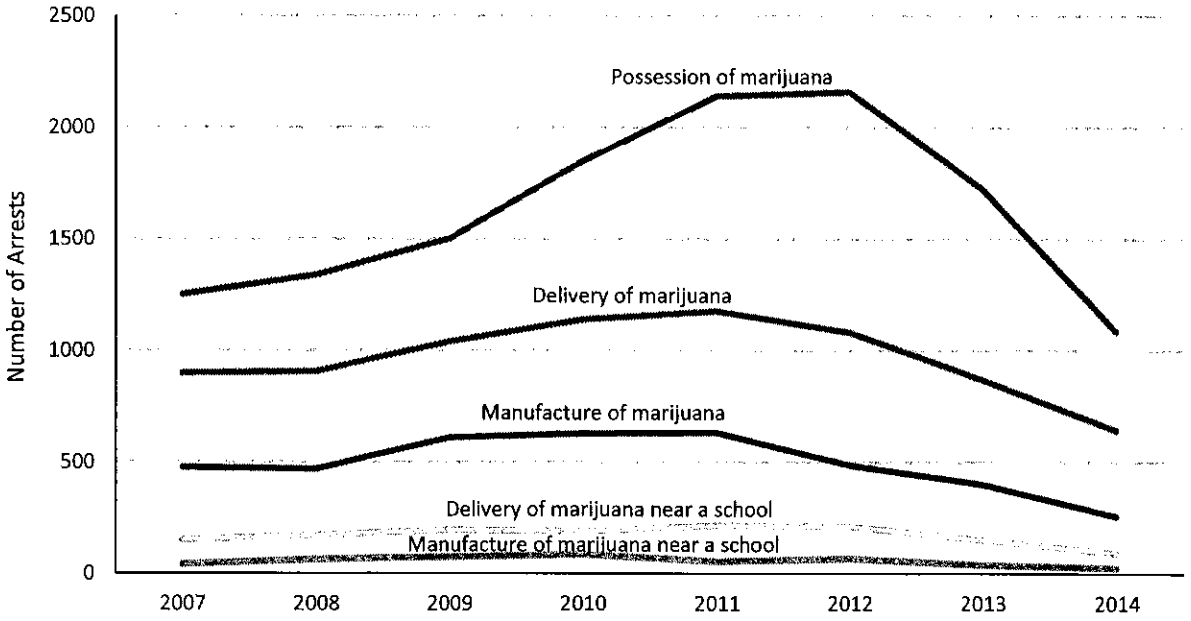
‡Reduction in penalties for >1 ounce of marijuana possession & marijuana manufacturing.

Data source: Oregon State Police arrest data.
Oregon Criminal Justice Commission, 2007–September 2015

As shown in Figure 39:

- The rate of marijuana arrests has decreased in the past five years, from a peak quarterly average of 35 arrests per 100,000 adults during 2011 to nine arrests per 100,000 adults during 2015 (Figure 39).
- During 2006–2014 (prior to marijuana legalization), marijuana arrests accounted for 16% of all drug-related arrests in Oregon (data not shown)

Figure 40. Marijuana arrests among Oregon adults, by charge type, 2007–2014

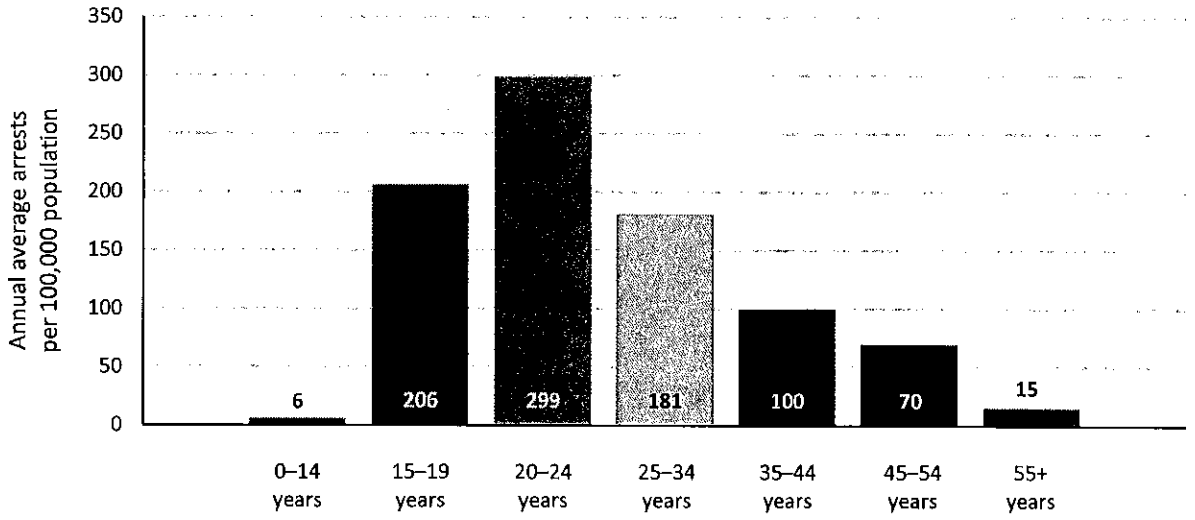


Data source: Oregon State Police arrest data.
Oregon Criminal Justice Commission, 2007–2014

As shown in Figure 40:

- The number of marijuana arrests for all charge types combined decreased between 2011 (a total of 4,223 arrests) and 2014 (a total of 2,109 arrests).
- The largest decrease was seen for marijuana possession arrests, which declined from a peak of 4,223 arrests in 2011 to 2,109 arrests in 2014.
- In 2014, more than half of marijuana arrests were for possession (52%), one-third (35%) were for delivery of marijuana and one in seven (14%) were for manufacture of marijuana (data not shown).

Figure 41. Average annual marijuana arrest rates in Oregon, by age group*, 2007–2014



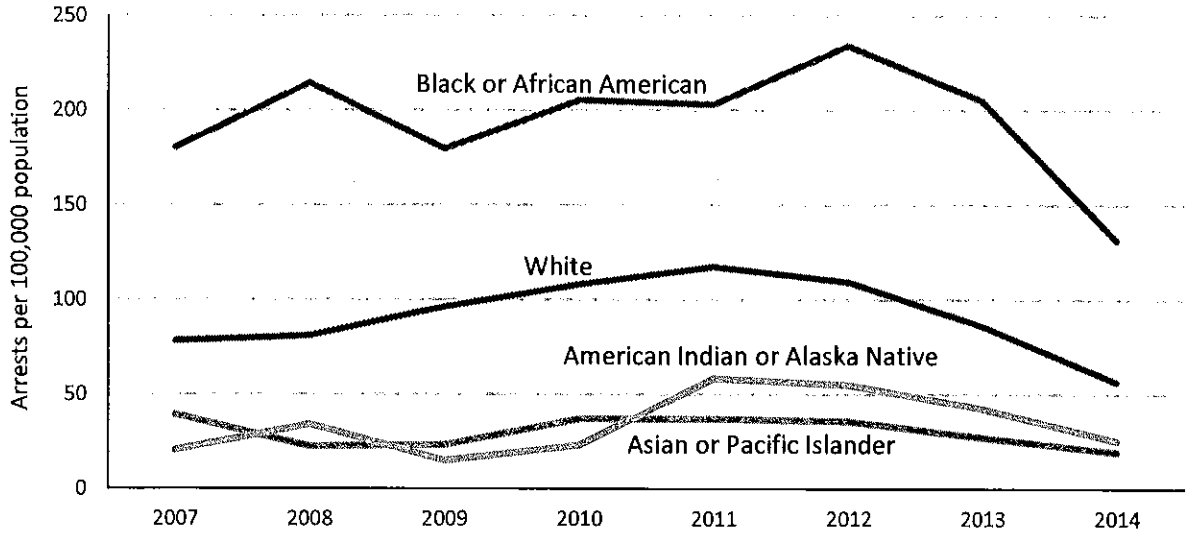
*Juveniles prosecuted as adults are included in this data.

Data source: Oregon State Police arrest data. Oregon Criminal Justice Commission, 2007–2014

As shown in Figure 41:

- During 2007–2014, the highest rate of marijuana arrests occured among 20–24 year olds.
- The majority of the people arrested for marijuana crimes were men (84%); 16% were women (data not shown).

Figure 42. Oregon marijuana arrest rates*, by race, 2007–2014



*Annual rates are age-adjusted.

Data source: Oregon State Police arrest data.
Oregon Criminal Justice Commission, 2007–2014

As shown in Figure 42:

- Racial differences exist in the rate of marijuana arrests. In 2014, the rate of marijuana arrests among Black or African Americans was 2.3 times higher than the marijuana arrest rate among Whites. This disparity in marijuana arrests did not significantly change from 2007 to 2014.
- The rates of marijuana arrests among Asian or Pacific Islander and American Indian and Alaska Native adults were lower or similar to the arrest rate for Whites from 2007 to 2014.

Future directions

This report provided a summary of information from readily available data sources that describe metrics related to marijuana and public health.

Other data sources will also provide important information moving forward. Key sources include:

- **Oregon ESSENCE.** ESSENCE is a syndromic monitoring system that collects information about emergency department visits for the purpose of identifying emerging public health threats (such as infectious disease outbreaks). Currently, a project is underway to accurately identify marijuana-related emergency department visits within the system. A first look report describing marijuana-related emergency department visit data from ESSENCE is planned for 2016.
- **Oregon Measures and Outcomes Tracking System (MOTS).** MOTS is a comprehensive electronic data system used by behavioral health service providers to improve care, control costs and share information. MOTS collects information about publicly funded addictions treatment, including which substances are being addressed through treatment. A plan to extract appropriate MOTS data for monitoring trends in publicly funded marijuana-related addictions treatment is in development.
- **Expanded Behavioral Risk Factor Surveillance System (BRFSS) measures.** This report included a summary of adult marijuana use data from the 2014 BRFSS. This was the first year that questions about marijuana use had been added to the Oregon BRFSS. Beginning in 2016, an expanded set of marijuana indicators was added to the survey, including to assess combined use of marijuana with alcohol or tobacco, whether users have experienced adverse effects associated with marijuana use, and whether parents are storing marijuana so that it is inaccessible to children. Reports from the 2016 data will be available in fall 2017.
- **Oregon's Pregnancy Risk Assessment Monitoring System (PRAMS).** PRAMS is a well-established and ongoing survey to assess maternity-related health, conducted among women that recently had a baby in Oregon. Questions about marijuana use prior to

pregnancy, during pregnancy and after delivery will be collected beginning in 2016. This will be the first population-based information available in Oregon to describe maternal marijuana use during pregnancy and post-partum (including among breastfeeding mothers). Data from calendar year 2016 will be available in fall 2017.

Other data sources under investigation include emergency medical services and trauma data, hospital discharge data, traffic crash data and marijuana-related student discipline data. Information will be reported as it becomes available from these or other potential sources that provide greater understanding about marijuana and public health.

Data sources

Youth behavior and attitude data

Oregon Healthy Teens (OHT) and Student Wellness Survey (SWS) are anonymous, school-based surveys conducted by the Oregon Health Authority. Both surveys collect health behavior information from eighth- and 11th-graders in most counties across Oregon. Data are weighted to represent students proportionally across Oregon. Unweighted data are used for race-specific estimates. The trend of current marijuana use among Oregon 8th- and 11th-graders used both SWS (2012 and 2014 school years) and OHT (2013 and 2015 school years). Additional analysis was conducted for OHT 2015 school year.

For more information about OHT, go to https://public.health.oregon.gov/BirthDeathCertificates/Surveys/OregonHealthyTeens/Pages/index.aspx.

For more information about SWS, go to https://oregon.pridesurveys.com/.

Adult behaviors

The Behavioral Risk Factor Surveillance System (BRFSS) is an ongoing random-digit-dialed telephone survey of adults ages 18 or older concerning health-related behaviors. The BRFSS was developed by the Centers for Disease Control and Prevention (CDC) and is conducted in all states in the United States. Each year, between 5,000 and 15,000 adult Oregonians are interviewed. The BRFSS includes questions on health behavior risk factors such as diet, weight control, tobacco and alcohol use, physical activity, preventive health screenings, and use of health care services. The data are weighted to represent all adults aged 18 and older. The Medicaid Behavioral Risk Factor Surveillance System (MBRFSS) was a special version of BRFSS, conducted in 2014 among the Oregon adult Medicaid-enrolled population and including an oversample of selected racial/ethnic groups.

For more information about the Oregon BRFSS, go to https://public.health.oregon.gov/BirthDeathCertificates/Surveys/AdultBehaviorRisk/Pages/index.aspx.

The National Survey on Drug Use and Health (NSDUH) is an annual nationwide survey involving interviews with approximately 70,000 randomly selected individuals aged 12 and older. The NSDUH provides national and state-level data on the use of tobacco, alcohol, illicit drugs (including non-medical use of prescription drugs) and mental health in the United States. NSDUH biennial state-level reports published online were used for this report.

For more information about NSDUH and results, go to www.samhsa.gov/data/population-data-nsduh.

Oregon Medical Marijuana Program (OMMP)

The OMMP provides quarterly "statistical snapshot" reports of current patients, caregivers, growers and grow sites, based on their applications. Reports are routinely updated and posted at https://public.health.oregon.gov/DiseasesConditions/ChronicDisease/MedicalMarijuanaProgram/Pages/data.aspx.

Oregon Poison Center (OPC)

The Oregon Poison Center (OPC) uses Toxicall®, a data software program for documentation of each poison center case. Poison center staff collect extensive demographic, clinical and substance information from each caller. Statistical data from the OPC is obtained through custom data queries of Toxicall. De-identified data elements from each poison center in the country are transmitted to the National Poison Data System (NPDS). The NPDS enables queries of national aggregate poison center data.

Each call reported represents one exposure; calls that discuss exposures for two people would be counted twice. Overall OPC call levels have declined slightly during the years presented in this report. There were 40,902 total calls in 2013, 39,949 in 2014 and 39,657 in 2015.

More information about the Oregon Poison Center is available at www.ohsu.edu/xd/outreach/oregon-poison-center/index.cfm.

Crime

Law Enforcement Data Systems (LEDS) arrest data were provided by the Oregon State Police for all drug-related charges between 2006 and September 2015. Each record in the data set represents a unique charge in an arrest. This data system captures all adult arrests where the subject is taken into custody (booked and fingerprinted). Juveniles that are processed as adults are also included in the system. Adult and juvenile arrests that did not result in the subject being taken into custody are not captured in this data set (e.g., citations). All rates in analysis were age-adjusted to the 2000 U.S. standard population.

For more information about LEDS, go to www.oregon.gov/osp/CJIS/Pages/index.aspx.

Health Promotion & Chronic Disease Prevention Panel Survey

The Oregon Public Health Division's Health Promotion & Chronic Disease Prevention Section conducted an online survey of Oregon adults in November 2015. The online survey consisted of 66 questions and was taken by a total of 2,000 adults (ages 18 years and older) living in Oregon. Survey respondents were invited to participate though a professionally maintained panel. Panelists were provided an incentive by the panel vendor to participate in surveys, but were not given any additional incentive by the Oregon Public Health Division for participation. The survey asked questions about tobacco use, attitudes about community policies to regulate tobacco products, active transportation (walking, biking) and marijuana use and attitudes. Statistical weights were applied to the data after collection so that respondents reflect the demographic characteristics of Oregon's adult population, a common practice for population-based survey analysis that ensures the survey results better represent all Oregon adults.

Oregon medical marijuana dispensaries and local bans

Information about local bans was collected from the Oregon Medical Marijuana Program record of cities or counties that have prohibited the establishment of registered medical marijuana processors and/or dispensaries, and/or prohibited early retail sales of marijuana in registered medical marijuana dispensaries (www.oregon.gov/oha/mmj/Documents/MMDP%20Opt%20Out%20List.pdf). Ordinances that prohibit medical marijuana facilities and/or early retail sales must have been reported to the Oregon Health Authority.

Registered medical marijuana dispensary information was obtained from the Oregon Medical Marijuana Program dispensary registry (www.oregon.gov/oha/mmj/Pages/directory.aspx).

Both local ban reports and dispensary data were collected Nov. 30, 2015.

Resources

The following websites provide more information on topics related to this report. Resources available at each website are summarized below each listing.

Oregon Health Authority: Marijuana and Your Health

http://public.health.oregon.gov/PreventionWellness/marijuana/Pages/index.aspx

- Marijuana and health and safety
- Frequently asked questions
- Summary of the law
- Description of the Public Health Division's role
- Scientific Advisory Committee reviews of evidence on marijuana-related health effects

Oregon Medical Marijuana Program (OMMP)

http://public.health.oregon.gov/DiseasesConditions/ChronicDisease/medicalmarijuanaprogram/Pages/index.aspx

- Registers patients and caregivers including medical marijuana as part of treatment for specific medical conditions

Oregon Medical Marijuana Dispensary Program

www.oregon.gov/oha/mmj/Pages/about.aspx

- Information about the licensing, regulation and oversight of medical marijuana facilities in Oregon
- Includes a current directory of medical marijuana dispensaries

Educate Before You Recreate Public Education Campaign

http://whatslegaloregon.com/

- Infographic summarizing marijuana laws in Oregon

Oregon Liquor Control Commission (OLCC)

www.oregon.gov/olcc/marijuana/Pages/default.aspx

- Recreational marijuana licensing: current information about recreational marijuana licensing, including routinely updated lists of cities/counties prohibiting licensed recreational marijuana facilities
- Updates on developing laws and rules

Measure 91: Control, Regulation and Taxation of Marijuana and Industrial Hemp Act

www.oregon.gov/olcc/marijuana/Documents/Measure91.pdf

- Measure text, as passed by Oregon voters in November 2014

Appendix A

This report provides data in charts with confidence intervals (see example in figure on following page). It is unlikely that point estimates (%) reported from any surveys based on a sample of people are *exactly* the same as the "true" value for the total population. Confidence intervals help to understand the size of this uncertainty.

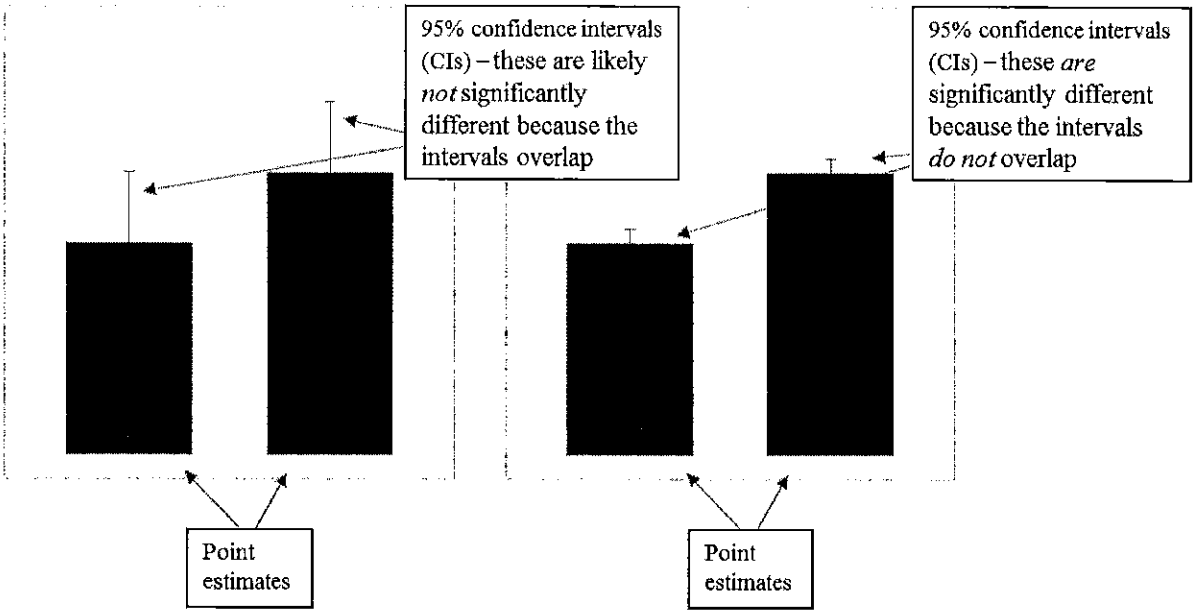
Our report uses 95% confidence intervals. If there is no bias in the data collection system, there is a 95% chance (95 times of 100) that the confidence interval will include the true value for the total population. Groups with smaller numbers of people included in surveys (e.g., racial minorities) will have larger confidence intervals relative to groups with larger numbers of people because there is less precision (or confidence) for those estimates.

The "margin of error" is a common term for the $\pm$ (plus or minus) value around a point estimate, which in total represents the confidence interval.

Readers are advised to consider the precision of point estimates provided in this report by using confidence intervals around estimates. Generally, when the confidence intervals for two groups overlap, it is not certain that the true value of results for these groups are truly different. If the confidence intervals do not overlap, then we believe the true values of results for these two groups are different.

Throughout this report, unless otherwise noted, only statistically significant results are described in text as being "higher" or "lower" than other groups.

Example of confidence intervals displayed in report charts



The marijuana universal symbol means a product contains marijuana and should be kept in its original packaging, out of the reach of children.

Oregon Health Authority
PUBLIC HEALTH DIVISION
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Fax: 971-673-1299

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OHA 8509 (03/16)

Monitoring Impacts of Recreational Marijuana Legalization

2015 Baseline Report

Introduction

In 1998, Washington state voters approved Initiative 692, permitting the medical use of marijuana for certain terminal or debilitating conditions and allowing physicians to advise patients about the medical use of marijuana.

In 2011, the Washington State Legislature passed Engrossed Second Substitute Senate Bill 5073 (E2SSB 5073), amending and clarifying the law on medical marijuana. The bill created a patient registry, allowed for multiple-patient collective gardens and created a state licensing system for producers, processors and dispensers. Citing concerns about putting state employees at risk of federal prosecution, Gov. Chris Gregoire vetoed the portions of E2SSB 5073 that would have directed state employees of the state departments of Health and Agriculture to authorize and license commercial businesses that produce, process or dispense marijuana. The surviving provisions of the bill increased protection for qualifying patients and their designated providers to grow marijuana for a patient's use or to participate in collective gardens, without state regulation.

In 2012, Washington state voters approved Initiative 502, legalizing the recreational use of marijuana by individuals 21 or older. It charged the Washington State Liquor Control Board with licensing and regulating the production, processing and sale of marijuana.

Recreational marijuana sales began July 8, 2014, and as of March 1, 2015, there are 123 licensed marijuana retail stores in the state. In contrast, there are an estimated 1,100 medical marijuana dispensaries in Washington's still-unregulated medical marijuana market. Lawmakers are advancing legislation to regulate medical marijuana.

It is important to note that the data in this report, other than those specific to the implementation of I-502, reflect the current impact of marijuana in Washington, most of which is acquired outside the regulated market.

Highlights and key findings

1. **HEALTH**

- Among students surveyed, current marijuana use increased by grade, with the sixth graders having the lowest use at 1 percent in 2012, and 12th-graders the highest at 27 percent in 2012.
- Between 2006 and 2012, use among 12th-graders increased by an average of 4 percent per year. No trends were seen for grades 6, 8 or ten.
- Use among adults surveyed is highest for those ages 18 to 24, 15 percent in 2013.
- Use among adults ages 45 to 64 is increasing by 33 percent per year, from 4 percent in 2011 to 8 percent in 2013. No trends were seen within the other age groups.
- The percentage of 12th-graders who first used marijuana at age 15 is increasing by 6 percent per year, from a low of 8 percent in 2006 to a high of 11 percent in 2012.
- Among adults who had ever used marijuana, nearly half reported that they were between ages 14 and 17 the first time they tried it; this was true for each survey year. No trends in age at first use were identified for these adults.
- Among students, ease of access increased by grade, but no trends were identified over time in any of the grades surveyed.
- Between 2011 and 2013, there was an average of 155 marijuana-related calls per year to the Poison Control Center; in 2014, it markedly increased to 246.
- While the number of youths receiving state-funded substance use disorder (SUD) treatment has decreased, the proportion receiving such treatment for marijuana has increased from a low of 61 percent in 2007 to a high of 78 percent in 2013.

1. **HEALTH** (continued)

- Population-based rates of state-sponsored SUD treatment for marijuana use among youths has increased by 5 percent per year from 2006 to 2013. Concurrently, rates for state-sponsored SUD treatment for youths for other drugs decreased by 11 percent per year from 2009 to 2013
- Among drivers involved in a traffic fatality who are tested for drugs or alcohol, there is a 4 percent per year decrease in those testing positive for marijuana in combination with other drugs and/or alcohol, from a high of 27 percent in 2004 to a low of 15 percent in 2013. No trend was identified for those who tested positive for marijuana only, with percentages ranging from a high of 7 percent in 2004 to a low of 2 percent in 2013.*

2. **ENFORCEMENT**

- Arrests for any drug or narcotic decreased by 17 percent between 2012 and 2013.
- Incidents involving marijuana decreased by more than half between 2012 and 2013; concurrently, incidents involving amphetamines , heroin and crack cocaine increased.**
- Incidents where marijuana was seized decreased for all quantities involved.
- While highways and roads remained the most common location where marijuana incidents occurred, such incidents decreased from 2,462 in 2012 to 768 in 2013. However, incidents increased at secondary or primary schools, from 258 in 2012 to 345 in 2013.
- All criminal activities involving marijuana decreased between 2012 and 2013. Possession, which is the most common incident, decreased from 5,133 in 2012 to 2,091 in 2013.
- Drug-only DUI arrests, which do not differentiate marijuana from other drugs, decreased from a high of 1,710 in 2011 to a low of 1,229 in 2014, for an overall decrease of 28 percent.

Highlights and key findings (continued)

2. **ENFORCEMENT** (continued)
   - Marked decreases are seen in marijuana-related non-prison convictions, dropping from a high of 502 in 2011 to a low of 98 in 2014, and in prison convictions, from 73 in 2011 to 13 in 2014.
   - For the 2013-14 school year, 4 percent of public school students were suspended or expelled; of that 4 percent, 11 percent (or 0.4 percent of all students) were suspended or expelled for marijuana.
3. **REVENUES AND TAXES**
   - As a new enterprise, sales and excise tax revenues markedly increased. However, the rate of increase appears to be leveling off: Sales for September to October rose by 49 percent; from October to November by 24 percent; and from November to December by 6 percent.
   - Sales in December 2014 equaled more that $17 million; excise taxes for that month were $4.3 million.
   - State revenues from retail and from business and occupation taxes also increased. In November 2014 (the most current data available), those taxes totaled $1.5 million.
4. **PRODUCTION AND SALES**
   - Licensed producers and processors appear to be equally located in urban and rural locales. Similarly, high-volume producers/processors are also somewhat evenly distributed.
   - Retailers tend to be more commonly located in urban and suburban communities; however, some high-volume retailers are located in non-urban communities, particularly those that border other states.
   - Of the six counties with the highest per capita sales, four are border counties: Whatcom, Clark, Klickitat and Spokane.
4. **PRODUCTION AND SALES** (continued)
   - Average retail price decreased by 9 percent per month, from a high of $25 in August 2014 to a low of $14 in January 2015.
   - The number of retailers increased more than five-fold, from 18 in July 2014 to 96 in January 2015.
5. **CITY AND COUNTY ORDINANCES**
   - Forty-one cities currently have temporary moratoria on retail sales of recreational marijuana.
   - Fifty cities have prohibitions on those sales.
   - Five counties have temporary moratoria on recreational sales in unincorporated regions.
   - An additional five counties have prohibitions on recreational sales in unincorporated regions.

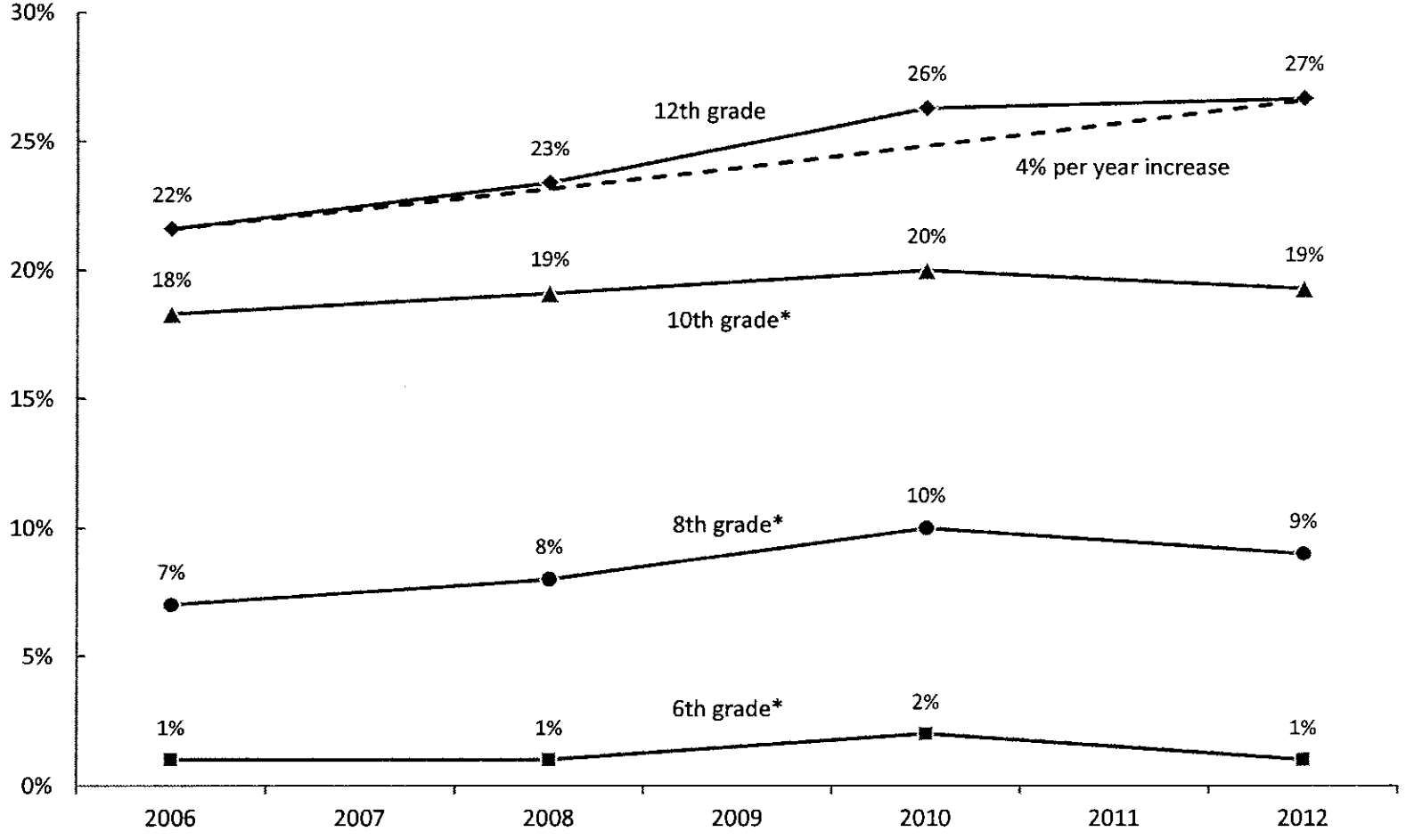
* While traffic fatalities overall have been decreasing, the number of drivers involved in such crashes who are tested for alcohol and drugs has proportionately increased, from a low of 42 percent in 2004 to a high of 62 percent in 2013.

** As defined by the FBI, an "incident" occurs when any law enforcement officer investigates a scene or situation, whether that investigation results in an arrest or not. Incidents involving multiple illicit drugs or other criminal activities are counted only once, and are included in whichever category is listed first by the local law enforcement agency. The order used by those agencies is not hierarchical.

1.1 Current Use – Students

Taken from the Healthy Youth Survey, which is administered every two years to sixth-, eighth-, 10th- and 12th-graders, the question, "Have you used marijuana in the past 30 days?" gauges current marijuana use among students. As seen below, for 12th-graders, use is increasing by 4 percent per year, from 22 percent in 2006 to 27 percent in 2012. For all other grades there are no significant trends.

Source: Washington State Health Youth Survey, 2006-2012

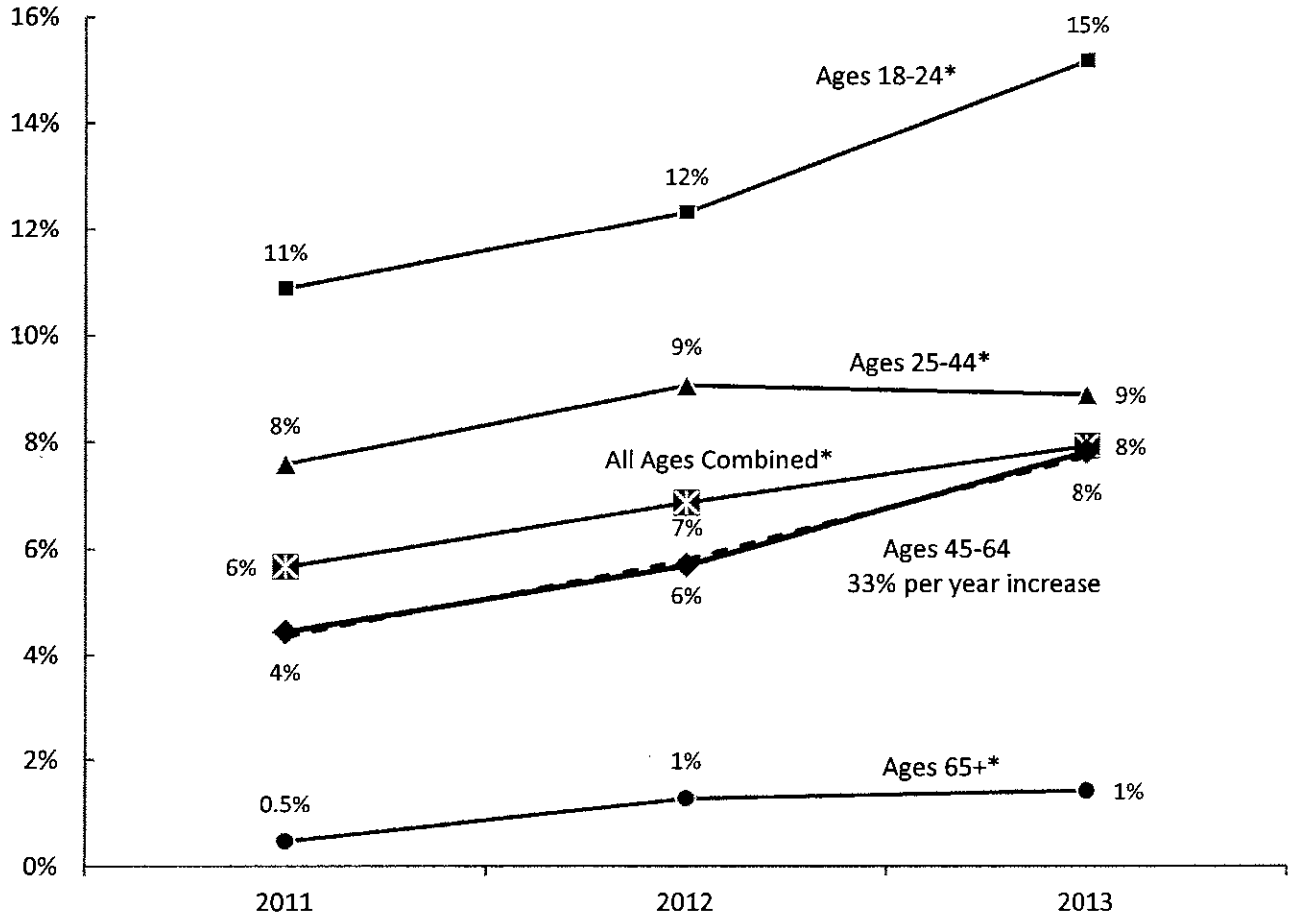


* No significant trend

1.2 Current Use – Adults

In the Behavioral Risk Factors Surveillance Survey, respondents ages 18 and older are asked, "Have you smoked marijuana in the past 30 days?" With 15 percent responding "Yes" in 2013, those ages 18 to 24 are the most likely current users. There is a significant trend in increased use among those ages 45 to 64, from 4 percent in 2011 to 8 percent in 2013, equaling a 33 percent per year increase. No other trends were identified.

Source: Washington State Behavioral Risk Factors Surveillance System

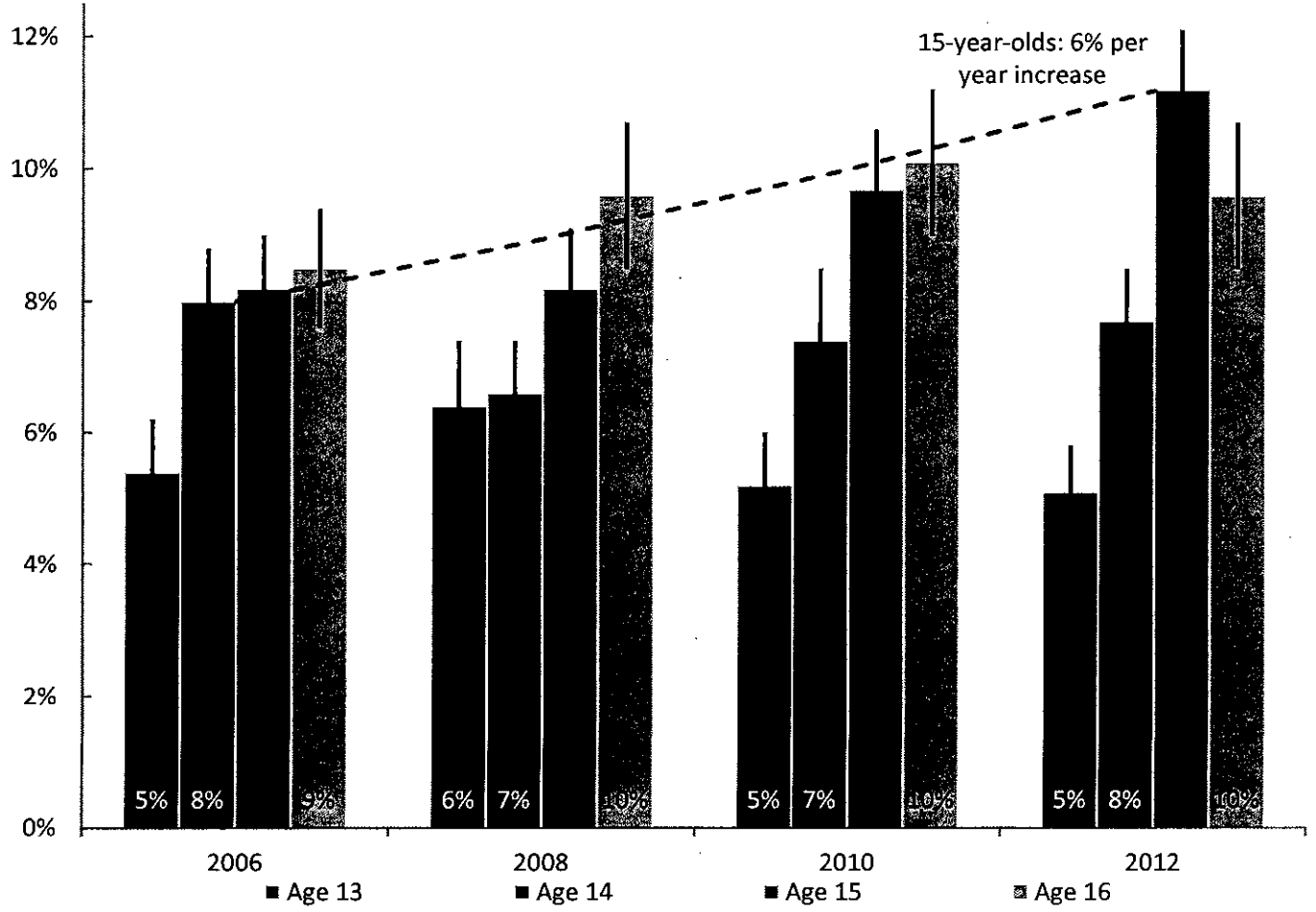


* No significant trend

1.3 Age at First Use – Students

When asked , "How old were you the first time you smoked marijuana?" 12th-graders who responded that they were age 15 grew from a low of 8 percent in 2006 to a high of 11 percent in 2012. This constituted a 6 percent per year increase. No trends were identified for the other reported ages of first use.

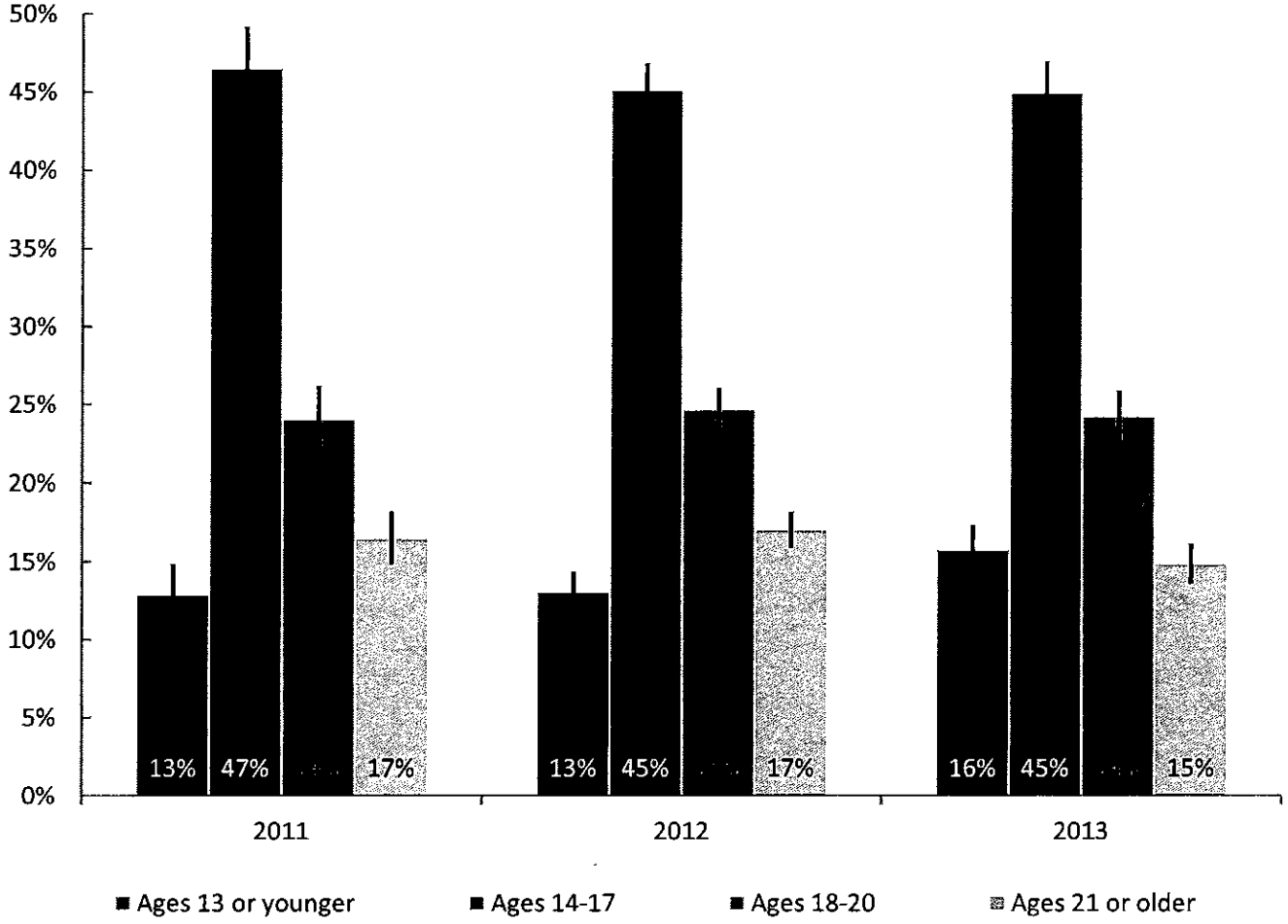
Source: Washington State Health Youth Survey, 2006-2012



1.4 Age at First Use – Adults

Among adult respondents who had ever smoked marijuana, the question was asked, "How old were you the first time you smoked marijuana?" In the age groups shown here, nearly half of those who had smoked marijuana first did so between the ages 14 and 17, regardless of the survey year. No trends were identified.

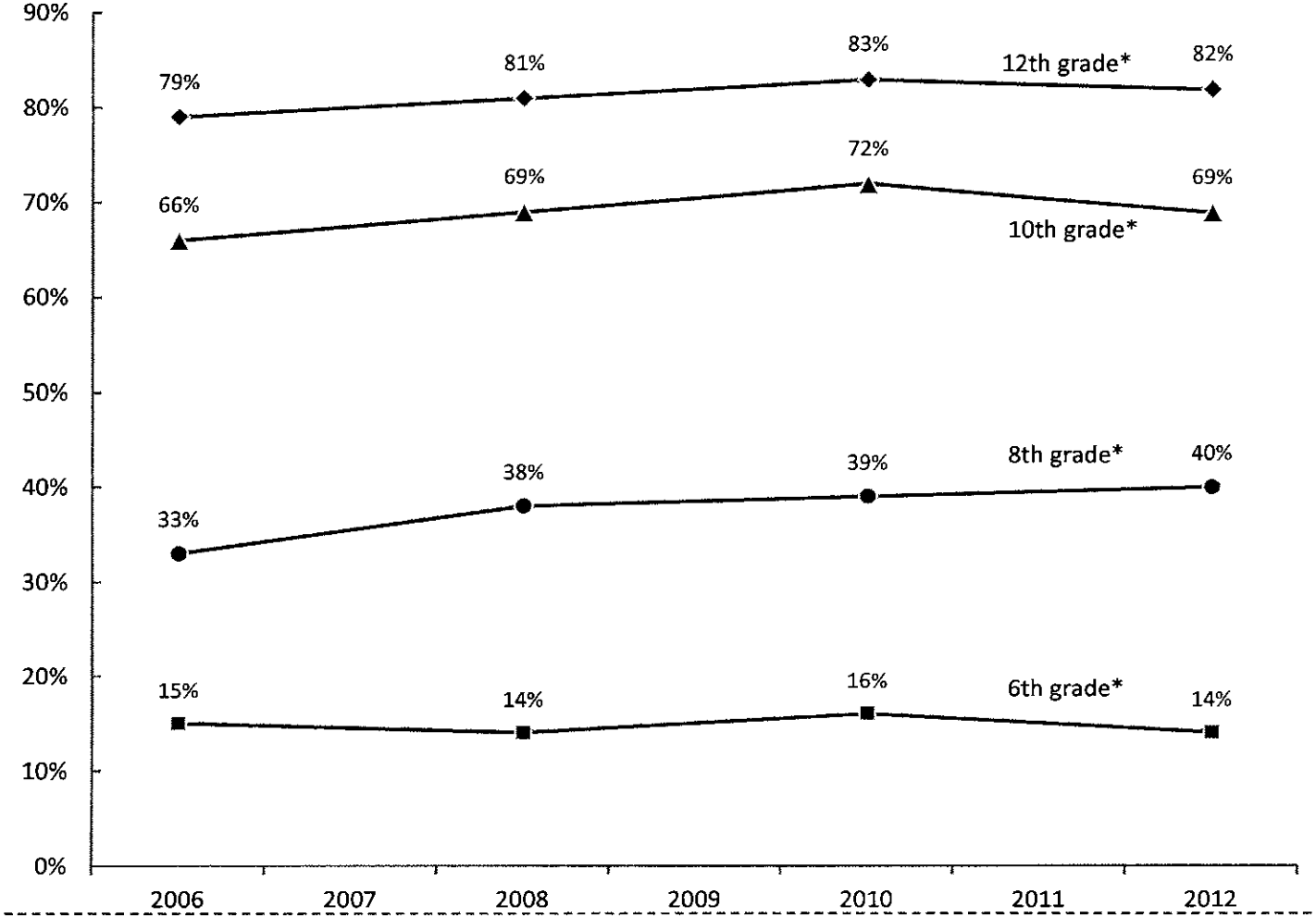
Source: Washington State Behavioral Risk Factors Surveillance System, 2011-2013



1.5 Access – Students

Asked, "If you wanted to get some marijuana, how easy would it be to get some?" this measure includes, by convention, those answering "sort of hard," "sort of easy" and "very easy." While access differs by grade level, no significant trends are seen over time.

Source: Washington State Health Youth Survey, 2006-2012

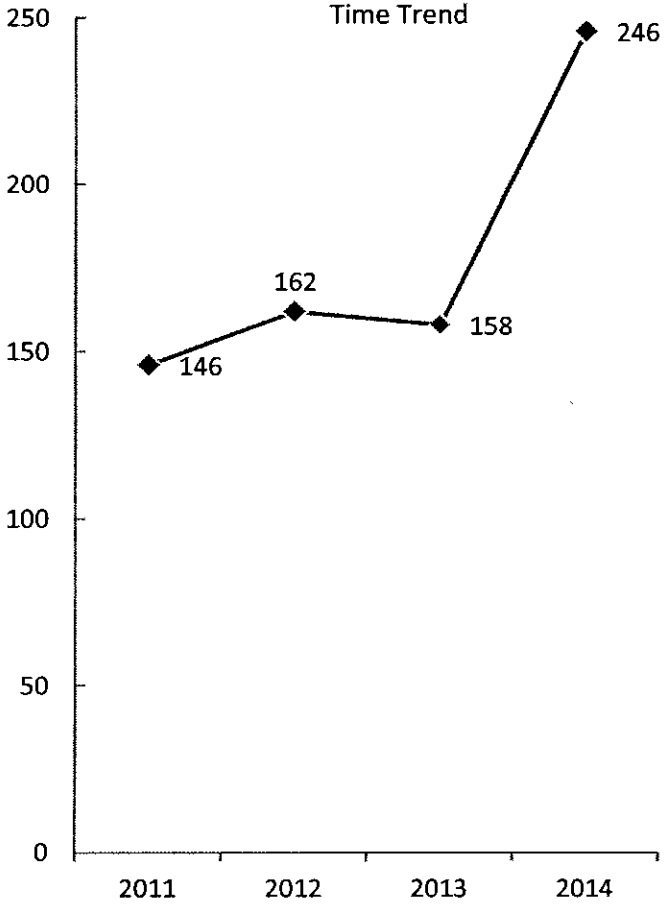


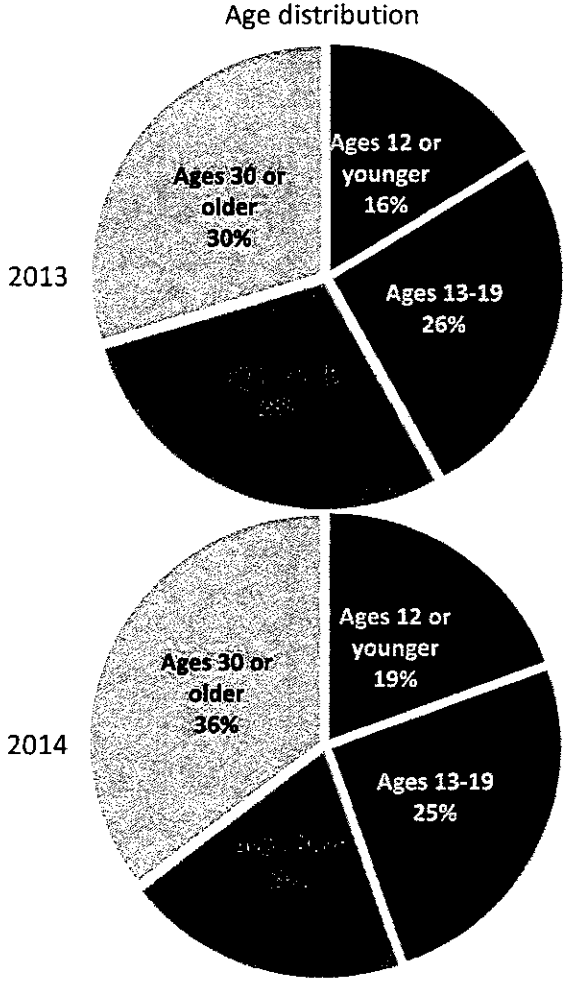
* No significant trend

1.6 Poisonings

Marijuana-related calls to the Washington Poison Center were relatively constant from 2011 to 2013, but those calls increased from 158 in 2013 to 246 in 2014. The percentages of calls by age group were, however, similar in 2013 and 2014, especially when taking into consideration the relatively small numbers involved in 2013, with those ages 30 or older constituting the largest percentage and those ages 12 or younger the smallest.

Source: Washington Poison and Drug Information Center

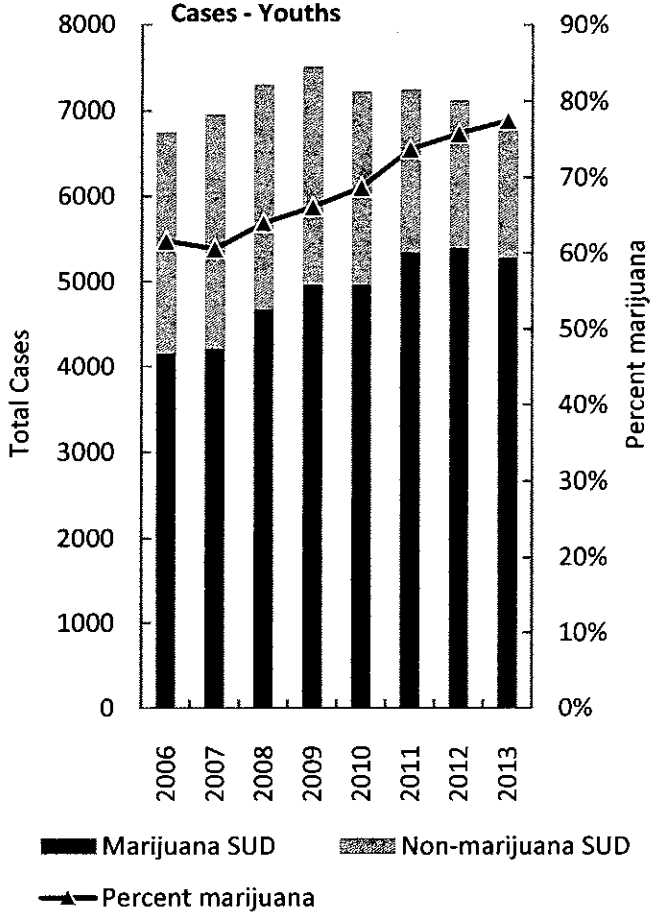


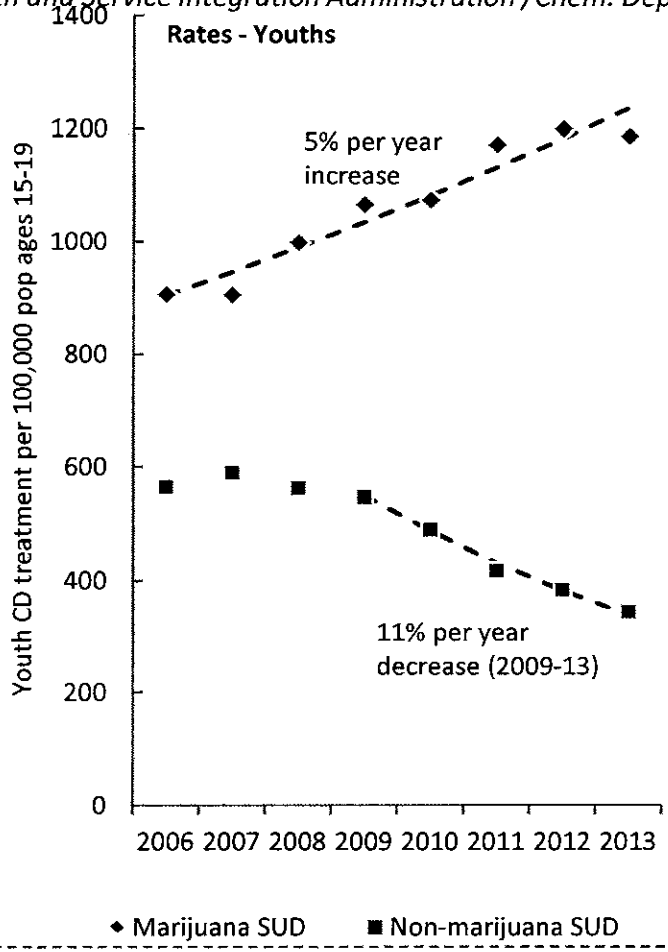


1.7 Substance Use Disorder Treatment

Substance use disorder (SUD) treatment for youth receiving publicly funded services decreased between 2009 and 2013. However, as a proportion of the total SUD cases, treatment for marijuana increased from 61 percent in 2007 to 78 percent in 2013. Age-specific rates for youth marijuana SUD treatment have also been increasing, on average, by 5 percent per year. Rates for non-marijuana related SUD treatment decreased by 11 percent per year from 2009 to 2013. SUD youth may be court ordered or referred to treatment in other ways.

Source: Department of Social and Health Services (Behavioral Health and Service Integration Administration /Chem. Dependency)

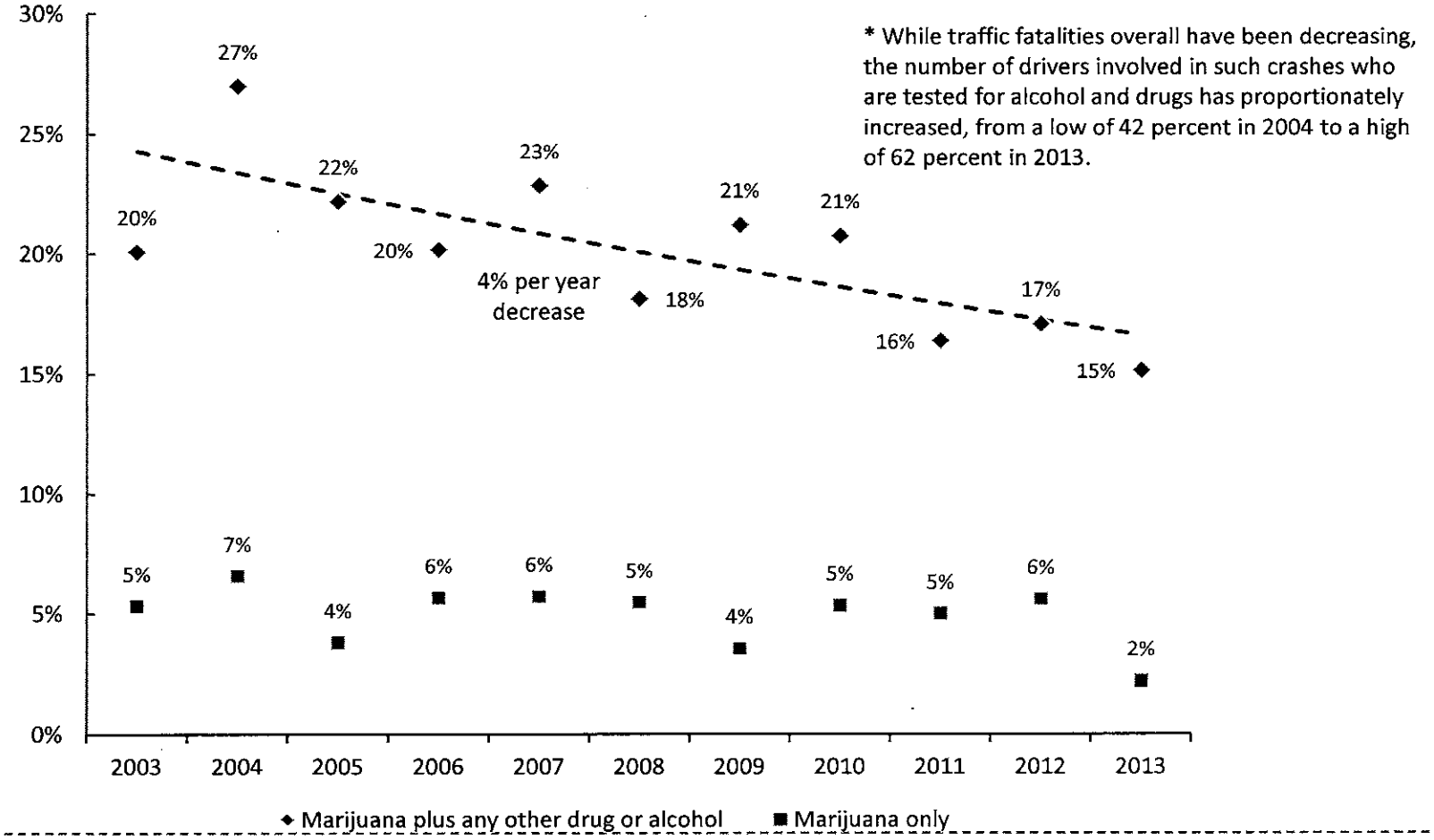




1.8 Traffic Fatalities

As a percentage of drivers involved in traffic fatalities who are tested for alcohol and drugs*, there is a 4 percent per year decrease in proportion of drivers involved in fatal crashes who tested positive for marijuana in combination with other drugs or alcohol, from a high of 27 percent in 2004 to a low of 15 percent in 2013. No trend was identified among those who were tested and tested positive for marijuana only, ranging from a high of 7 percent in 2004 to a low of 2 percent in 2013.

Source: Washington Traffic Safety Commission

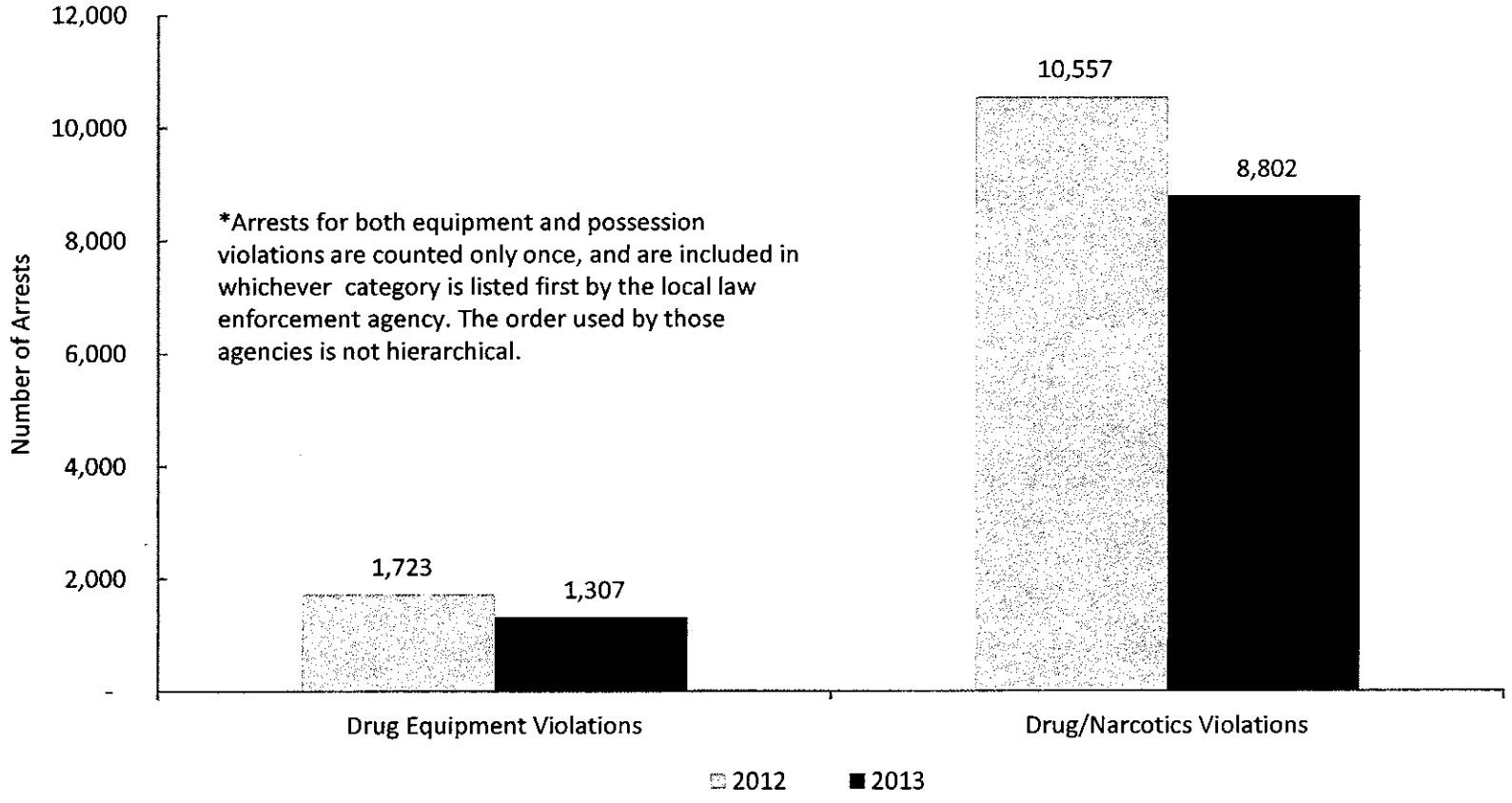


* While traffic fatalities overall have been decreasing, the number of drivers involved in such crashes who are tested for alcohol and drugs has proportionately increased, from a low of 42 percent in 2004 to a high of 62 percent in 2013.

2.1 Drug or Narcotic Arrests

Each of the arrests shown below may include multiple drug and/or narcotic offenses.* Between 2012 and 2013, there was a 24 percent decrease in arrests for drug equipment violations, and a 17 percent decrease in arrests for drug or narcotic violations. Drug equipment refers to equipment or devices used in preparing and/or using drugs or narcotics.

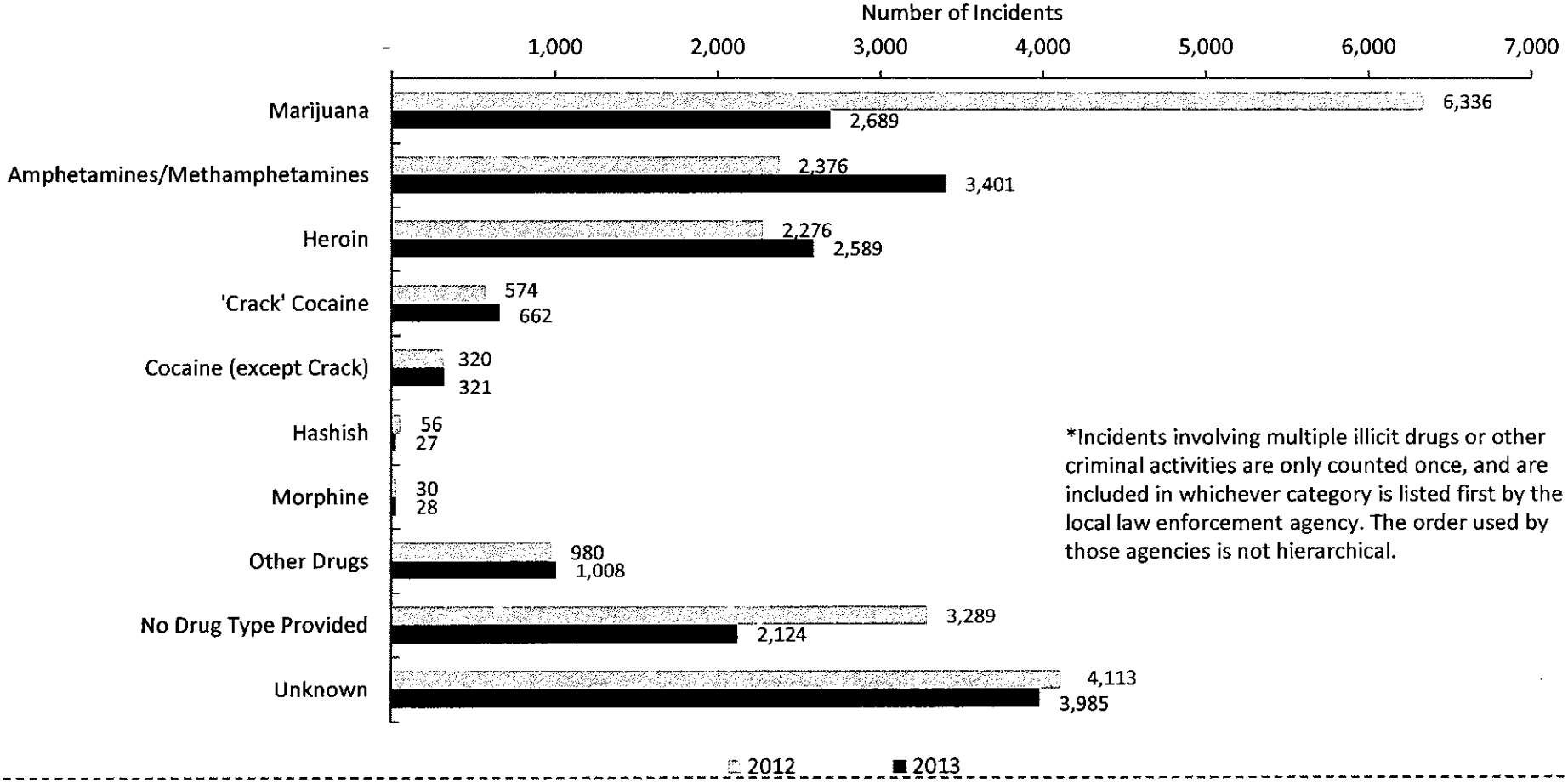
Source: Washington Association of Sheriffs and Police Chiefs (does not include Washington State Patrol data)



2.2 Drug or Narcotic Incidents

As defined by the FBI, an "incident" occurs when any law enforcement officer investigates a scene or situation, whether that investigation results in an arrest or not. Each incident may involve multiple illicit drug or other criminal activities.* As seen below, between 2012 and 2013, the number of incidents involving marijuana decreased by more than half (58 percent). During that same time period, incidents involving amphetamines or methamphetamines increased by 43 percent, while those involving heroin increased by 13 percent.

Source: Washington Association of Sheriffs and Police Chiefs (does not include Washington State Patrol data)

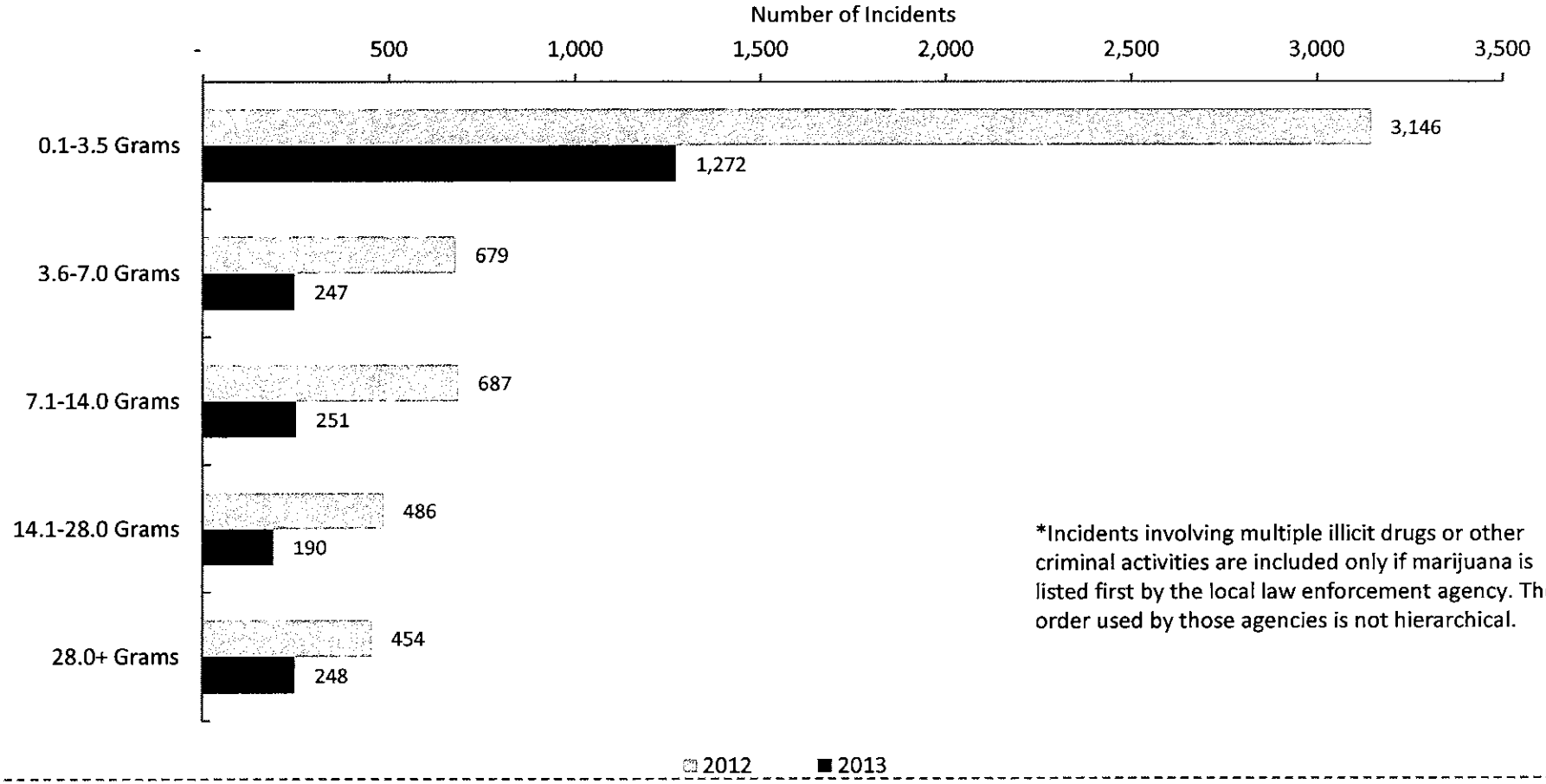


*Incidents involving multiple illicit drugs or other criminal activities are only counted once, and are included in whichever category is listed first by the local law enforcement agency. The order used by those agencies is not hierarchical.

2.3 Marijuana Quantities Seized

Incidents where the quantity of marijuana seized was reported in grams (or in a unit that could be converted) are shown below.* For 2012 and 2013, the most frequent number of seizures occurred for quantities of 3.5 grams (an eighth of an ounce) or less. From 2012 to 2013, the number of such seizures dropped by 60 percent, from 3,146 in 2012 to 1,272 in 2013. Similar proportionate reductions were also seen for all other amounts seized.

Source: Washington Association of Sheriffs and Police Chiefs (does not include Washington State Patrol data)

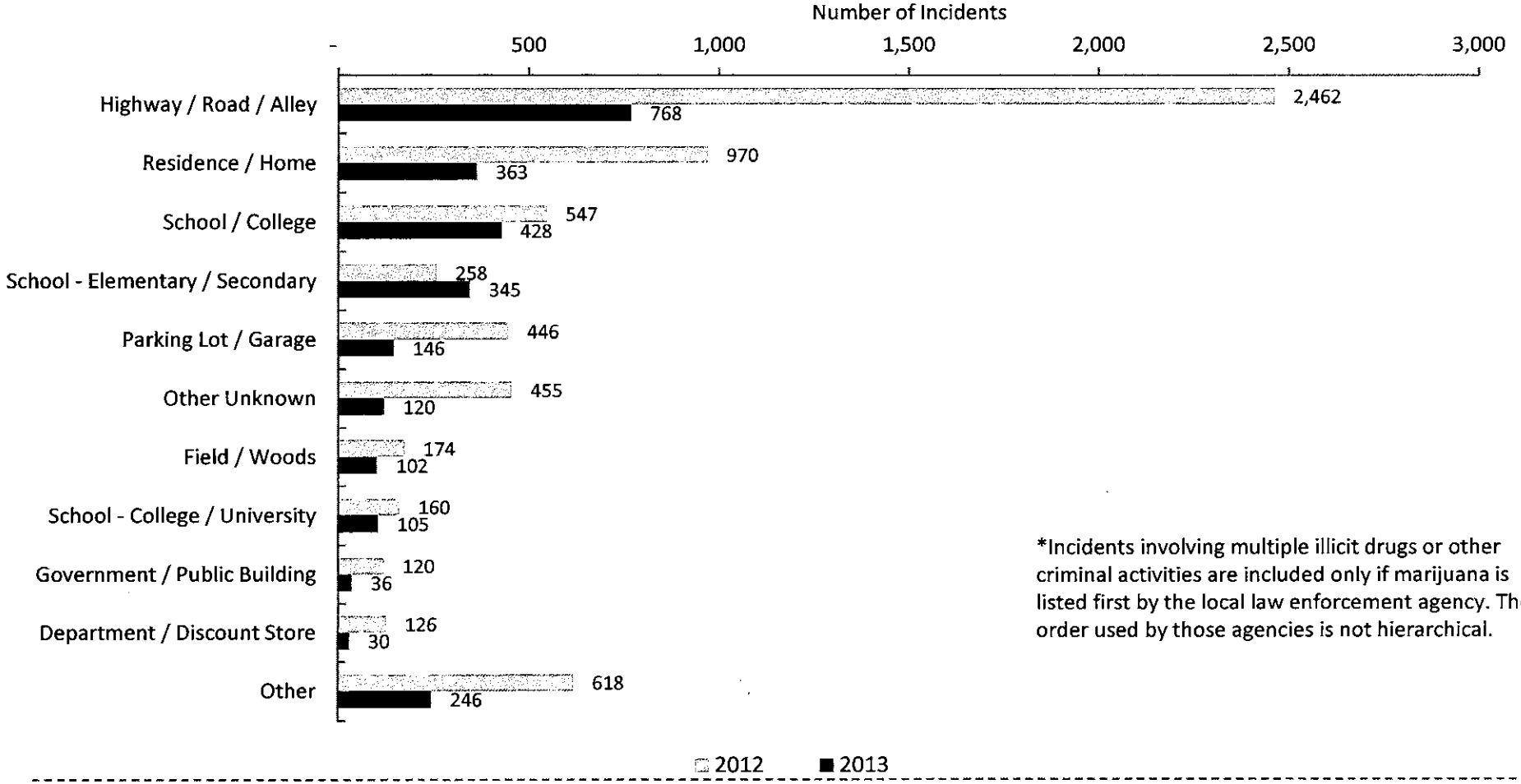


*Incidents involving multiple illicit drugs or other criminal activities are included only if marijuana is listed first by the local law enforcement agency. The order used by those agencies is not hierarchical.

2.4 Incident Locations

Marked decreases were seen in nearly all locations where there were incidents involving marijuana.* For highways, roads or alleys, the number of incidents decreased by nearly 70 percent, from 2,462 in 2012 to 768 in 2013. Of these locations, an increase was seen only in elementary or secondary schools, where there was a 34 percent increase from 2012 to 2013.

Source: Washington Association of Sheriffs and Police Chiefs (does not include State Patrol data)

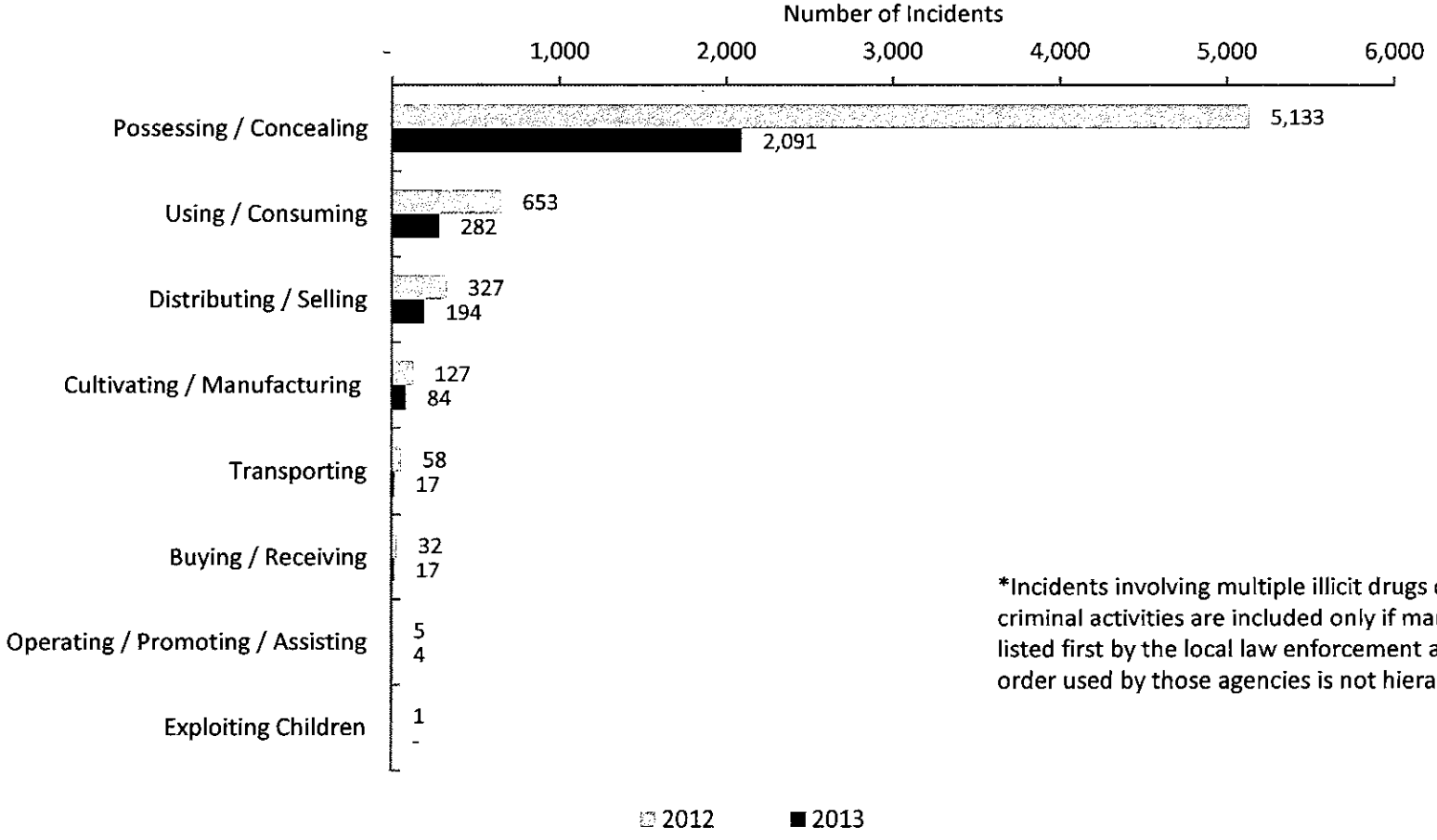


*Incidents involving multiple illicit drugs or other criminal activities are included only if marijuana is listed first by the local law enforcement agency. The order used by those agencies is not hierarchical.

2.5 Criminal Activities Involving Marijuana

For 2012 and 2013, possession was the most common criminal activity involving marijuana; however, the number of such incidents decreased by nearly 60 percent between those two years.* Decreases were also seen across all other activities.

Source: Washington Association of Sheriffs and Police Chiefs (does not include Washington State Patrol data)

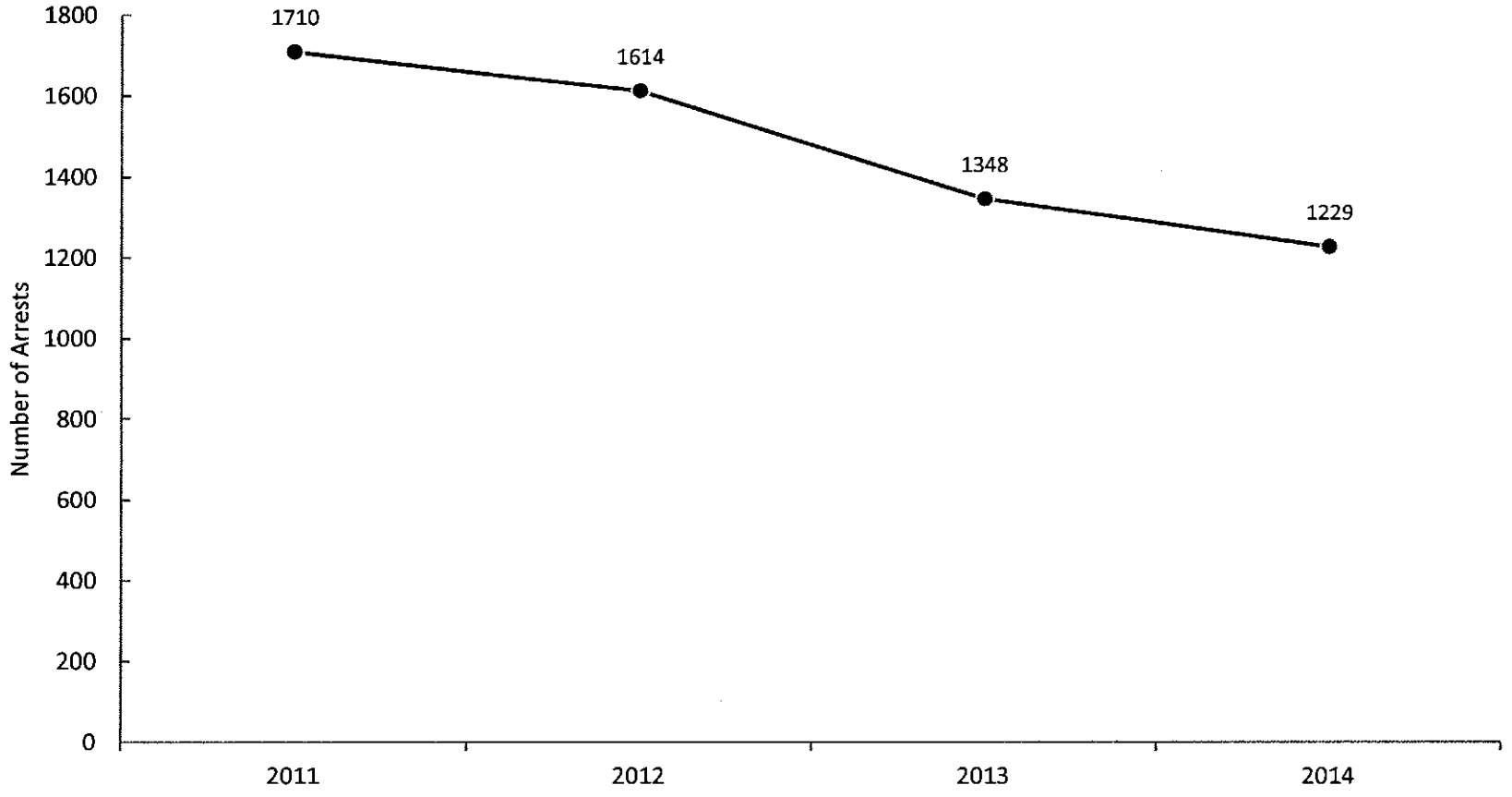


*Incidents involving multiple illicit drugs or other criminal activities are included only if marijuana is listed first by the local law enforcement agency. The order used by those agencies is not hierarchical.

2.6 Drug-only DUI Arrests

Drug-only DUI arrests do not differentiate marijuana from other drugs. These arrests moved from an annual high of 1,710 in 2011 to a low of 1,229 in 2014, for an overall decrease of 28 percent during those four years.

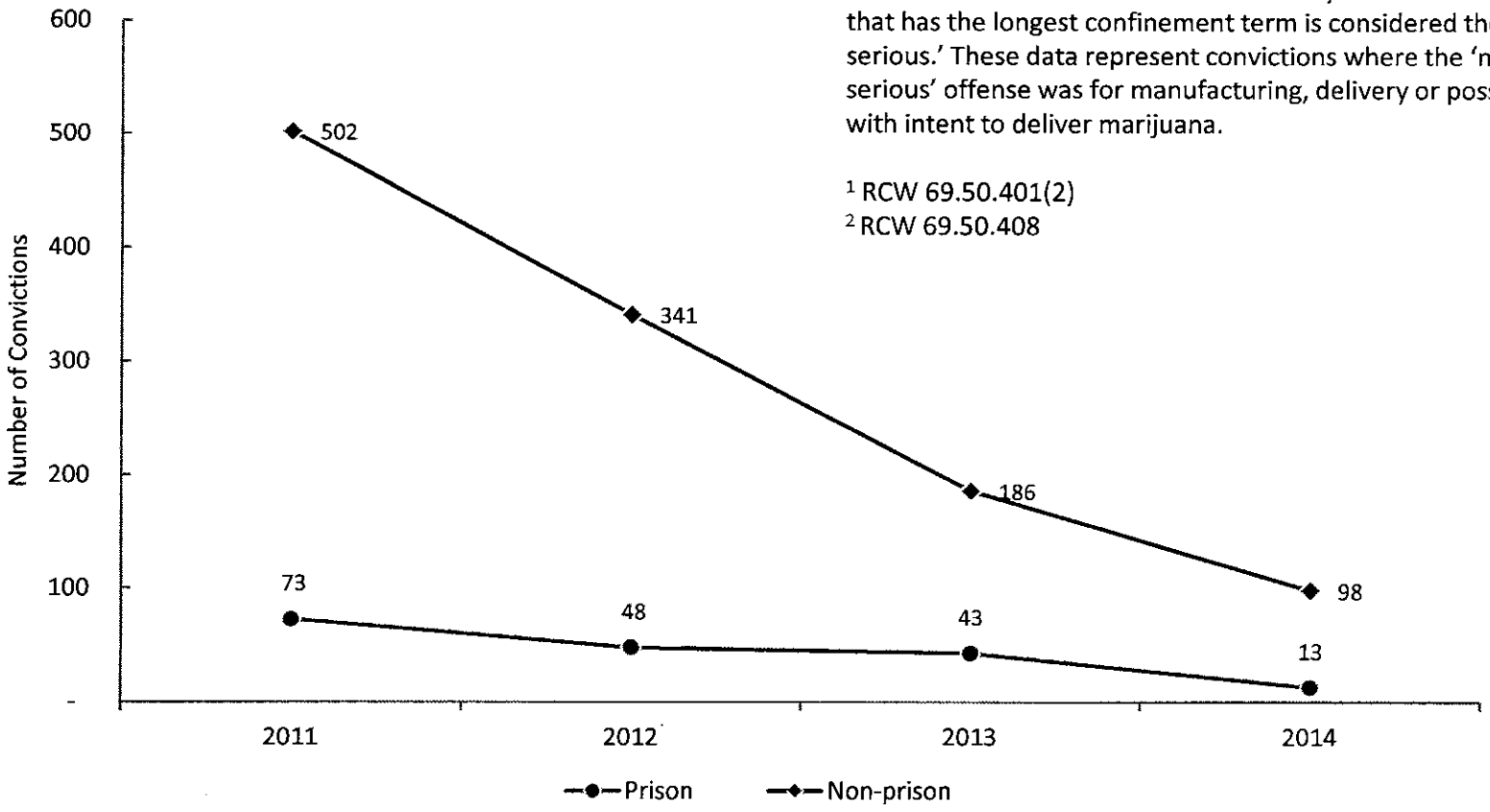
Source: Washington State Patrol



2.7 Marijuana-related Convictions

From 2011 to 2013, the only convictions for the manufacturing, delivery or possession with intent to deliver marijuana[1] were first-time convictions; in 2014, five of the 98 non-prison convictions were repeat convictions.[2] Overall, marked decreases are seen in both non-prison convictions, dropping by 80 percent from 2011 to 2014, and in-prison convictions, dropping by 82 percent during that same time period.

Source: Washington State Caseload Forecast Council, Statistical Summary of Adult Felony Sentencing



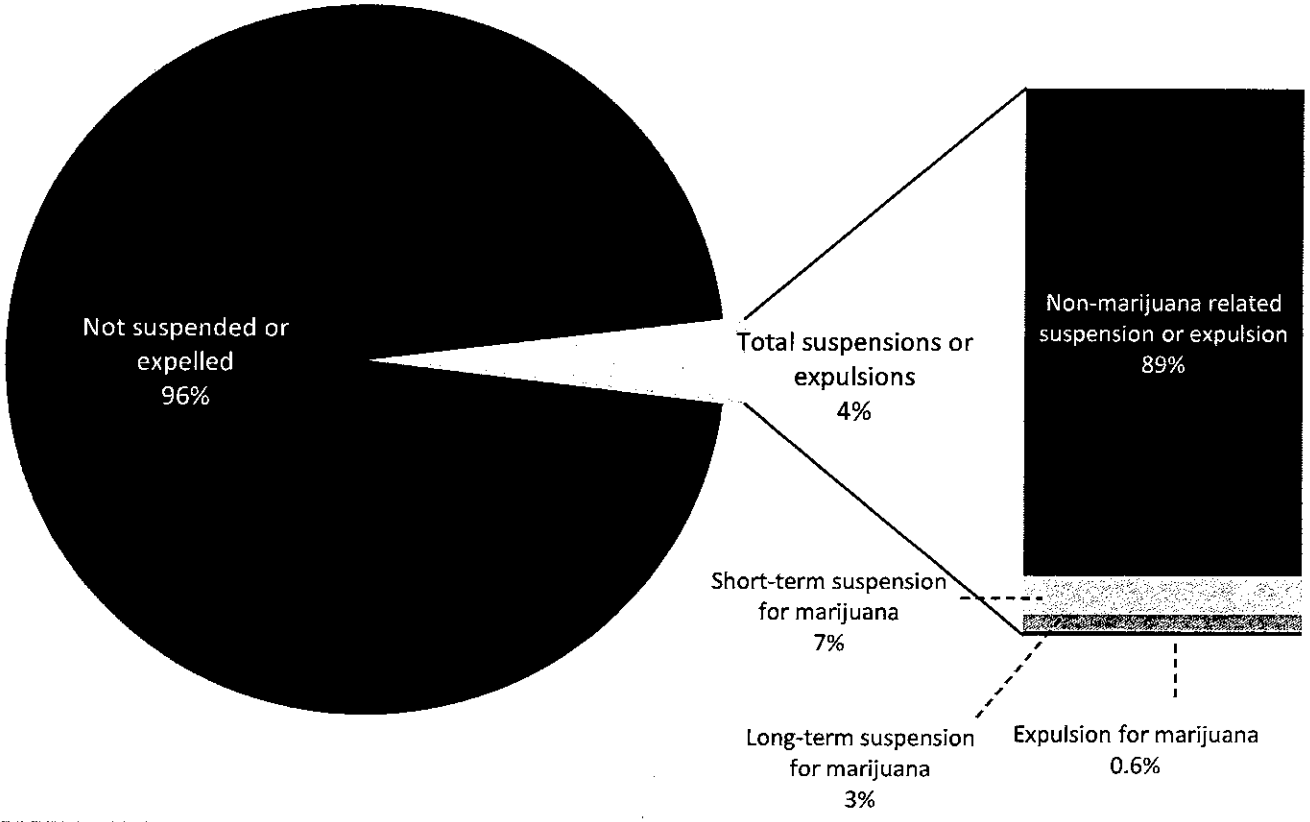
*Conviction data are based on a hierarchy where the offense that has the longest confinement term is considered the 'most serious.' These data represent convictions where the 'most serious' offense was for manufacturing, delivery or possession with intent to deliver marijuana.

[1] RCW 69.50.401(2)
[2] RCW 69.50.408

2.8 Suspensions or Expulsions from Schools – Students

Currently, data are available only for public schools for the 2013-14 school year. As shown below, 4 percent of all students were suspended or expelled during that school year, and of those suspended or expelled, 11 percent (or 0.4 percent of all students) were suspended or expelled due to marijuana possession, with 7 percent of those suspended or expelled receiving a short-term suspension (10 or fewer consecutive days), 3 percent receiving a long-term suspension (more than 10 consecutive days) and 0.6 percent being expelled.

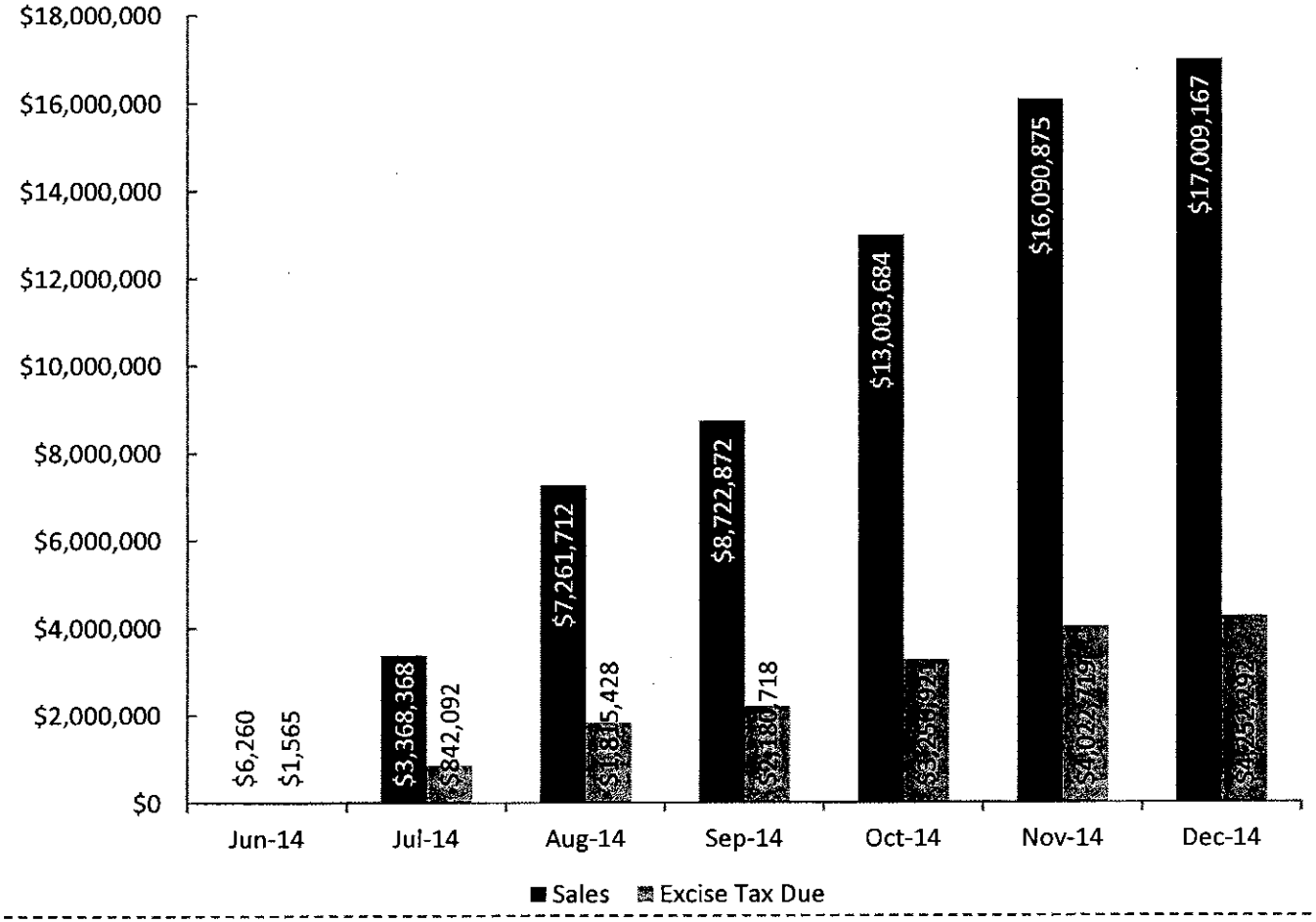
Source: Office of Superintendent of Public Instruction



3.1 Recreational Marijuana Revenues with 25 Percent Excise Tax

Per reports from the Liquor Control Board, sales and excise taxes dramatically rose during the first few months of legalization. However, while sales from September to October increased by 49 percent, those from October to November grew by 24 percent and those from November to December by 6 percent. For each month, excise taxes equaled 25 percent of the total sales.

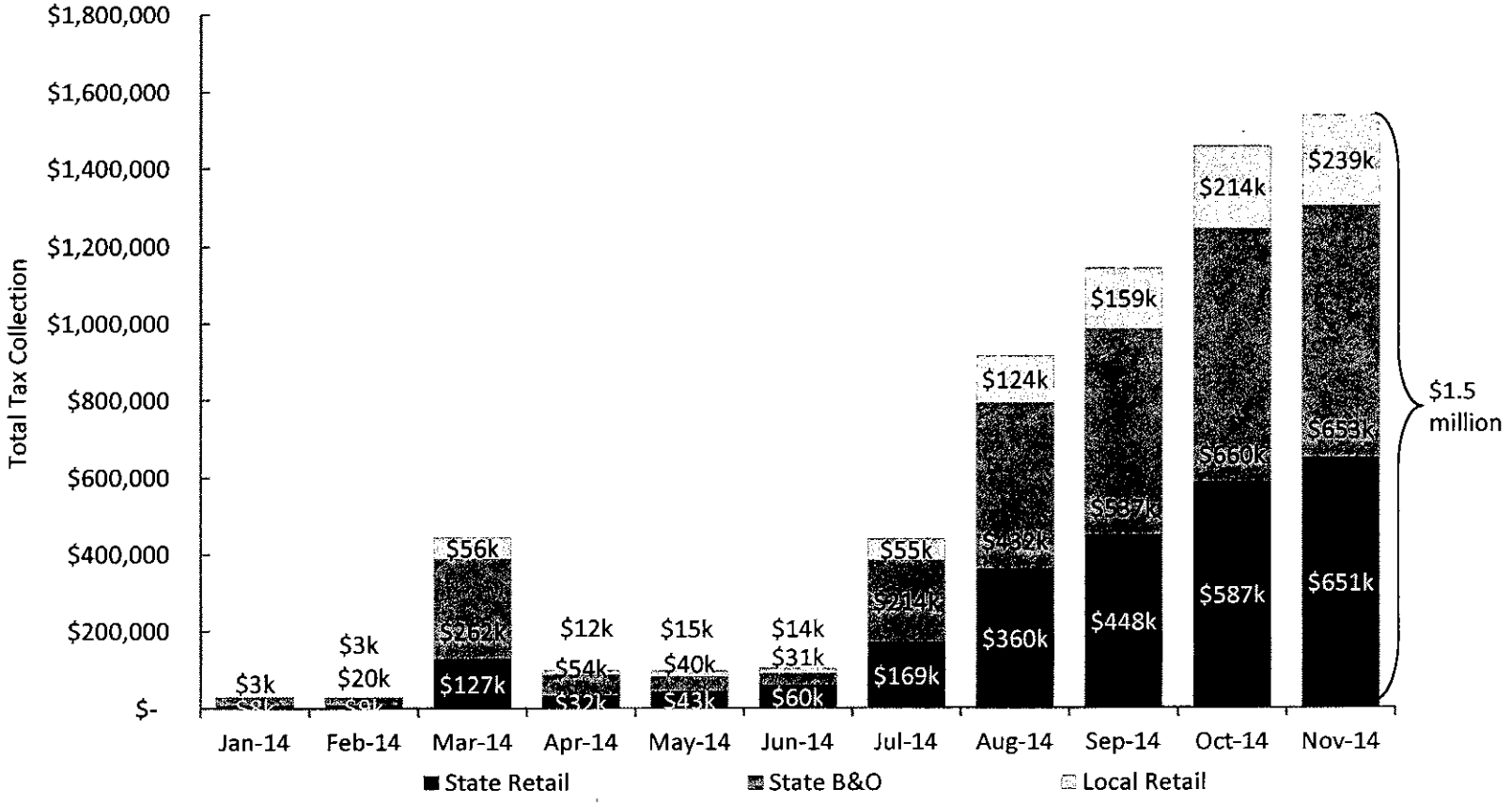
Source: Washington State Liquor Control Board



3.2 Recreational Marijuana Reported Revenues with Retail and Business and Occupation Taxes

Department of Revenue reported sales of recreational marijuana differ from those reported by the Liquor Control Board (likely due to reporting lags). However, the patterns of sales over time are similar. The taxes shown below include state and other retail taxes as well as business and occupation (B&O) taxes, but do not show total sales. In November 2014, tax revenues equaled $239,000 in local retail sales taxes, $653,000 in state B&O taxes and $651,000 in state retail taxes, for a total of $1.5 million in taxes that month. These taxes are in addition to the excise taxes collected.

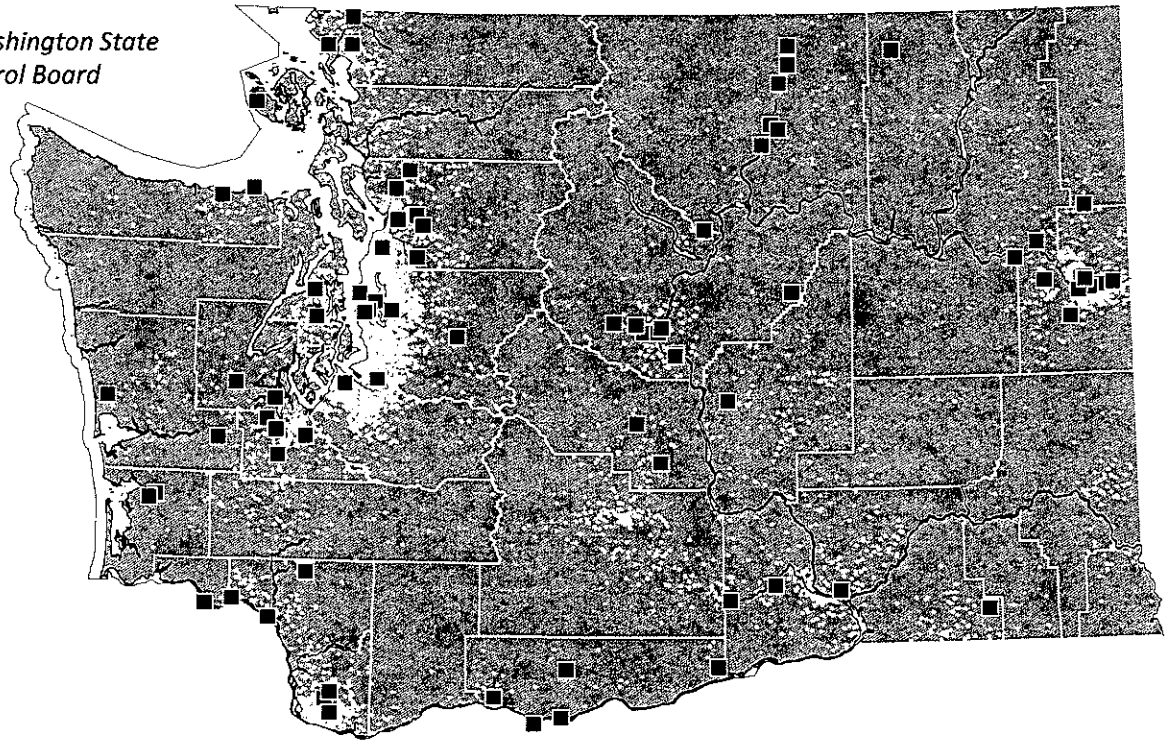
Source: Washington State Department of Revenue



4.1a Producers/Processors – Locations

The licensed producers locations (as of September 2014) shown within a population density map suggest that production is somewhat equally divided between high- and low-population regions. With only a few exceptions, producers also act as processors.

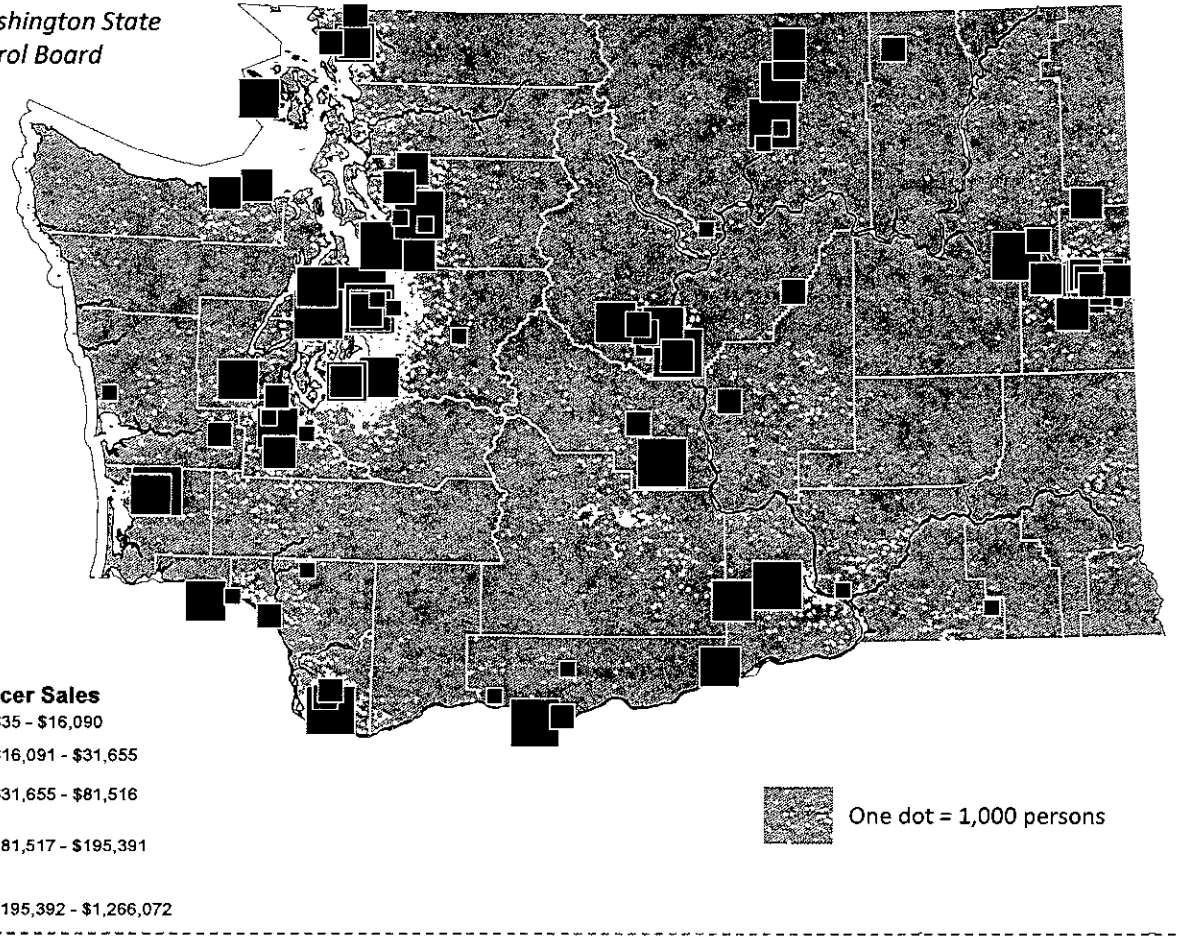
Source: Washington State Liquor Control Board



4.1b Producers/Processors – Volumes

Volumes of sales by producers (as of September 2014) suggest that large-volume producers are also somewhat equally distributed between high- and low-population regions.

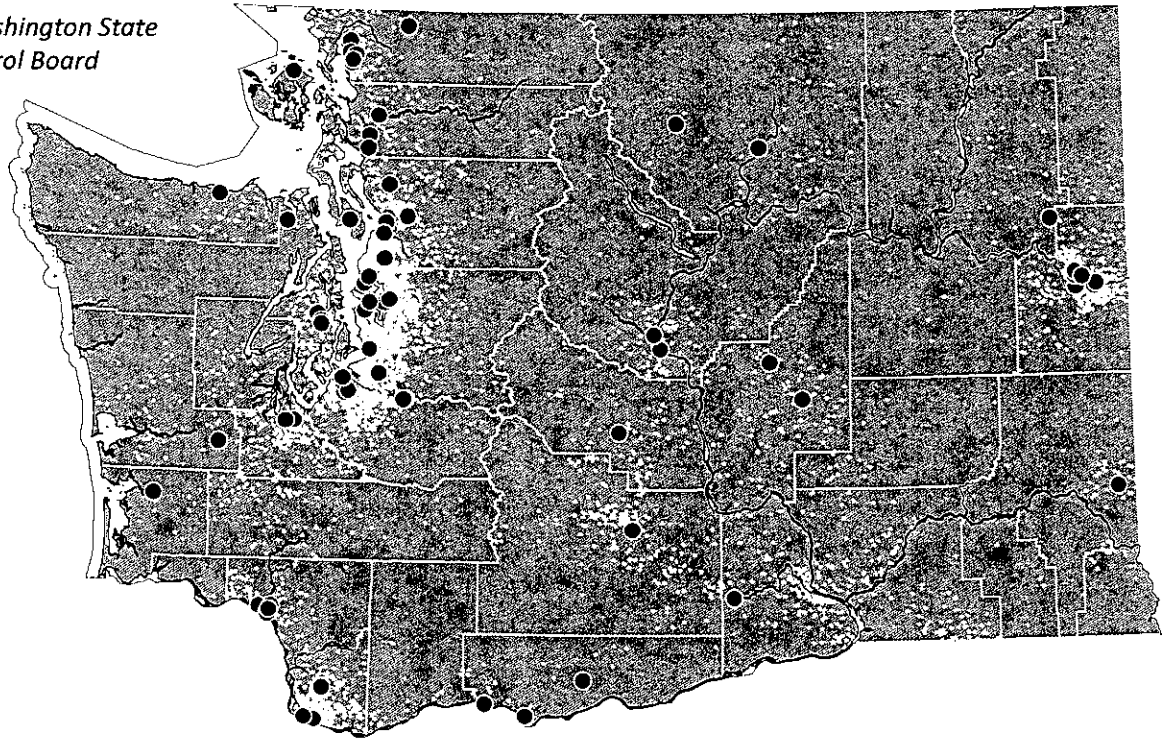
Source: Washington State Liquor Control Board



4.2a Retailers – Locations

Recreational marijuana retailers locations (as of September 2014) suggest that most are generally concentrated in more urban environs, such as the Puget Sound region and larger cities elsewhere.

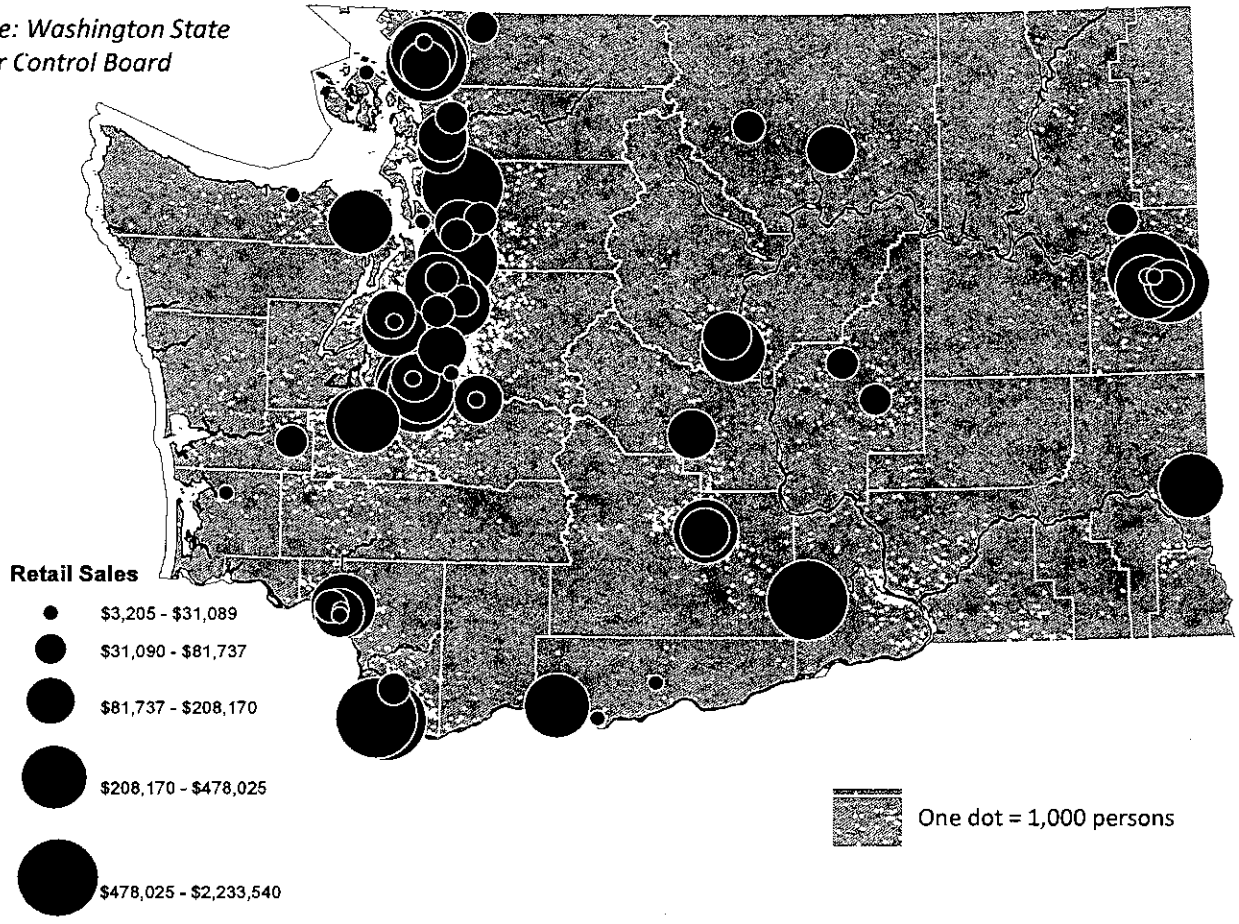
Source: Washington State Liquor Control Board



4.2b Retailers – Volumes

Retail sale volumes for recreational marijuana also generally suggest that large sales occur in more urban areas, with seemingly notable exceptions in Klickitat, Benton and Whitman counties.

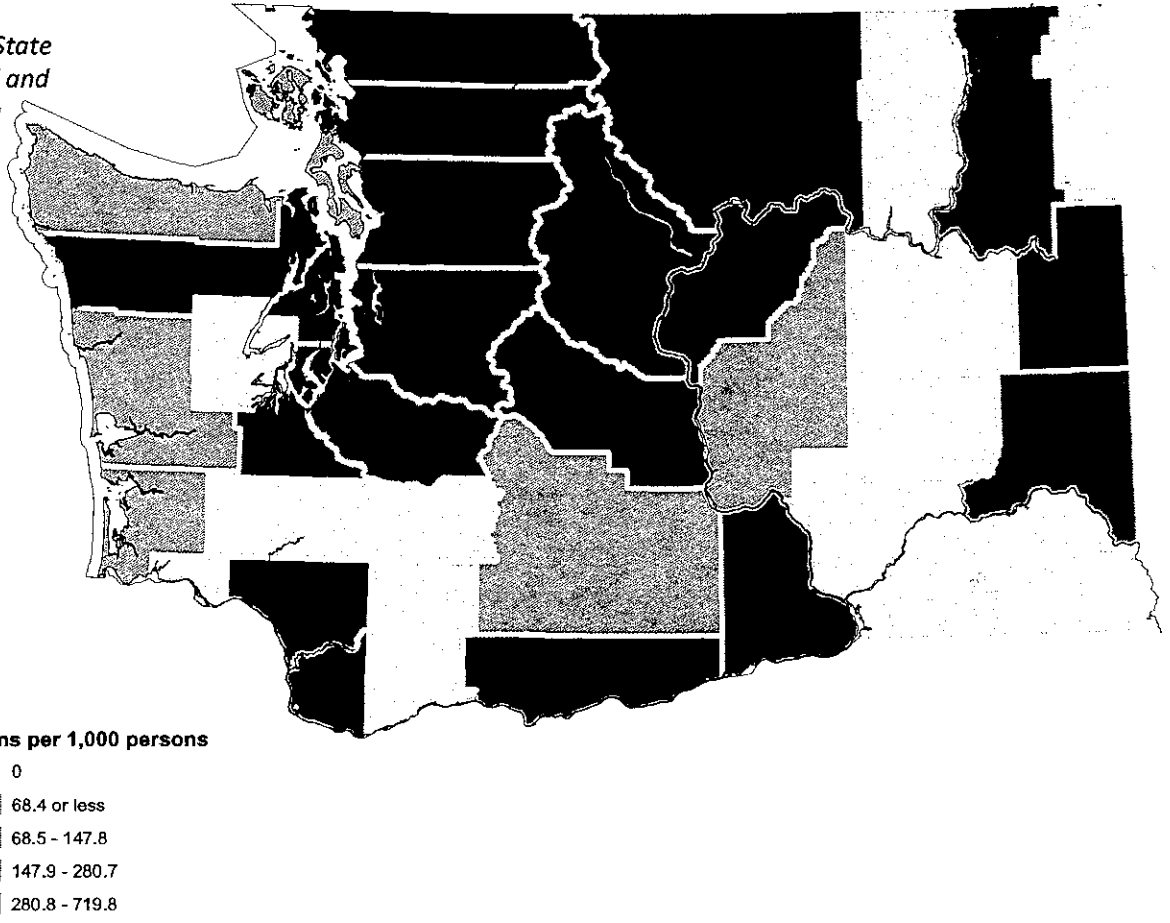
Source: Washington State Liquor Control Board



4.3 Per Capita Sales by County

Grams of recreational marijuana sold per 1,000 persons living within the county where the sales occurred (as of September 2014) are mapped below. Of the six counties with the highest per capita sales, four (Whatcom, Clark, Klickitat and Spokane) are on the state's borders.

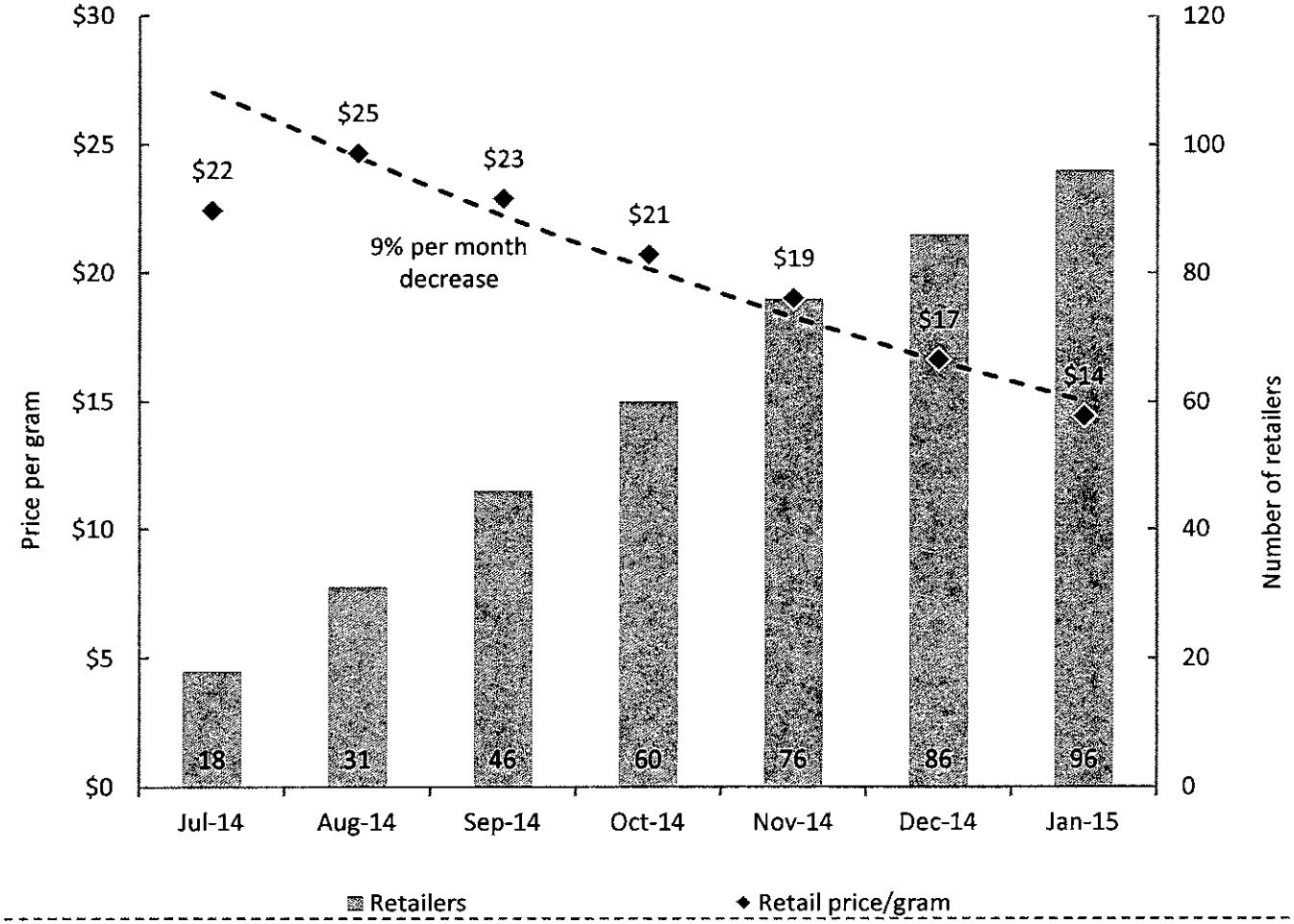
Source: Washington State Liquor Control Board and OFM population data



4.4 Retailers and Price per Gram

The weighted average price per gram dropped from a high of $25 in August 2014 to a low of $14 in January 2015, averaging a 9 percent per month decrease. Meanwhile, the number of retailers has increased more than five-fold, from 18 in July 2014 to 96 in January 2015.

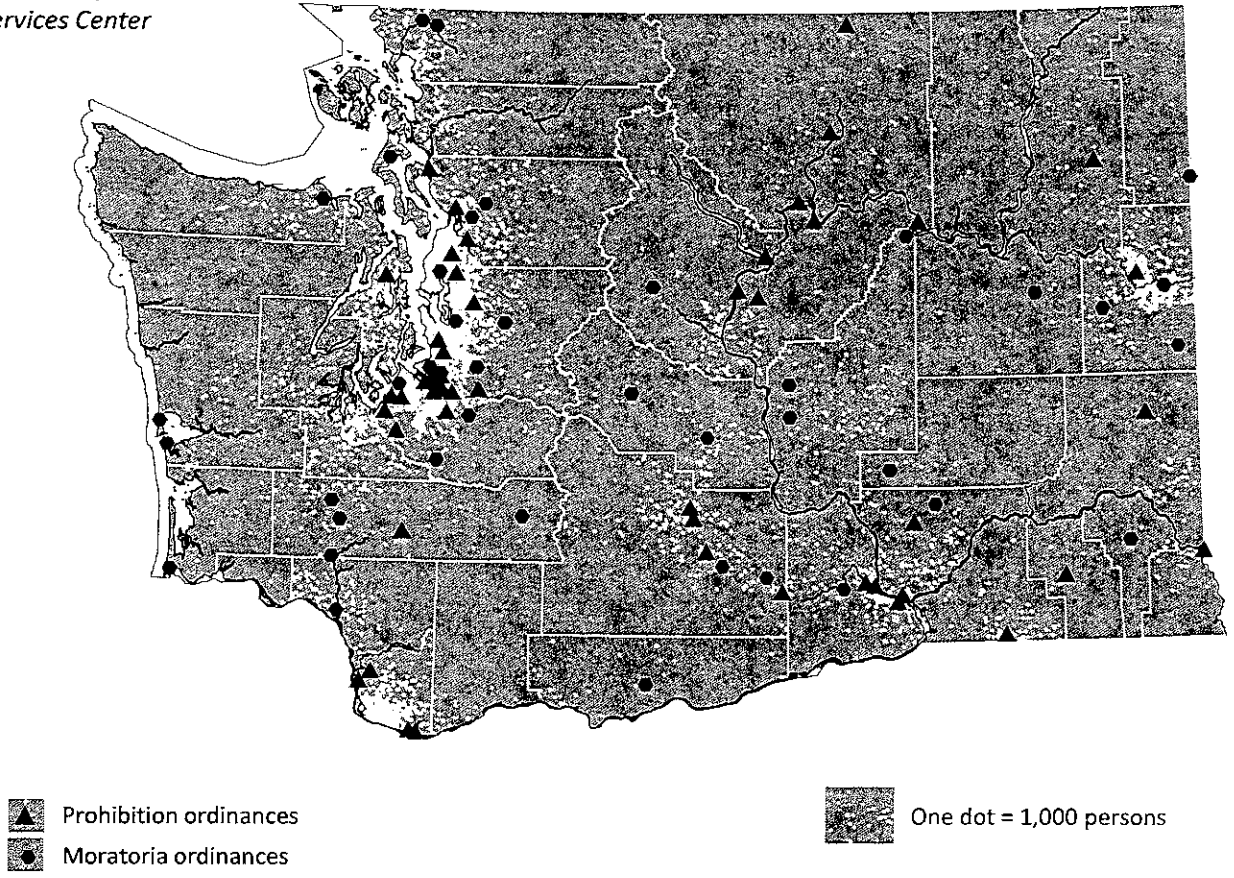
Source: Washington State Liquor Control Board



5.1 Cities with Prohibitions or Moratoria on Retail Sales

Cities with moratoria and prohibitions for retail sales of recreational marijuana are shown below. These data are current as of February 2015.

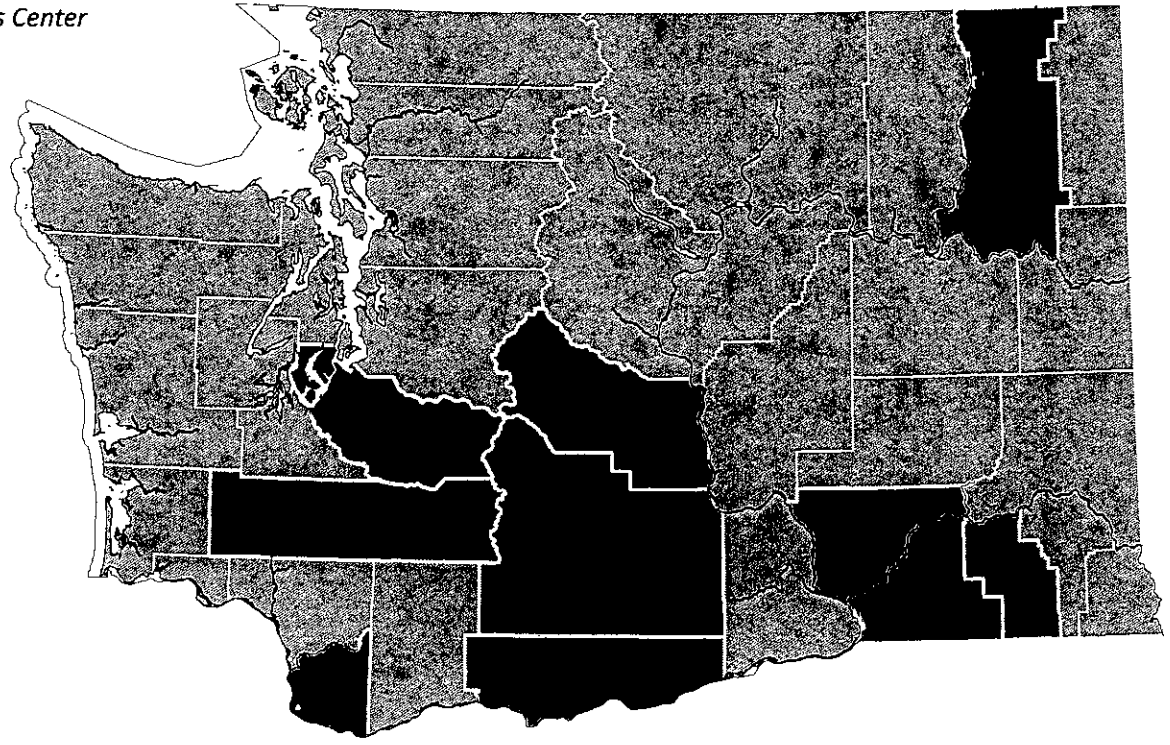
Source: Municipal Research and Services Center



5.2 Counties with Prohibitions or Moratoria on Retail Sales

Counties where unincorporated regions have moratoria or prohibitions on the sale of recreational marijuana are shown below. These data are current as of February 2015.

Source: Municipal Research and Services Center



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"We change laws."

Medical Marijuana Dispensaries and Their Effect on Crime

Opponents of medical marijuana sometimes speculate that medical marijuana dispensaries will lead to increased crime rates in surrounding areas.[1] These dispensaries, they claim, will attract thieves and robbers to the facilities and breed secondary crimes in surrounding areas. Such claims have prompted empirical and statistical analyses by researchers and law enforcement agencies. In what should not come as a surprise, given the robust security at most medical marijuana facilities, these studies have routinely shown that, contrary to these concerns, dispensaries are not magnets for crime. Instead, these studies suggest that dispensaries are no more likely to attract crime than any other business, and in many cases, by bringing new business and economic activity to previously abandoned or run-down retail spaces, dispensaries actually contribute to a reduction in crime.

While the data is reassuring, one public safety challenge for dispensaries and adult use marijuana stores has been that many have been forced to operate as cash-only businesses because of banks' concern about federal legal issues. However, with new guidance that was issued by the federal government in February 2014, it is expected that more small banks and credit unions will open accounts for marijuana businesses.

What follows is a brief summary of anecdotal and scientific evidence, including law enforcement data analyses and academic research on medical marijuana dispensaries and their effect on crime. For more information on dispensaries, medical use of marijuana, state laws, and other issues related to medical marijuana, please visit mpp.org/medical.

2009 Los Angeles Police Department survey — In response to debate over medical marijuana regulations by the Los Angeles City Council, and claims from medical marijuana opponents that dispensaries were magnets for crime, Los Angeles Police Chief Charlie Beck asked his department to produce a report comparing the robbery rates of L.A. banks and medical marijuana dispensaries. The report indicated that there were 71 robbery reports filed with the LAPD at the city's 350 banks. Despite there being far more medical marijuana dispensaries — more than 800 at the time according to Beck — there were fewer robbery reports filed at dispensaries: just 47.

When asked about the report, and claims that dispensaries are crime magnets, Beck said, "I have tried to verify that because, of course, that is the mantra. It really doesn't bear out. … Banks are more likely to get robbed than medical marijuana dispensaries."[2]

2009 Denver Police Department survey — An analysis of robbery and burglary rates at medical marijuana dispensaries conducted by the Denver Police Department at the request of the Denver City Council found that the robbery and burglary rates at dispensaries were lower than

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[1] "'Across the state, we're seeing an increase in crime related to dispensaries,' said Ernie Martinez, a Denver police detective who is president of the Colorado Drug Investigators Association." "Medical marijuana dispensaries' effect on crime unclear," *The Denver Post*, January 24, 2011. http://www.denverpost.com/news/marijuana/ci_17178820#ixzz1ngbvMOlI.

[2] "LAPD Chief: Pot clinics not plagued by crime," *Los Angeles Daily News*, January 17, 2010. http://www.dailynews.com/news/ci_14206441.

area banks and liquor stores and on par with those of pharmacies. Specifically, the report found a 16.8 percent burglary and robbery rate for dispensaries, equal to that of pharmacies. That's lower than the 19.7 percent rate for liquor stores and the 33.7 percent rate for banks, the analysis found.[3]

2010 Denver Police Department analysis — In late 2010, the Denver Police Department looked at crime rates in areas in and around dispensaries. The analysis showed that through the first nine months of 2010, crime was down 8.2% relative to the same period in 2009. The decrease was comparable to the city's overall drop in crime of 8.8%.[4] *The Denver Post* completed a similar analysis and found that crime rates in some areas with the highest concentration of dispensaries saw bigger decreases in crime than neighborhoods with no dispensaries.[5]

2010 Colorado Springs Police Department analysis — An analysis by the Colorado Springs Police Department found that robbery and burglary rates at area dispensaries were on par with those of other businesses. Specifically, the department's data indicated that there were 41 criminal incidents reported at the city's 175 medical marijuana businesses in the 18-month period ending August 31, 2010. Meanwhile, over that same period, there were 797 robberies and 4,825 burglaries at other city businesses. These findings led the department's spokesman, Sgt. Darrin Abbink, to comment, "I don't think the data really supports [dispensaries] are more likely to be targeted at this point."[6]

October 2011 UCLA study, "Exploring the Ecological Link Between Crime and Medical Marijuana Dispensaries," — Researchers from UCLA, funded by the National Institute on Drug Abuse, used data from 95 census tracts in Sacramento to analyze two types of crime (violent and property) in areas with varying concentrations of dispensaries. What they found was that while factors traditionally understood to lead to increased crime — for example, large percentages of land zoned for commercial rather than residential use, a high percentage of one-person households, the presence of highway ramps, and a higher percentage of the population being ages 15-24 — were positively associated with crime in those areas, "the density of medical marijuana dispensaries was not associated with violent or property crime rates." In their conclusion, the researchers said, "[t]hese results suggest that the density of [medical marijuana dispensaries] may not be associated with increased crime rates or that measures dispensaries take to reduce crime (i.e., doormen, video cameras) may increase guardianship, such that it deters possible motivated offenders."[7]

Specifically, the study applied the "routine activity theory" of crime, which suggests that crime is more likely when three criteria are met: (1) a motivated offender, (2) a suitable target, as defined by factors like value, visibility, and access, and (3) a lack of guardianship such as low residency or poor security. The authors hypothesized that the lack of a relationship between dispensaries and crime could be attributable to either of two possible conclusions: either medical marijuana dispensaries were no more valuable a target than other businesses in the area — a possibility supported by the law enforcement surveys in L.A. and Denver discussed above — or heightened security at dispensaries was sufficient to deter criminal activity in the area.

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[3] "Analysis: Denver pot shops' robbery rate lower than banks," *The Denver Post*, January 27, 2010. http://www.denverpost.com/ci_14275637.
[4] See note 1, *supra.*
[5] *Id.*
[6] "Marijuana shops not magnets for crime, police say," *Fort Collins Gazette*, September 14, 2010. http://www.gazette.com/articles/wall-104598-marijuana-brassfield.html.
[7] http://www.uclamedicalmarijuanaresearch.com/node/10.

June 2011 Regent University study — Researcher Maura Scherrer of Regent University looked at the perception of crime, and medical marijuana dispensaries' impact on crime, among residents of Denver neighborhoods with varying socio-economic profiles. In so doing, she found that most crimes, including robbery, vandalism, and disorderly conduct increased in Denver from 2008 to 2009. However, in areas within 1,000 feet of a dispensary, rates were down for most types of crime, including burglary, larceny, and a 37.5% reduction in disorderly conduct citations. In her conclusion the author notes, "it appears that crime around the medical marijuana centers is considerably lower than citywide crime rates; a much different depiction than originally perceived."[8]

February 2014 *Urban Geography* — Researchers from the University of South Florida, the University of Colorado, and the New York City Criminal Justice Agency set out to determine whether medical marijuana dispensaries in Denver could be considered locally undesirable land uses (LULUs), land uses that people do not want to live close to, but which provide services to the community.[9] The researchers studied 275 medical marijuana centers in 75 Denver neighborhoods and concluded that:

> "[w]hile public officials, and especially law enforcement, clearly warn residents about the negative effects of these centers on the communities in which they are situated, there is little evidence that residents are listening, as these centers do not appear to have any impact on the urban landscape — and therefore on the health of the communities in which they are located."[10]

The study did find that medical marijuana centers are more likely to be opened in areas that have higher crime rates, but that is not unusual because crime follows retail concentrations. "In short, medical marijuana facilities appear to … be more similar to drugstores and coffee houses than they are to LULUs."[11]

Los Angeles crime trends — Los Angeles has frequently been cited as the city with the most dispensaries and the least regulation of those dispensaries. It is also the most populous city in the state that has the oldest and the broadest medical marijuana law, where any medical condition qualifies. While L.A. voters do prefer some regulation and control — and they approved a ballot measure to create a regulatory system in May 2013 — the city that has been cited as having more dispensaries than Starbucks certainly has not suffered a crime epidemic as a result of its permissive policies. On the contrary, overall crime in Los Angeles has dropped dramatically since dispensing collectives became legal in 2004. Crime rates have plummeted in the past 11 years, with decreases each of those 11 years. They are now the lowest they have been since 1949.[12]

The Effect of Medical Marijuana Laws on Crime: Evidence from State Panel Data, 1990-2006[13] — Researchers Robert Morris, Michael TenEyck, J.C. Barnes, and Tomislav Kovandzic

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[8] Study available at http://adr.coalliance.org/codr/fez/view/codr:983.

[9] Lyndsay N. Boggess, Deanna M. Pérez, Kathryn Cope, Carl Root & Paul B. Stretesky, Urban Geography (2014): Do medical marijuana centers behave like locally undesirable land uses? Implications for the geography of health and environmental justice, *Urban Geography*.

[10] *Id.* at p. 15

[11] *Id.* at p.16

[12] Kathy Mather, "L.A. crime falls for 11th year; officials note historic drops," *L.A. Times*, Jan. 13, 2014. http://www.latimes.com/local/lanow/la-me-ln-crime-falls-20140113,0,3357277.story#axzz2vJ6f1xlX

[13] Morris RG, TenEyck M, Barnes JC, Kovandzic TV (2014). "The Effect of Medical Marijuana Laws on Crime: Evidence from State Panel Data, 1990-2006." *PLoS ONE* 9(3): e92816. doi: 10.1371/journal.pone.0092816

analyzed the association between the enactment of a medical marijuana law and state crime rates for all Part 1 offenses — homicide, rape, robbery, assault, burglary, larceny, and auto theft — as collected by the FBI. The purpose was to help inform the debate on whether passage of medical marijuana laws leads to increased crime rates. The researchers used fixed-effects panel design to identify what, if any, effect passage of a medical marijuana law has on crime rates. This design analyzes changes individual states see in their respective crime rates over time and compares the changes to the crime rate trends among states that enacted medical marijuana laws and those that did not.

While all states experienced a reduction in Part 1 offenses during the period studied, those that had passed a medical marijuana law experienced greater reductions in those offenses than those states that had not. The researchers conclude that enactment of a medical marijuana law "is not predictive of higher crime rates and *may* be related to reductions in rates of homicide and assault."[14] They note that the most "important finding . . . is the lack of evidence of any increase in robbery or burglary, which are the type of crimes one might expect to gradually increase over time if the [medical marijuana laws lead to increased crime] theory was correct."[15]

[14] *Id.* at 5.
[15] *Id.*

How does marijuana use affect school, work, and social life?

Image by ©IStock.com/AntonioGuillem

Research has shown that marijuana's negative effects on attention, memory, and learning can last for days or weeks after the acute effects of the drug wear off, depending on the person's history with the drug.[53] Consequently, someone who smokes marijuana daily may be functioning at a reduced intellectual level most or all of the time. Considerable evidence suggests that students who smoke marijuana have poorer educational outcomes than their nonsmoking peers. For example, a review of 48 relevant studies found marijuana use to be associated with reduced educational attainment (i.e., reduced chances of graduating).[54] A recent analysis using data from three large studies in Australia and New Zealand found that adolescents who used marijuana regularly were significantly less likely than their non-using peers to finish high school or obtain a degree. They also had a much higher chance of developing dependence, using other drugs, and attempting suicide.[55] Several studies have also linked heavy marijuana use to lower income, greater welfare dependence, unemployment, criminal behavior, and lower life satisfaction.[56,57]

To what degree marijuana use is directly causal in these associations remains an open question requiring further research. It is possible that other factors independently predispose people to both marijuana use and various negative life outcomes such as school dropout.[58] That said, people report a perceived influence of their marijuana use on poor outcomes on a variety of life satisfaction and achievement measures. One study, for example, compared people involved with current and former long-term, heavy use of marijuana with a control group who reported smoking marijuana at least once in their lives but not more than 50 times.[59] All participants had similar education and income backgrounds, but significant differences were found in their educational attainment: Fewer of those who engaged in heavy cannabis use completed college, and more had yearly household incomes of less than $30,000. When asked how marijuana affected their cognitive abilities, career achievements, social lives, and physical and mental health, the majority of those who used heavily reported that marijuana had negative effects in all these areas of their lives.

Studies have also suggested specific links between marijuana use and adverse consequences in the workplace, such as increased risk for injury or accidents.[60] One study among postal workers found that employees who tested positive for marijuana on a pre-employment urine drug test had 55 percent more industrial accidents, 85 percent more injuries, and 75 percent greater absenteeism compared with those who tested negative for marijuana use.[61]

Going to Pot?
The Impact of Dispensary Closures on Crime *

Tom Chang
USC Marshall School of Business

and

Mireille Jacobson
The Paul Merage School of Business, UCI and NBER

March 2017

Abstract

Jurisdictions that sanction medical or, more recently, recreational marijuana use often allow retail sales at dispensaries. Dispensaries are controversial as many believe they contribute to local crime. To assess this claim, we analyze the short-term mass closing of hundreds of medical marijuana dispensaries in Los Angeles. Contrary to popular wisdom, we find an immediate increase in crime around dispensaries ordered to close relative to those allowed to remain open. The increase is specific to the type of crime most plausibly deterred by bystanders, and is correlated with neighborhood walkability. We find a similar pattern of results for temporary restaurant closures due to health code violations. A likely common mechanism is that "eyes upon the street" deter some types of crime.

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1 Introduction

One of the most dramatic shifts in public opinion in the U.S. over the past four and a half decades has been a surge in support for marijuana legalization, both medical and, increasingly, recreational. Currently 60% of adults in the U.S. favor broad-based marijuana legalization, compared to only 12% in 1969 (Swift 2016), and nearly 90% think adults should be allowed to use marijuana for prescribed medical purposes (CNN/ORC 2014). Despite this support, 44% indicate that they would be somewhat or very concerned if a "store that sold medical marijuana" opened in their area (The Pew Research Center 2010). In particular, many maintain that these stores, usually called dispensaries, attract or, even, cause crime (McDonald and Pelisek 2009; National Public Radio 2010; Reuteman 2010).

The idea that marijuana dispensaries attract crime has proved influential with policy-makers. For example, an Oregon state senator argued that a law allowing cities to ban dispensaries was important to "empower them to protect our children and families" (Zheng 2014). In Los Angeles, the setting for this study, the city council cited crime in its 2010 decision to cap the number of dispensaries in the city.[1] Yet, empirical evidence to support any link (positive or negative) between marijuana dispensaries and crime is quite limited. State difference-in-differences estimates find no relationship between medical marijuana laws and crime rates (Morris et al. 2014). Since not all medical marijuana states have operational dispensaries, however, these estimates do not speak directly to the impact of dispensaries on crime. The density of dispensaries across 95 census tracts in Sacramento, CA is uncorrelated with either violent or property crime rates (Kepple and Freisthler 2012).[2] Well-known limitations of cross-sectional analyses and a general lack of statistical power in that study suggest the importance of continued work on the topic.

How, in theory, might medical marijuana dispensaries affect crime? First, marijuana use, which may be concentrated around dispensaries if some buyers consume onsite or nearby, may be criminogenic. Similar effects have been cited for alcohol outlets, where

[1]See the fifth paragraph of Ordinance 181069 `http://clkrep.lacity.org/onlinedocs/2008/08-0923_ord_181069.pdf`

[2]The Denver and Colorado Springs Police Departments each analyzed the number of crimes around dispensaries and compared them to the numbers around banks, pharmacies, and other businesses (Ingold, 2010; Rodgers, 2010). Neither found that dispensaries attract crime, although recent work demonstrates that dispensaries in Denver tend to be located in high crime neighborhoods (Boggess et al. 2014).

openings and availability in Los Angeles and other jurisdictions are associated with increases in crime (Teh 2008; Scribner et al. 1995; Gorman et al., 1998; Scribner et al., 1999; Gruenewald and Remer 2006; Gruenewald et al. 2006; Franklin et al. 2010; Grubesic and Pridemore 2011). In contrast to alcohol, however, some work suggests marijuana may not increase crime commission per se (Pacula and Kilmer, 2003) and may even inhibit aggressive behavior (Myerscough and Taylor 1985; NAS 1994; Hoaken and Stewart 2003).[3]

Second, given the quasi-legal status of these stores and their products, dispensary customers, employees or owners may resort to violence to resolve disputes (Miron 1999; Resignato, 2000).[4] If so, we might expect increases in crimes such as aggravated assault, which increased for such reasons with the emergence of crack cocaine (Grogger and Willis 2000).

Third, crime could increase near dispensaries as individuals try to finance their purchases through the proceeds of crime (Grogger and Willis 2000). If so, we would expect theft or other property crimes to increase with dispensaries. Finally, marijuana users and the dispensaries they frequent, which are a direct source of drugs and cash, may offer opportunities that attract criminals. Anecdotal evidence suggests that dispensaries have been subject to break-ins and robberies (e.g., see McDonald and Pelisek, 2009). Thus, we would expect an increase in robbery and burglary around dispensaries.[5]

While these channels seem plausible and have captured public attention, dispensaries could, in principle, decrease crime. Dispensaries tend to have their own security systems and often security guards to protect their assets and resolve disputes. Analyses of business improvement districts find that private security can have large returns in terms of crime

[3]The correlation between marijuana use and non-drug crime, although positive, is generally small (Bennett et al. 2008) and largely inconclusive (Pedersen and Skardhamar 2010; Farrington 2010). Longitudinal studies that find clearer positive relationships, such as Green et al. (2010), cannot rule out the role of third factors that affect both the commission of non-drug crime and marijuana use (Caulkins et al. 2012).

[4]We describe dispensaries as quasi-legal for several reasons. First, although medical marijuana use is legal in California, large-scale production and sales are not. Second, while cooperative are allowed under California law, Los Angeles and other localities can tightly regulate and, in some cases ban, their operations. Finally, under federal law, it remains illegal to manufacture, distribute or possess marijuana. Consequently, dispensaries have been targeted and raided by federal law enforcement.

[5]In this case, dispensaries may affect the spatial distribution of crime rather than increase the overall level. Such a change has clear negative implications for dispensary neighbors, but may not have broader societal implications. The welfare impact of geographic redistribution of crime depends on such factors as heterogenous effects (e.g., different costs across neighborhoods), multiplicative effects (if two crimes in one area impose higher costs than one crime in each of two areas) and economies of scale (if two crimes in one area is less costly than one crime in each of two areas).

reduction (Brooks, 2008; Cook and MacDonald 2011). Likewise, if police allocate more patrols around dispensaries, they might reduce crime as in Di Tella and Schargrodsky (2004). To the extent that dispensaries increase foot traffic through a neighborhood, they might prevent crime by increasing "eyes on the street" (Jacobs 1961). In addition, by legitimizing the marijuana trade, actors in this market may have legal channels to resolve disputes. This last possibility is somewhat less plausible given the ambiguous legality of many aspects of the medical marijuana market, such as large scale distribution.

Finally, if marijuana is a substitute for alcohol, as suggested by Anderson, Hansen and Rees (2013) and Crost and Rees (2013), increased access to marijuana could reduce crime since drinking increases arrests for both property crime (Carpenter 2007) and violent crime (Carpenter and Dobkin 2015). Ultimately, given the range of theoretical predictions, the impact of dispensaries on crime is an empirical question.

To evaluate the claim that dispensaries attract or otherwise contribute to crime, we exploit a plausibly exogenous source of variation in dispensary activity -- the temporary shutdown of medical marijuana dispensaries in the City of Los Angeles. On June 7, 2010, roughly 70% of the nearly 600 shops operating in the city of Los Angeles were ordered to close (Hoeffel 2010a). The shutdown came after years of concern and indecision over how to handle the burgeoning medical marijuana dispensary business in the city. In September 2007, the city adopted an "Interim Control Ordinance" (ICO), placing a temporary moratorium on new dispensaries and requiring existing dispensaries to register with the city by November 13, 2007 (see Appendix Table 1 for a timeline).

Given the limited time that dispensaries had to submit a registration form along with the required city business tax registration certificate, registration was quite ad hoc. How the city would use the registrations was unclear and the market continued to grow for several years despite the moratorium. In January 2010, final regulations, including closure orders, were adopted. The new ordinance set the number of dispensaries in the city at 70. Dispensaries that had registered between September and November 2007 and had been operating legally since that time were grandfathered, meaning that the number of legal dispensaries in the city could exceed 70 in the short run.

Consistent with the seeming arbitrariness of the closure criteria, we find that dispen-

saries ordered to close and those allowed to remain open look similar on observable dimensions. In other words, closure orders were not correlated with observable dispensary characteristics (including the level of or trend in crime around specific dispensaries) that might have otherwise made them of specific interest to law enforcement. We leverage the quasi-random nature of closure orders using a difference-in-differences framework and detailed data on exact dispensary locations and crime reports by city block to compare daily crime counts within varying radii (as small as 1/8 of a mile) around dispensaries ordered to close and those allowed to remain open. If dispensaries attract crime, then crime should decrease around dispensaries subject to closure relative to those allowed to remain open.[6]

Contrary to conventional wisdom, we find no evidence that closures decreased crime. Instead, we find a significant relative increase in crime around closed dispensaries. Like compliance with the closures orders themselves, which first was high, fell off with legal challenges and collapsed after a December 2010 injunction (Hoeffel 2010b), the increase in crime is temporary. Relative crime rates return to normal within four weeks. The increase is also very local – the estimated crime effects decrease rapidly and monotonically with distance around dispensaries. Bearing in mind that our analysis captures short-run effects, these findings imply that closing medical marijuana dispensaries is unlikely to reduce crime. Although there may be a myriad of reasons to regulate the number of marijuana dispensaries, protection from crime is one that seems difficult to substantiate.

We perform several analyses to better understand how dispensary closures affect crime. First, we analyze crime by categories. We find that the increase in crime is strongest and most precise for the type of crime most plausibly deterred by the presence of bystanders – property crime and theft from vehicles, specifically. Second, we analyze the interaction between closures and neighborhood foot traffic. We proxy for foot traffic using Walk Scores, a proprietary measure that scores each address based on the walking time to amenities, population density, block length and the density of street intersections. We find that the the magnitude of the crime effect varies in a non-linear way with Walk Scores. Specifically, the magnitude of the closure effect varies negatively with walkability, except in the most

[6]An alternative question, not explicitly evaluated here, is how dispensaries affect crime relative to alternative business types (e.g., ice cream parlors, convenience stores or banks.) While we cannot speak to this directly, our analyses of temporary restaurant closures can help shed light on this issue.

geographically isolated areas for which closures have no measurable effect on crime.

To shed further light on mechanisms, we explore the generalizability of the findings. Specifically, we analyze the impact of temporary restaurant closures due to public health code violations on crime in Los Angeles County. Despite the very different nature of these businesses, the reason for and timing of their closures, and the identifying assumptions, we find a nearly identical pattern of results. Crime increases in the local neighborhood around closed restaurants, the increase is driven by property crime, the effect is concentrated in areas without a high volume of foot traffic, and the effect disappears as soon as the restaurant reopens.

The common pattern of results for dispensaries and restaurants suggests that business closures in general exert a significant negative crime externality. By extension, businesses offer very local protection against some types of crime. Given that police are unlikely to systematically change their behavior in response to temporary restaurant closures, this analysis further suggests that changes in policing cannot explain the common pattern of results. Rather, a likely common mechanism may be "eyes upon the street" (Jacobs 1961), meaning that the presence of individuals helps deter crime. While part of the canon of modern urban design and crime prevention, this theory is virtually unsupported by rigorous empirical evidence. In addition, Jane Jacob's original 1961 formulation of the hypothesis makes clear that the impact of additional individuals on local crime is theoretically ambiguous; crowds provide some form of natural policing but also more perpetrators of and opportunities for crime. Our findings suggest that the first channel dominates, at least in the case of medical marijuana dispensaries and restaurants in urban environments.

The rest of the paper is organized as follows. In section 2 we discuss the June 2010 closure of medical marijuana dispensaries in Los Angeles and describe our data. In section 3 we describe our analytic approach for the dispensary analysis. In section 4 we present our main results. In section 5 we discuss spatial and temporal displacement. In section 6 we presents the institutional details of and results from our analysis of temporary restaurant closures due to health code violations in Los Angeles County. In section 7 we explore potential mechanisms behind the shared pattern of findings. In section 8 we conclude.

2 Medical Marijuana Dispensaries in Los Angeles

In 1996, voters in California approved Proposition 215, the state's medical marijuana law. Marijuana dispensaries opened to serve the patients newly qualified to use the drug under the law. Like the state as a whole, the City of Los Angeles saw rapid growth in dispensaries after the 2004 passage of a bill (SB 420) that clarified several operational aspects of the state's medical marijuana law.[7] At its peak, some estimates put the number of dispensaries in the City of Los Angeles at over 800 (McDonald and Pelisek 2009).

Not all Los Angeles residents welcomed these stores. Many believed that dispensaries attract crime and law enforcement fueled these concerns. In a July 2005 report, the LAPD cited several felony narcotics arrests made at dispensaries and speculated that "crimes such as theft, robbery and assault have occurred and will occur along with the sale of marijuana from these locations." As a result, they called for restricting dispensaries to commercial areas in the city if not banning them outright.[8] A later report by the Los Angeles Police Commission argued that the increase in dispensaries within the city (from 4 to 98 between July 2005 and November 2006) was tied to an increase in crime in reporting districts that had received complaints about dispensaries.[9] While these crime changes were not compared to that around other businesses or areas, many found the argument persuasive.

In 2006, the City Attorney's Office laid out options for regulating dispensaries – a land use ordinance establishing zoning requirements, an interim moratorium until state law was "further clarified" or an outright ban. Almost a year later, in September 2007, the city adopted an "Interim Control Ordinance" (ICO) that temporarily banned new dispensaries and required existing ones to register with the city by November 13, 2007. The ICO aimed to pacify constituents concerned with the growth of dispensaries while the city drafted permanent legislation.

While in principle the ICO should have stopped the growth in dispensaries, in practice it had the opposite effect. Hundreds of dispensaries opened after the moratorium by filing

[7]Among other things, SB 420 recognized a patient's right to cultivate marijuana through nonprofit collectives and cooperatives, i.e., dispensaries, a right that was later affirmed in People v. Urziceanu. See http://caselaw.lp.findlaw.com/data2/californiastatecases/C045276.PDF

[8]See http://clkrep.lacity.org/onlinedocs/2005/05-0872_rpt_atty_10-19-06.pdf

[9]See http://californiapolicechiefs.org/site/uploads-calchiefs/2012/02/fact_sheet.pdf

applications for "hardship exemptions" allowed under the ICO (McDonald and Pelisek, 2009).[10] The large number of applicants stemmed in part from the recognition that the city would not prosecute dispensaries until their hardship applications had been reviewed and that the city council was in no hurry to review applications. By June 2009, when the city council first began to rule on the hardship exemption applications, over 500 applications had been submitted (Hoeffel, 2009). On June 19, 2009, the city passed an ordinance amending the ICO to eliminate the hardship exemption.[11]

Although intended as a stop-gap measure, the ICO remained in place for more than a year and half. On January 26, 2010 the city council approved final legislation limiting the number of dispensaries in the city to 70 but grandfathering in those that had registered and been operating legally since the ICO.[12] Based on the 2007 registrations, 187 dispensaries were initially deemed eligible to apply for permits to remain operational. All other dispensaries were to cease operation by June 7, 2010. On May 4, 2010, the city sent "courtesy notices" to the 439 dispensaries that were being ordered to shut their doors.[13] Several listed establishments were later identified as ancillary businesses (e.g., clinics offering medical marijuana recommendations or smoke shops selling paraphernalia).[14] Our own scrutiny of the city's lists eliminated several duplicate listings, yielding 180 dispensaries eligible to remain open and 417 dispensaries ordered to close.

Some dispensaries and patient advocates responded to the city's notices by filing temporary restraining orders to prevent the closures. Efforts to win temporary restraining orders proved unsuccessful (Yoshino 2010; Kim 2010). That the appeals continued up to 3 days before June 7, 2010, however, suggests that dispensaries were not preparing weeks in advance to close. While the city declined to detail how the law would be enforced, it noted that it would "rely on reports from police, neighbors and building inspectors to identify violators" (Hoeffel 2010a). This characterization suggests that special patrols and

[10]Hardship exemption requests often cited delays beyond a dispensary's control, such as in receiving a city business tax registration certificate required for registering. However, many later applicants cited failure to register because of fear imposed by federal authorities (Hoeffel 2009).

[11]http://clkrep.lacity.org/onlinedocs/2009/09-0964_ord_180749.pdf

[12]See http://clkrep.lacity.org/onlinedocs/2008/08-0923_ord_181069.pdf

[13]For a sample letter, see http://blogs.laweekly.com/informer/2010/05/pot_shops_warned_to_close.php

[14]E.g., see http://www.latimes.com/local/la-me-closing-dispensaries-htmlstory.html.

enforcement units were not allocated, although we know of no data on this point.

Early reports on compliance with the law indicated that most of the dispensaries ordered to close on June 7, 2010 did so.[15] Within weeks, however, compliance seemed to break down and legal challenges to the law mounted (Wei and Romero 2010; Guerrero, 2010). In December 2010 an injunction was issued against the law and in January 2011 the city's dispensary closures were formally invalidated.[16]

2.1 Crime Data

To assess the relationship between medical marijuana dispensaries and crime, we analyze incident level crime data provided by the Los Angeles Police Department (LAPD) and the Los Angeles Sheriff's Department (LASD) to The Los Angeles Times (LAT) as part of its "Mapping L.A." project."[17] The LAPD provides police services to neighborhoods throughout the city while the LASD provides primary police services to all unincorporated parts of Los Angeles County, to all Metropolitan Transportation Authority (MTA) stations within the city and beyond, nine community college campuses throughout the county, as well as to numerous contract cities in the county.[18] The crime data include the date, time and location of reported crimes at the block level.[19]

Crimes not reported to the LAPD or LASD are not in our dataset. Thus, some crime committed in adjacent jurisdictions, such as the City of Santa Monica, is not captured

[15]The LA City Attorney's office estimated that only 20-30 stores defied the initial closure order (Rubin and Hoeffel 2010).

[16]Specifically, a Los Angeles County Superior Court Judge issued an injunction barring the city from enforcing many aspects of the medical marijuana ordinance, including dispensary closures based on registration (or lack thereof) at the time of the moratorium (Hoeffel 2010a).

[17]See `http://maps.latimes.com/crime/` for details on the data. As noted in the FAQ, the LAPD and LASD provide the raw data directly to the LAT.

[18]According to the LAT, they capture data from 42 LASD contract cities: Agoura Hills, Artesia, Avalon, Bellflower, Bradbury, Calabasas, Carson, Cerritos, Commerce, Compton, Cudahy, Diamond Bar, Duarte, Hawaiian Gardens, Hidden Hills, Industry, La Canada Flintridge, La Habra Heights, La Mirada, La Puente, Lakewood, Lancaster, Lawndale, Lomita, Lynwood, Malibu, Maywood, Norwalk, Palmdale, Paramount, Pico Rivera, Rancho Palos Verdes, Rolling Hills, Rolling Hills Estates, Rosemead, San Dimas, Santa Clarita, South El Monte, Temple City, Walnut, West Hollywood, Westlake Village. See `http://maps.latimes.com/about/#why-no-crime-reports`

[19]For mapping purposes, the LAT data repeat some crimes that occur at the boundaries of neighborhoods. See `http://maps.latimes.com/about/#double-crime-counting`. We clean the data to eliminate any multiple counts introduced for mapping purposes.

here.[20] Nonetheless, the LAT data should contain the vast majority of crimes occurring around the City and County of Los Angeles.[21] In addition, the dataset has gone through a rigorous vetting process by the Los Angeles Times, including the correction of numerous data omissions and flaws.[22] More importantly for our estimation, since any data omissions are determined by geographic coverage not dispensary closures and occur both pre and post closure, the missing data should not bias our findings.

The LAT crime data capture Part I offenses, defined as "serious crimes [that] occur with regularity in all areas of the country, and are likely to be reported to police" (FBI 2010). We analyze total Part I crimes and subcategories of Part I crimes defined by either the LAPD's Crime Class Code Hierarchy or the FBI's coding, which is used by the LASD and in national level datasets such as the Uniform Crime Reports. The LAPD's categories differ somewhat from the FBI's coding; specifically, the LAPD breaks out theft into general theft and theft from vehicles because of the high share of crime in the theft from vehicles category.[23] Since the LAPD comprises 98% of our data in the dispensary analysis and much of data for the restaurant analysis, we have adopted this as our main coding system.

2.2 Dispensary Data

We use information from the Los Angeles City Attorney's Office (LACAO) on the exact location of dispensaries subject to closure or allowed to remain open. Of the 597 dispensaries in our dataset, 417 were ordered to close and 180 were allowed to remain open.[24] Figure 1 shows the geographic distribution of dispensaries by closure status.

We code dispensaries based on their closure order status, adopting an intent-to-treat (ITT) approach to the analysis. As described above, the city initially reported that nearly

[20]Some crime in these areas are included because the LASD had jurisdiction, e.g., at an MTA stop, or because the LAPD was called.

[21]Together the LAPD and LASD provide police services for about 63% of the 9.9 million LA County residents – about 3.8 million within the city, 1.1 million in unincorporated parts of the county and another 1.4 million in contract cities (based on authors' calculations).

[22]For details see `http://maps.latimes.com/about/#crime-data-sources`

[23]For a discussion of the LAPD's categories for Part I offenses, see `http://projects.latimes.com/mapping-la/about/#what-crimes`

[24]The initial number of dispensaries cited by the LACAO was closer to 640 shops. However, careful scrutiny of the official list of dispensaries ordered to close and allowed to remain open revealed many duplicate listings as well as listing of shops that were subsequently deemed not to be dispensaries (these were generally clinics offering medical marijuana recommendations or smoke shops selling paraphernalia).

all shops complied with their orders to close. However, a small number of dispensaries that were supposed to close were later raided by the LAPD (see Rubin and Hoeffel 2010) or reported to be operating by the LA Weekly, (see Wei and Romero 2010). While the LACAO later indicated that the closure orders were not nearly as effective as they originally claimed and that many dispensaries defied their orders, it is unclear whether the revised statements apply to the short or long run. If indeed a substantial number of dispensaries failed to close immediately after the June 7, 2010, the results may significantly understate the true effect of dispensary closures on crime. In sensitivity checks, we replicate our analysis but recode as open or drop entirely dispensaries that, according to reports from the Los Angeles Times and the LA Weekly, defied the city's orders to close (Rubin and Hoeffel 2010, Wei and Romero 2010). Such revisions do not materially affect our results.

3 Empirical Strategy

We estimate the effect of dispensary closures on crime using a regression of the following basic form:

$$C_{it}^{d} = \alpha_i + \beta * 1(closed_{it}) + \delta_t + \epsilon_{it} \tag{1}$$

where C_{it}^{d} is the number of crimes within a distance d of a dispensary i on date t, α_i is a dispensary fixed effect, δ_t is a date fixed effect and closed is an interaction between $1(date \geq June7)$, an indicator for dates after and including the June 7, 2010 closures, and 1(closed), an indicator for dispensary closure status, as determined by city orders and in some sensitivity checks by reports of defying these orders. The main post June 7 and closure indicators are subsumed in fixed effects for date and dispensaries, respectively.

Given the (non-negative) count nature of the crime data, we estimate equation (1) using a Poisson regression model. All standard errors allow for two-way clustering to account for serial correlation of an arbitrary structure at the dispensary level as well as correlation across dispensaries on a given day (Cameron, Gelbach and Miller, 2011). With robust standard errors, the Poisson model is a quasi-maximum likelihood estimator that does not impose the equality of mean and variance condition and leads to consistent standard errors (Winkelmann and Zimmermann 1992). Allowing for overdispersion with a negative

binomial model, which we show in sensitivity checks, yields similar results.

We use the 10 days prior to and 10 days after (but not including) the closure date (June 7) for the main analysis. We drop June 7 because of the possibility of enhanced police presence to enforce closures, the general confusion over the meaning of the date (e.g., whether stores had to shutter on June 7 or the day after), and potential protests against closing on the proscribed date. In addition, since there can be a lag between the commission and reporting of a crime, crime reports for the closure date may be contaminated by crime committed in the pre-closure period, which would attenuate the estimates. As we show in sensitivity checks, the results are robust to the inclusion of the closure date.

We focus on a short (20 day) time window because many closures were temporary. As the legality and enforceability of the measure came under question, many dispensaries reopened or were replaced by other businesses. In addition, the short window increases our confidence that our results are due to dispensary closures and not differences in longer run crime trends around open and closed dispensaries. Analyses that extend the window around June 7 but decompose the post-closure period into smaller time periods confirm the immediate but temporary impact of closure orders on crime.

The identifying assumption for our analysis is that, in the absence of closures, crime and the factors that impact crime in the immediate area around dispensaries subject to closure would be similar (or at least not differentially different post-closure) to those in the immediate area around dispensaries allowed to remain open. While the somewhat arbitrary process the city took to determine closure status suggests this should be the case, we present several pieces of evidence to support this claim.

First, in Table 1, we show that daily crime counts at 1 or 1/3 mile around dispensaries ordered to close (col (1)) and allowed to remain open (col (2)) are virtually indistinguishable in the pre-period.[25] This remains true even when we narrow to 1/4 or 1/8 mile around dispensaries (not shown), and for total Part I crime as well as for Part I property and violent crime, and across subcategories of Part I crime.

Second, we compare crime trends around dispensaries ordered to close and those al-

[25]We use 1/3 of a mile because that is the distance where we detect changes in crime across both dispensaries and restaurants, i.e., this distance best balances the trade-off between local crime effects and the loss of power from considering a very small area with few crimes on any given day.

lowed to remain open. As shown in Figure 2a, at 1 mile, average daily Part I crimes are indistinguishable by closure status in both the pre and post period. A different pattern emerges when we consider crime in the immediate area around a dispensary. Specifically, at 1/3 of a mile (Figure 2b), average Part I crime tracks closely in the pre-period but diverges after June 7. This is suggestive of a closure effect on localized crime. The divergence in Part I crime trends after June 7 can also be seen at 1/8 of a mile (Figure 2c).[26]

Third, we find that dispensaries are indistinguishable based on closure status across a range of zip code characteristics from the 2010 census and 2011 ACS. Dispensaries are located in zip codes of about 42,000 people or 15,500 households, irrespective of closure status. Median household income, median age, housing occupancy rates and the share foreign-born are also independent of closure status. We also consider Walk Scores, a walkability measure that rates an address based on a weighted function of walking distance to amenities in 9 different categories, such as grocery, restaurants, and entertainment. (Walk Score 2011). Scores, which are on a scale of 0 to 100, are adjusted for pedestrian-friendliness, such as block connectivity. Dispensaries in Los Angeles tend to be in very walkable areas (scores of 70-89 are considered 'Very Walkable') and while we fail to reject zero difference in Walk Scores across dispensary types at the 10% level (p-value 0.056), this difference is quite small in magnitude – about 2.3 points (74.9 vs. 77.2) or less than 1/5 of a standard deviation (13.7 points) in Walk Scores. A comparison of the distribution of Walk Scores by closure status in Appendix Figure 2 shows that the mean difference is driven by a few dispensaries in very low Walk Score areas that were ordered to close.[27] Our results are not sensitive to these outliers. In short, the descriptive statistics are consistent with de-facto random closures, with open dispensaries serving as good controls for closed dispensaries.

Next we consider the possibility of spatial clustering of dispensary closures. If closure status is geographically clustered, it could impact inference and lead to over-rejection of the null of no effect of closures on crime (Barrios et al. 2012). In the last row of Table 1,

[26]Consistent with the patterns at 1 mile, we see no obvious impact of dispensary closures on citywide Part I crime counts or counts by region (see Appendix Figures 1a and 1b). This null effect is consistent with either the change in crime around dispensaries being too small to show up in citywide crime counts or a displacement of crime from areas farther to nearer to closed dispensaries.

[27]Excluding the 31 dispensaries characterized as "Car-Dependent," the difference in mean Walk Scores for dispensaries ordered to close and those allowed to remain drops to 0.5 with values of 76.9 and 77.4 respectively.

however, we demonstrate that the likelihood that a closed dispensary's nearest neighbor is open is similar to the likelihood that an open dispensary's nearest neighbor is open. Both probabilities are about a third and are statistically indistinguishable from each other, suggesting that closure status is not geographically clustered, and standard approaches to inference (e.g., two-way clustering) should be valid in this setting.

A separate but related issue is the overlap of crime catchment areas. Because dispensaries often locate close to one another, a given crime may be assigned to multiple dispensaries, particularly as we widen the catchment area. This overlap will likely bias our results towards zero, and potentially affect inference. To deal with this issue, below (in section 5.1) we present analyses using only dispensaries without nearby neighbors. Consistent with the predicted downward bias, the results are larger in magnitude but still statistically significant when we reduce or eliminate overlap, despite a greatly reduced sample size.[28]

Finally, we run a series of placebo regressions that analyze crime 1, 2, or 3 months *prior* to the closure orders taking effect (section 5.1). These regressions provide another check on whether our results are driven by differential crime trends around dispensaries that registered with the city in 2007 (and thus were eligible to remain open) and those that failed to do so. As discussed below, the placebo checks provide further support for the identification strategy.

4 Main Results

Our main Poisson regression model estimates of the impact of dispensary closures on total Part I crimes are in Table 2. In col (1), we show the pre-closure mean of Part I crime at 1/8, 1/4, 1/3, 1/2, 1 and 2 miles around dispensaries ordered to close. For crime at each of these distances, we show the results of the intent-to-treat (ITT) analysis (col (2)), the analysis that recodes dispensaries that were known to have defied closure orders as open (col (3)) and the analysis that drops known defiers (col (4)).

At distances of 1 to 2 miles, the estimated effects of closure on Part I crime are rather precisely estimated zeros. At 1/2 of a mile the effects are larger but insignificantly different from zero. At 1/3 of a mile, we detect increases in Part I crime of about 12 to 14% around

[28]We thank Steve Raphael for suggesting this check for a related, unreleased RAND report.

dispensaries ordered to closed relative to those allowed to remain open.

The point estimates imply increases between 14 to 16% at 1/4 of a mile and 23 to 24% at 1/8 of a mile around dispensaries ordered to close relative to those allowed to remain open. These findings suggest that while dispensary closures affect (increase) total Part I crime, they do so only in a very localized fashion (i.e., in the immediate vicinity of the affected business). Columns 2 and 3 show a similar pattern of results when we recode known defiers or drop them from our sample.[29]

4.1 Robustness Checks and Sensitivity Analyses

In Table 3 we present results from placebo regressions in which we repeat the ITT analysis but code the closure period as 1, 2 or 3 months prior to the actual June 7 closure date. As in our main analysis, we use 10 days each of pre and post data and drop the placebo closure date. Col (1) in Table 3 repeats our main ITT result from Table 2, while cols. (2) - (4) show results of the ITT analysis using placebo closure dates. Unlike the true closure period results, we find no clear pattern of results using placebo dates (e.g., monotonically increasing/decreasing with distance). The placebo estimates are sometimes positive and sometimes negative and are never significant at short distances (less than 0.5 miles) around a dispensary. These findings suggest our main results are not driven by systematic differences in crime trends by closure orders.

Next, we check whether the results are sensitive to model choice. First, we re-run the regressions using a negative binomial model in place of a Poisson model to deal with over dispersion. Second, we use a zero-inflated Poisson regression model to handle excess zeros in the data. As shown in Appendix Table 2, the estimates from both models are quite similar to our main Table 2 estimates.

In Appendix Table 3, we explore the impact of extending the study window. Specifically, we present (ITT) results that lengthen the study period to 60 days but include 3 separate indicators for closure days 1-10 (col 1), 11-20 (col 2), and 21-30 (col 3). We break up the

[29]Since defiant dispensaries may differ systematically from other dispensaries, recoding them as open or dropping them could introduce bias. In practice, since we know of only nine defiant dispensaries, we use this exercise to demonstrate that the results are not driven by the treatment of defiant dispensaries. As expected, the treatment of defiers has little effect on the magnitude or significance of the coefficients.

extended post-period into three parts because lengthening the post-closure period likely introduces control days to the treatment period since, as documented in McDonald and Pelisek (2009), some dispensaries reopened within a couple of weeks of closure.[30] Col (1) shows that increasing the pre-period generates results similar to our main specification with slightly tighter confidence intervals: the estimated effect of the first 10 days of closure on total Part I crime at 1/8 of a mile is almost 30% and is significant at the 1% level. At 1/4 and 1/3 of a mile, the first 10-day estimates are 12 and 9%, respectively, consistent with a decreasing monotonic relationship between the distance around dispensaries and the change in crime. Col (2) shows the effects of dispensary closures 11-20 days after the event. We find effects that are both smaller in magnitude and only significantly different from zero (at the 10% level) at 1/3 of a mile. Estimates for the 21-30 day closure period in col (3) are much less precise and are inconsistent in sign. This analysis confirms that pre-period trends are not driving our findings and that temporary dispensary closures had an immediate and temporary impact on crime.

In Appendix Table 4, we test the sensitivity of the results to confusion over the closure date and potential lags in crime reporting. Specifically, we drop June 6-8, 2010 from the analysis. Because this significantly limits our sample, we show results using 9, 19 and 29 days on either side of the June 7, 2010 but excluding June 6-8. Those results are quite similar and, in many cases, more precisely estimated than our main Table 2 results.

Finally we examine the effect of the multiple counting of crimes due to geographic overlap in dispensary neighborhoods. Because closure status is not geographically clustered, the main effect of this overlap is to mechanically bias our estimates towards zero, leading to an underestimate of the magnitude of the closure effect. To see this, we would ideally analyze dispensaries that have no neighbors within a wide radius, e.g., 1 mile. In practice, less than 5% of dispensaries are so geographically isolated. Consequently, in Appendix Table 5, we show sensitivity checks using the less restrictive requirements that dispensaries have a nearest neighbor more than 1/3 mile or more than 1/2 mile away. Using these restrictions leaves us with 158 dispensaries with a nearest neighbor more than 1/3 mile

[30]In addition, lengthening the post-period could reduce our estimates if they capture a generic business effect, as suggested by the restaurant analysis below, and new businesses open at the site of closed dispensaries.

away and 79 dispensaries with a nearest neighbor more than 1/2 mile away.

Across both restricted samples, the magnitude of the change in Part I crime is consistently larger than in the sample as a whole. The results for crime at 1/3 and 1/4 of a mile are statistically significant, despite the greatly reduced sample size. Restricting to dispensaries with a nearest neighbor more than 1/3 mile away, the estimates imply that Part I crime within a radius of 1/4 mile was about 47% higher around dispensaries ordered to close compared to those allowed to remain open, more than triple the main estimate in Table 2. When we restrict to the 79 dispensaries with a nearest neighbor more than 1/2 mile away, the estimates imply that Part I crime within 1/4 mile is 93 percent higher around dispensaries ordered to close compared to those allowed to remain open. While the results in Appendix Table 5 follow the expected pattern of increasing in magnitude as we reduce catchment overlap, the set of geographically isolated dispensaries may differ on other unaccounted for dimensions. As such, we cannot use the difference in these coefficients relative to the full sample to measure the average downward bias. Rather, these results provide suggestive evidence that our main results underestimate the true effect sizes.

4.2 Results for Crime by Type

We next analyze categories of Part I crimes, which are divided by the FBI into property and violent crimes. We estimate separate models for the following property crimes: burglary, grand theft auto, and larceny theft. Larceny theft is separately broken out as thefts from vehicles and other theft. Arson, a sub-category of Part I property crime is too rare to analyze separately. For violent Part I crime, we analyze aggravated assault and robbery. Murder and rape, which are included in total Part I violent crimes, are also too rare to analyze separately (see Appendix Table 6 for pre-closure mean).[31]

Table 4 shows the impact of dispensary closures on crime by type using the preferred ITT approach that codes closures according to order status. These results show that the effect of dispensary closures loads on property crimes, specifically larceny, and, breaking that out further, theft from vehicles. As with total crime, the effects are very local and

[31]Appendix Table 6 makes apparent the difficulty in analyzing rare crimes. For example, even at 2 miles, there were only an average of 0.04 murders per day around dispensaries ordered to close. At 1/8 of a mile, the count is 0.0002.

monotonically decrease with catchment area radii. This monotonic decrease in the closure estimates and confidence intervals can be seen clearly in Figures 3 and 4, which plot the implied percent change in Part I crimes and theft from vehicles, respectively, along with 95 percent confidence intervals at distances from 1/8 to 2 miles. At distances of 1/2 mile or greater we find no effect of closures on crime, and the small coefficients with relatively tight confidence intervals means we can explicitly rule out even small increases in crime at these larger distances. At 1/3 of a mile the models imply that property crimes increase by 12%, largely driven by increases in larceny and, specifically, theft from vehicles. Even more locally, the estimated effects imply that thefts from vehicles increase by almost 30% at 1/4 of a mile and by 100% at 1/8 of a mile around dispensaries ordered to close relative to those allowed to remain open. While the percent increase in crime near closed dispensaries is large, proper interpretation of these effects must take into account the low number of crimes around each dispensary on any given day. For example, combining the results of Tables 1 and 2, we see that closing a dispensary leads to just 0.0512 additional crimes (0.0399 additional property crimes) per day within a third of a mile of the closed dispensary.

Burglary is the one exception to the general monotonic pattern. Here we find a large, *negative* and marginally significant (p-value=0.07) coefficient for closures at 1/8th of a mile, positive and statistically insignificant coefficients at 1/4th, 1/3rd and 1/2 of a mile, a small negative and statistically insignificant coefficient at 1 mile, and a small negative statistically significant coefficient at 2 miles. While intriguing, this non-monotonic pattern does not admit to an obvious explanation. In addition, unlike the results for total crime or larceny, the burglary results do not hold up in robustness checks and are based on a very small number of events, with an average of 0.0245 burglary per day at 1/8 of a mile. As such, this result should be interpreted with caution.

As with our main results, we find that results for crime by type are insensitive to the treatment of defiers (see Appendix Table 7, which drops defiers, and Appendix Table 8, which recodes them as open) or the inclusion of the closure date (see Appendix Table 9).

5 More crime or displaced crime?

A crucial question in determining the social costs of crime associated with dispensary closures is whether the changes represent an increase (or decrease) in total crime or a shift of crime across either space or time. If crime is spatially displaced, then the increase in crime near a closed dispensary may be offset by decreases in crime further away. Since our main results show that closures lead to significant crime increases at distances of 1/4 to 1/3 of a mile around a dispensary, spatial displacement would imply corresponding decreases in crime at distances of greater than 1/4 to 1/3 mile. To check for this type of displacement, we examine the impact of closures on crime in concentric rings around each dispensary.[32]

Specifically, in Table 5 we analyze crime occurring between 1/4 and 1/3 of a mile, 1/3 and 1/2 of a mile, 1/2 to 1, 1/2 to 2 and 1 to 2 miles around dispensaries. At distances of 1/4 to 1/3 of a mile (a band fully contained within the radii where we find increases in crime) the coefficient on closure is, with the exception of violent crimes, positive. The increase within this band is not statistically distinguishable from zero, however. At 1/3 to 1/2 of a mile, the property crime estimate is negative but close to zero, albeit with a wide confidence interval. Since the overlap issue discussed previously should be exacerbated at larger radii, the magnitude of the estimates within the larger rings could be more downward biased than those at smaller distances. But given that these coefficients are never significant, these results do not provide strong evidence for (or against) spatial displacement.

Analogous to spatial displacement, temporal displacement of crime would mean that the changes in crime associated with closures are offset by changes in crime either before or after the closure period. While the dispensary closure date was well known in advance, there are no clear "re-opening" dates.[33] As such if criminal activity exhibited a significant ex-ante temporal elasticity, we would expect a decrease in crime around dispensaries scheduled to

[32] An alternative approach to checking for displacement would aggregate our data to larger geographic levels as in Freedman and Owens (2011) or sum results across areas as in Aliprantis and Hartley (2015). We choose not to take this approach for several reasons. First, dispensaries may border neighborhoods or police reporting districts, two potential levels of analysis. In this case, aggregation can mask displacement as an increase in crime in an area assigned the dispensary appears bigger when measured relative to a decrease in a neighboring area. In addition, the effects we observe here may be too small relative to the city or region to statistically detect in aggregated data, even in the absence of any actual displacement.

[33] Note that re-opening could be due to either the dispensary deciding to re-open (as many did) or the space itself being taken over by another business.

close but prior to actual closures as criminals waited until June 7 to commit crimes.

We find little evidence of pre-closure differences in either the level or trend in daily crime around dispensaries ordered to close relative to those allowed to remain open. Most directly, since extending the pre-period window around June 7, 2010 yields similar results (see Appendix Table 3), it is unlikely that a pre-period decline in crime in anticipation of future crime commission can explain our results. In other words, criminals do not appear to postpone (or move forward) crimes in anticipation of the mass closure of dispensaries. Given the variation in pre-closure crime levels, we can generally rule out economically significant temporal displacement in the period just prior to the June 7, 2010 closures.

6 Restaurant Closures and Crime

While the results above demonstrate that crime increased near dispensaries that closed relative to those allowed to remain open, such an increase is consistent with multiple mechanisms (see Section 2). Here, we attempt to disentangle some of the possible mechanisms by testing whether this closure effect is unique to dispensaries or reflects a more general business closure phenomenon. We do this by performing a parallel analysis for temporary restaurant closures due to public health code violations in Los Angeles County.

6.1 Background on Restaurant Closures

In Los Angeles County, the Department of Public Health (DPH) is charged, under the California Uniform Retail Food Facilities Law (CURFFL), with enforcing uniform statewide health and sanitation standards for retail food facilities according to the"science-based standards." DPH inspects all facilities that provide food to the public (restaurants, bakeries and markets). Based on the guidelines outlined in the California Retail Food Code (Cal-Code), DPH environmental health specialists grade restaurants on various health and sanitation measures including improper holding temperatures, poor personal hygiene of food employees, contaminated equipment and the presence of vermin and, depending on the outcome, may order a temporary shutdown for remediation.

Based on a Food Official Inspection Report (FOIR), restaurants receive a numerical score between 0-100. Restaurants that score 70 and above are given a grade card that

must be posted in an easily visible location (90-100 is an "A", 80-89 a "B", 70-79 a "C"). Restaurants that score less than 70 receive a numerical score card rather than a grade. Restaurants that score less than 70 twice in any twelve month period are subject to closure and the filing of a court case. Such closures are rare. More commonly, if the inspection turns up a "major violation," meaning a violation, such as vermin harborage or infestation, sewage disposal problems or food temperature problems, that poses an imminent health hazard, the restaurant is subject to immediate closure without a permit suspension hearing.[34] Restaurants closed for major violations remain closed until a subsequent follow-up inspection confirms that the situation has been satisfactorily resolved. Follow-up inspections generally take place within two-days but can take up to a week.[35]

Restaurants are inspected twice a year, although those that handle large quantities of "risky foods" (e.g., meat) or consistently score low may be inspected three times a year. The DPH may conduct an additional inspection in response to consumer complaints. Individual inspectors work specific geographic areas determined by the local environmental health office. They work with supervisors to set a schedule for restaurant inspections in increments of one or more months. While inspection scheduling is not standardized, inspections are, depending on the specific supervisor, scheduled weeks to months ahead of time. As such, although the timing of inspections are not explicitly randomized, the process makes it highly unlikely that the exact timing of inspections are correlated with trends in crime in the immediate area around each restaurant. In addition, DPH officials have stated that local conditions (including crime) have no bearing on the timing of inspections.

6.2 Restaurant Data

Data on restaurant closures are from the Environmental Health Division (EHD) of the Los Angeles County DPH, the enforcement division in charge of inspecting retail food facilities. The EHD data include the name and exact location of restaurants closed by the agency, the date of closure, the reason for closure, and in most cases a reopen date. In total, we have 888 restaurant closures during our study period, February 1, 2010 to October 31, 2010.[36]

[34]See: `http://publichealth.lacounty.gov/eh/docs/RetailFoodInspectionGuide.pdf`

[35]This timing is based on conversations with LA County Department of Public Health officials.

[36]The study period was determined by the original data made available to us by the LAPD.

Most closures are caused by "major violations," with roughly two-thirds of the closures in our sample due to vermin harborage or infestation. The next most common offense is a lack of potable or hot water, which accounts for 12 percent of closures. Of the 888 closures, 766 or 86% of them have valid reopen dates. In all the cases we investigated, restaurants with no-reopen dates were in fact open and operational. In multiple conversations with EHA, we were unable to obtain any official reason for missing reopen dates. As described below, we take three approaches to dealing with restaurants with missing restaurant reopen dates – assigning the median closure period of 2 days, treating them as permanently closed or dropping them from the sample. Our primary approach uses the median closure period but, as shown below, the results are not sensitive to this choice.

6.3 Restaurant Analysis

We focus on the universe of Los Angeles County restaurants that were closed for heath code violations between February 1, 2010 to October 31, 2010.[37] Using the same basic specification as in equation (1), we define $1(closed)$ as the period between a restaurant's closure and reopen date. Because we restrict the sample to restaurants with health code violations, the identifying assumption for this analysis is that the *timing* of closures is uncorrelated with crime in the area immediately around the affected restaurant.

Paralleling our dispensary analysis, we drop each first closure day in the analysis. In addition to the concern that crimes reported on closure dates may have occurred prior to that date, many restaurants will be closed for only part of the first closure day. In other words, some restaurants ordered to close temporarily remain open for part of the first closure day – both before and during the inspection. However, as with dispensaries, the results are similar when we include the first closure day in the analysis (shown below).

Appendix Table 10 shows summary statistics for restaurants in the 10 days prior to closure. Since all restaurants in our sample were subject to closure, there are no separate time-invariant restaurant characteristics for closed and open restaurants. Rather, these summary statistics show pre-closure characteristics of neighborhoods around restaurants

[37]Since we will require 10 days of pre and post closure data, the restriction is actually restaurants closed between February 10, 2010 and October 21, 2010.

subject to closure during our sample period. In general, the neighborhoods around restaurants do not look dramatically different from that around dispensaries (in Table 1). The most noteworthy differences are that these neighborhoods are slightly more populous, with larger families (i.e., fewer households, despite more people) and lower family incomes. And, consistent with the fact that restaurant closures occur across the county, not just in the city of Los Angeles, the average Walk Score is slightly lower (71.1) around restaurants than either dispensaries ordered to close (74.9) or allowed to remain open (77.2).

While the inspection scheduling process makes it unlikely that inspections are correlated with crime (since it would require that the DPH be able to predict crime at a very disaggregated level), a related concern is that the probability of closure *conditional* on an inspection is correlated with local crime conditions.[38] If the probability of closure is affected when crime in the immediate vicinity of a restaurant is rising – because, for example, the inspector does a less rigorous review in order to minimize his exposure to crime – it could bias our results. To assess these concerns, we run placebo regressions to test for differences in crime within 1/4, 1/3, 1/2, 1 or 2 miles around restaurants in the days leading up to a closure. In other words, we estimate a regression of the form in (1) but define a placebo closed dummy equal to 1 for the same length of time as the actual closure for the days prior to the closure event (see columns 1-3 in Appendix Table 11). As an alternate test, we define a placebo closed indicator for the day prior to, or the 2 days prior to the closure date (see columns 4-5 in Appendix Table 11). In all cases, we find no statistically significant relationship between the placebo closures and crime. The point estimates are also small in magnitude, with the exception of the 1 day dummy (column 4), which, representing the shortest placebo time period, also has the largest standard errors. In short, we find no evidence of systematic changes in crime in the days leading up to these restaurant closures.

[38]The importance of plausibly exogenous restaurant closures status is made clear by earlier work documenting a the complex relationship between crime and the business activity. For example Greenbaum and Tita (2004) find that surges in violence leads to less business formation and downsizing, while Sloan, Caudill and Mixon Jr. (2015) find that criminal activity is positively correlated with restaurant openings.

6.4 Restaurant Results

In Table 6 we show restaurant results that (i) recode those with missing reopen dates as having been closed for the median number of days closed across the sample, 2 days (col (2)), (ii) treat those with missing reopen dates as closed through the entire post-period (col (3)), or (iii) drop those restaurants with missing reopen dates (col (4)). As with the dispensary analysis, we limit this analysis to the 10 days prior to and 10 days after any restaurant's closure.[39] Since results at 1/8 of a mile generally do not converge, we show results for crime at 2, 1, 1/2, 1/3 and 1/4 mile around restaurants. Pre-closure means for Part I crime at each of these distances are provided in col (1).

Table 6 indicates that total Part I crime increases during temporary restaurant closures. At 1/3 of a mile, total Part I crime increases by about 9 to 12% around closed restaurants relative to open restaurants that were temporarily shut down within plus or minus 10 days. The results are similar irrespective of the treatment of restaurants without re-open dates. In addition, the results show a monotonic increase in the effect size as distance narrows up until 1/4 of a mile, at which point the coefficient is small and statistically insignificant.[40]

Table 7 presents results for the breakdown of crime by type, where restaurants with missing reopen dates are coded as closed for the median length of time in the data. As with dispensaries, we find that the effects of closures are concentrated on property crimes, specifically thefts from vehicles. The estimates imply an almost 30% increase in thefts from vehicles at 1/4 of a mile – generally the smallest radii we can analyze for restaurants. Again as with the dispensaries results, the effects quickly diminish with distance, becoming not just insignificant but also small in magnitude at distances of 1 mile and greater. As

[39]In addition to making this analysis as similar as possible to the dispensary closure analysis, the short time window addresses a concern regarding clustering in inspections. Specifically, the use of a short window around each closure helps ensure that identification is not affected by any gross correlations between the timing of inspections and local crime and reduces the possibility that any results are due to differences in medium or long-run crime trends. The focus on restaurants with similar closure dates also mechanically reduces overlap in the catchment areas simply by reducing the number of restaurants examined on any given day, which as previously discussed introduces a downward bias in our estimates.

[40]The difference in the crime change-distance pattern for restaurants and dispensaries likely reflects differences in catchment overlap and statistical power and not necessarily any difference in the magnitude of the effect across establishment types. While we have more restaurants than dispensaries (888 restaurants vs. 597 dispensaries), restaurants are generally closed for only a couple days and, more importantly, these closures are spread out over 250 calendar days as opposed to just one period for dispensaries.

detailed in the appendix, these results are robust to several additional sensitivity checks: lengthening the window of time around restaurant closures (Appendix Table 12), including closure days (Appendix Table 13), coding restaurants with missing re-open dates as closed for the full post-closure period (Appendix Tables 14) and dropping restaurants with missing reopen dates (Appendix Table 15).

We next check for the displacement of crime either spatially or temporally in response to temporary restaurant closures. As with dispensaries, we check for spatial displacement by examining changes in crime in rings of various sizes around closed restaurants. Table 8 shows the crime changes occurring between 1/4 and 1/3 of a mile, 1/3 and 1/2 of a mile, 1/2 to 1 mile, 1/2 to 2 miles and 1 to 2 miles around closed restaurants. At 1/4 to 1/3 of a mile, which is fully contained within the radii where we find increases in crime around closed restaurants, the coefficient on closure is positive. The increase within this band is significant only for total crimes. The point estimates then drop and are both small in magnitude and not distinguishable from zero at 1/3 to 1/2 of a mile, suggesting that the increase in crime is localized to distances of less than 1/3 of a mile.

To test for temporal displacement, we re-run our standard regression but supplement the restaurant closure period indicator with dummies for both the re-open date and the re-open date plus 1. We focus on the reopening period since restaurant closures are unexpected and thus could not have caused pre-closure shifts in criminality. Rather, the temporary restaurant closures could have led criminals to shift crime earlier in time to the closure period. Such a shift would decrease crime after a reopening. Instead, as shown in Table 9, we find significant increases in crime at 1/3 of a mile around restaurants during the closure period but no compensating decrease in crime on either the re-open day or the day after.

The similarity in the broad pattern of results for restaurants and dispensaries despite the differences in the nature of these businesses, the reason for and timing of their closures, and the identifying assumptions of the analyses, provides additional evidence that the increase in crime following dispensary closures is not spurious. Furthermore, it suggests that the mechanism behind the decrease in crime is not dispensary-specific but indicative of a more general effect of business closures on crime.

7 Modes and Mechanisms

The results presented above show that temporary dispensary closures increase crime in the short-run and that temporary restaurant closures affect crime in a similar fashion. While the increase in crime after both dispensary and restaurant closures may be unrelated, it seems more likely that a common factor drives the shared pattern of results. Under this assumption, we can rule out dispensary-specific mechanisms such as the substitution of alcohol for marijuana or diminished access to formal dispute resolution channels in medical marijuana markets, as the driving force behind the increase in crime. Below, we explore the evidence for and against several possible common factors.

7.1 Walkability and the Role of "Eyes Upon the Street"

One potential common factor affecting crime may be a reduction in foot traffic. If dispensary and restaurant closures reduce foot traffic, informal policing or "eyes upon the street" (Jacobs 1961) may also be diminished and crime could increase. This hypothesis requires that the impact of business closures on crime be mediated through customer foot traffic. Such a connection seems intuitive since a closed business necessarily has fewer customers than an open one. The ideal data to test this would include measures of foot traffic by location. Given that such measures are unavailable, we use neighborhood characteristics to proxy for the *relative* impact of business closures on foot traffic in an area.

To proxy for foot traffic by location, we collect "Walk Scores" from www.walkscore.com by exact business address.[41] Scores range from 0 to 100, and are based on walking paths to amenities. Amenities within a 5 minute walk are given maximum points. More distant amenities receive points based on a decay function, with zero points after a 30 min walk. Pedestrian friendliness is comported into the measure based on population density, block length and intersection density. While Walk Scores do not capture the presence of sidewalks, street lights or speed limits, which likely improve the walking experience, they have been shown to be a useful measure of walkability (Hirsch et al. 2013).

[41] A complementary approach might be to use Dunn and Bradstreet data on the level of employment and the composition (retail vs. wholesale) of establishments at the address and block level as in Rosenthal and Ross (2010).

Walk Score identifies four categories of addresses based on their scoring system: Car-Dependent (0-49), Somewhat walkable (50-69), Very walkable (70-89) and Walker's paradise (90-100). Walkability is determined by the number and proximity of restaurants, bars, coffee shops, grocery stores, and so on. An address with a high Walk Score has many businesses and other features that generate foot traffic nearby whereas one with a low Walk Score has few businesses nearby and relatively little foot-traffic.

How should the Walk Score interact with business closures to affect crime? Since a business with a high Walk Score is located near many other businesses, its customers likely represent a small share of local foot traffic. On the other hand, the closure of a business in a low Walk Score area should have a proportionally large impact on total foot traffic. As such, the eyes upon the street hypothesis (hereafter EUS) would predict that, all else equal, the impact of business closures on crime should be negatively related to Walk Scores (i.e., that a closure should increase crime more in low Walk Score areas.)

A more complete consideration of foot traffic must acknowledge that people are both crime deterrents and crime targets. For very isolated, car dependent areas with little foot traffic, a business closure could reduce crime in the area by removing the few existing crime targets. As an extreme example, consider a business that is the only feature for 1/3 of a mile (i.e., in an extremely car dependent area) and that its closure decreases the number of people in the area from N to zero. Such a closure would substantially decrease foot traffic. But, since there are virtually no remaining crime targets in the immediate area, crime would likely decline despite the loss of crime-deterring eyes upon the street.[42] In this way, EUS predicts a non-monotonic relationship between business closures and Walk Scores: business closures will have smaller (and in the case of isolated areas possibly even negative) effects on crime in the most and least walkable areas and larger, positive effects in moderately walkable areas.

In Table 10 we explore the interaction of business (dispensary or restaurant) closures and walkability on crime. Panel A shows results for dispensary closures and Panel B for restaurant closures. Column 1 shows the impact of closures on total crime within 1/3 of a

[42]Along these lines Sandler (2012) finds that the eviction of residents from, and subsequent demolition of Chicago public housing led to a decrease in crime in the area immediately surrounding the demolition.

mile for dispensaries or restaurants with Walk Scores above versus below 70, corresponding to walkscore.com's cutoff between 'Very' and 'Somewhat' walkable.[43] We find a significant positive closure effect on crime for both dispensaries (Panel A) and restaurants (Panel B) with low Walk Scores, with effect sizes approximately double that found in the full sample (i.e., compared to Tables 2 and 6). When we examine crime by type (columns 3-6), we see that, as in the full sample, the interaction effect is driven by increases in property crime, specifically larceny and theft from vehicles. In low Walk Score areas, dispensary or restaurant closures have more than double the impact on property crime than they do in high Walk Score areas.

In column 2, we further divide up businesses using separate closure dummies for the Car-dependent, Somewhat walkable, Very walkable, and Walker's paradise categories. Here again we find that the closure effect is smaller in highly walkable areas (i.e., areas where a single business closure has little impact on total foot traffic) and larger and positive in the "somewhat walkable" areas. For "Car-dependent" areas, the sign of the coefficient flips and becomes negative; it is also both small in magnitude and statistically indistinguishable from zero. With the caveat that the coefficients for "car-dependent" and "somewhat walkable" areas are only marginally statistically different (p-values of 0.074 and 0.110 for restaurants and MMDs respectively), this pattern is consistent with a non-linear relationship between closures and walkability as predicted by EUS.[44]

While the Walk Score findings suggest that our main results are driven by changes in customer foot-traffic, interpreting the elasticities of these effects with respect to foot traffic is difficult since we have no measure of a business's customer base or, by extension,

[43]Nearly identical results are obtained by dividing the sample into above and below median Walk Scores.

[44]As an alternative proxy for foot traffic, we interacted the closure indicator with indicators for whether the dispensary's ZIP code was above or below median for the density of employees in all dispensary ZIP codes based on the 2010 census ZIP Code Business Patterns data. The results of this analysis are qualitatively consistent with out Walkscore results (see Appendix Table 16): closure effects are larger in less dense areas, where the closure of a dispensary represents a larger proportional decrease in foot traffic. That said, the estimates are somewhat difficult to directly compare to the Walkscore results. In particular, while the density of employees in a ZIP code is a better measure of business activity, it suffers, as a measure of foot traffic, from several shortcomings. First, it cannot distinguish between retail vs non-retail establishments (e.g., business parks and factories). More significantly, ZIP codes capture relatively large areas (over 3.6 (5.8) square miles for the median (mean) ZIP Code in either sample) while our business closure estimates (and foot traffic more generally) are localized; we observe crime effects within a radius of 1/3 of a mile or less, representing an area of approximately 0.35 square miles.

the change in the number of "eyes" associated with a closure. With this very strong caveat in mind, we can nevertheless generate a simple back of the envelope calculation as a face validity check on the magnitude of our coefficients with respect to EUS. Specifically if we assume that a business has 50 customers per day, the results for the 1/3rd mile catchment area suggest that it would take approximately 1,250-1,800 customers to deter one property crime. If we further assume that each customer effectively contributes 15 minutes of monitoring time, then our estimates suggest that it takes roughly 300-450 eyes-upon-the-street hours to deter one property crime.

7.2 Private Security and Public Policing

While our results are consistent with EUS, they may be consistent with several alternative explanations. Perhaps the most plausible alternative is that businesses provide formal, direct on-site security that deters crime. Studies of business improvement districts in Los Angeles have demonstrated the deterrent effect of paid security services (Brooks, 2008; Cook and MacDonald, 2011). Thus, closures may increase crime by removing security services. But, while dispensaries typically employ many forms of security, most restaurants have little more than security cameras, if anything at all. These cameras may not be external, as they often are for dispensaries. And, assuming they are external, it is unclear why restaurants would remove or disable cameras during temporary closure periods. As such, the dismantling of private security seems unlikely to be the main driver of crime effects that are common to both dispensaries and restaurants.

A second alternative explanation relates to changes in police presence, which have been shown to affect similar categories of crime. Klick and Tabarrok (2005) find that a large increase in police presence, combined with increases in closed-circuit surveillance cameras in Washington D.C., led to a significant decrease in a combined category of theft from vehicles and auto-thefts. Draca, Machin and Witt (2011) find that a 50% increase in police presence in London led to a reductions in larceny theft of around 20% in the affected neighborhoods. If closures decrease police presence, they could plausibly increase crime.

Like private security, changes in police service allocations seem unlikely to be a significant driver of our results. For restaurants, it is hard to imagine that police would formally

or informally change their behavior in response to temporary restaurant closure. For dispensaries, anecdotal reports suggest that, if anything, police presence may have increased in the days following the closures in order to check for compliance. This increase would be predicted to decrease rather than increase crime. Even if police presence did change in response to temporary restaurant and dispensary closures, the change, based on existing evidence from the literature, would have to be implausibly large to generate our findings. For example Draca et al. (2011) find effects similar in magnitude to our findings in response to a *50% increase* in police presence.

8 Discussion and Conclusions

Analyzing medical marijuana dispensary closures in the City of Los Angeles, we find no support for the idea that closing dispensaries reduces crime. Rather, temporary closures deter some types of Part I crime. To understand the mechanism, we evaluate the impact of temporary restaurant closures due to public health code violations. We find a nearly identical impact of these closures. Both temporary dispensary and restaurant closures increase Part I property crime, specifically theft from vehicles, in a very localized area around closed businesses. The magnitude of the closure effect is correlated with the relative impact of the closure on area foot traffic. Specifically, the increase in crime due to closures (dispensary or restaurant) is negatively correlated with neighborhood walkability in relatively walkable areas but reverses sign or is nonexistent in areas classified as car dependent.

That the pattern of results is so similar across the temporary closure of two different establishment types suggests a common factor may be at play. In other words, the main findings may not capture a dispensary specific effect on crime but rather a more general retail specific effect. Since temporary restaurant closures should have no meaningful effect on policing patterns, police presence is unlikely to be this common factor. On the other hand, the results on neighborhood walkability suggest that "eyes upon the street" may account for the common pattern of results

Taken together, our results provide support for the hypothesis that retail establishments, when operational, provide informal security through their customers. That is, to the extent that businesses bring foot traffic or as Jane Jacobs once famously proclaimed, "eyes upon

the street" to a neighborhood, they may deter certain types of "dark alley" crimes. While the idea that "eyes belonging to those we might call the natural proprietors of the street" (Jacobs 1961) can provide public safety on city streets has spawned many studies on the role of urban design and architecture on crime (Newman 1972; Hunter and Baumer 1982; Glaeser and Sacerdote 2000; Foster and Giles-Corti 2008), albeit not all in support of the hypothesis, credible empirical evidence on the impact of local activity on crime remains quite limited. Our results are consistent with a somewhat nuanced view: increased foot-traffic appears to decrease crime but only above a certain threshold of traffic.

Our findings have direct policy implications for regulating marijuana sales in the U.S. They imply that dispensary closures, and potentially the closure of other types of retails establishments, exert a significant negative externality in terms of neighborhood criminality. A quick back of the envelope cost calculation using the change in larceny theft at 1/3 of a mile (from Table 4) and crime costs from McCollister et al. (2010) suggests that an open dispensary provides over $30,000 per year in social benefit in terms of larcenies prevented.[45] This calculation ignores potential offsets in terms of quality-of-life issues, such as loitering, graffiti, double parking and noise.[46] In addition, the current study is underpowered to detect any impact of closures on high-cost, low frequency crimes such as robbery, aggravated assaults, homicide, rape or arson. Future research on the impact of dispensaries on these low-frequency crimes and on quality-of-life issues are crucial for understanding the full economic impact of these establishments.

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[45] A similar calculation using the point estimates for aggravated assault and robbery at 1/3 of a mile from Table 4 suggest social benefit of approximately $350,000 per annum. Given the relatively large standard errors on these estimates, this number should be mainly considered illustrative of the potential *relative* costs associated with property vs violent crimes.

[46] Indeed, these types of NIMBY issues may be the real cost of a dispensary to area residents.

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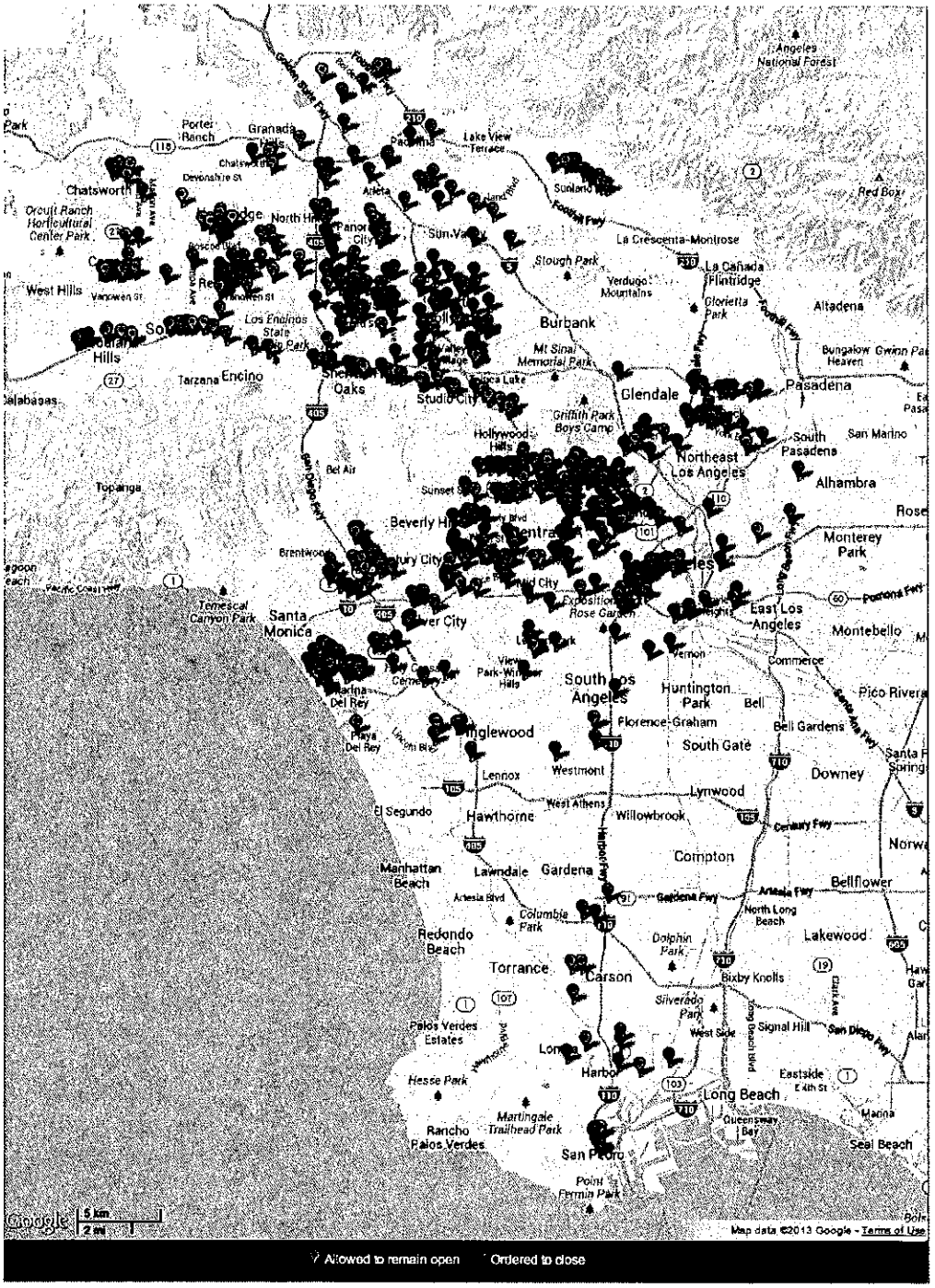


Figure 1. Dispensary location by closure order status.

Figure 2a. Mean Daily Part I Crime at 1 Mile by Closure Status

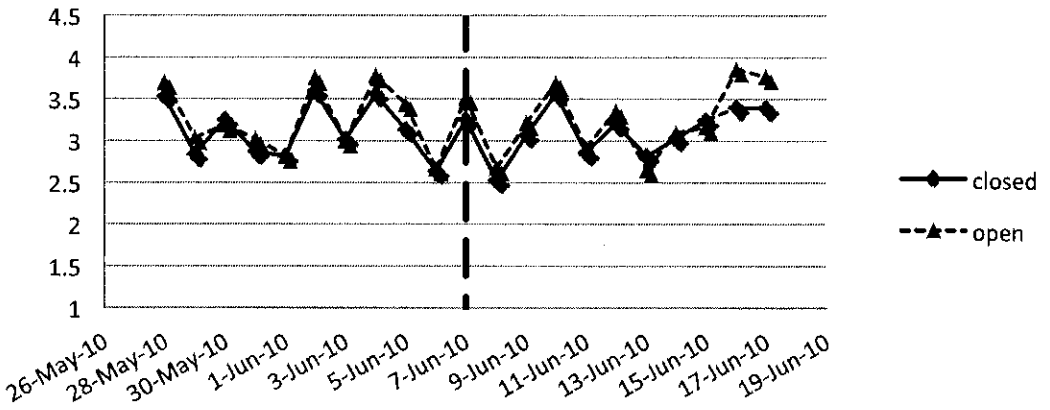


Figure 2b. Mean Daily Part I Crime at 1/3 Mile by Closure Status

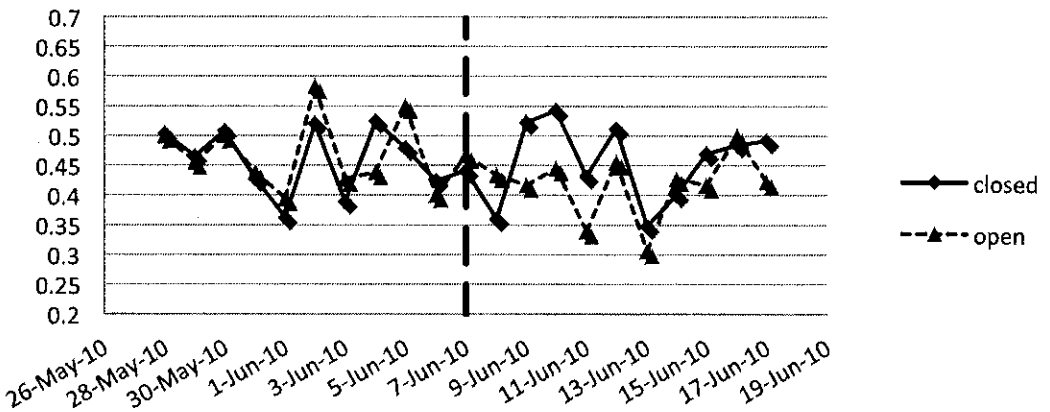
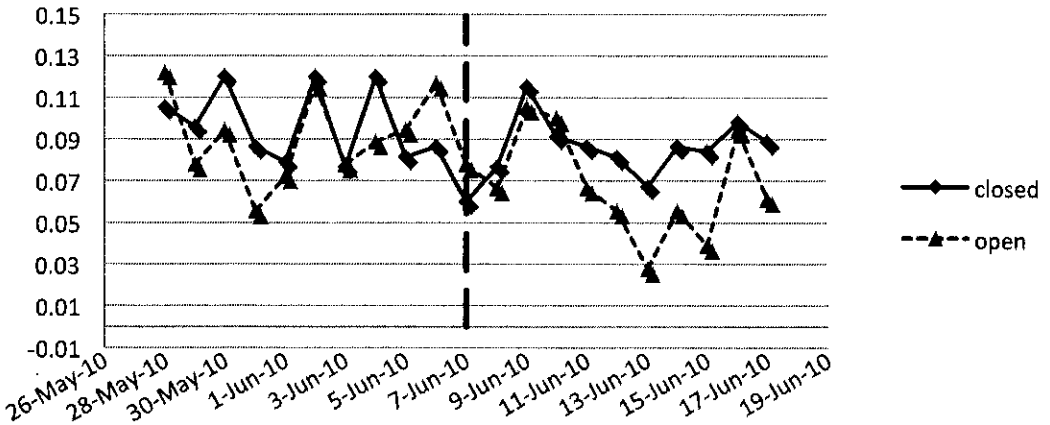


Figure 2c. Mean Daily Part I Crime at 1/8 Mile by Closure Status



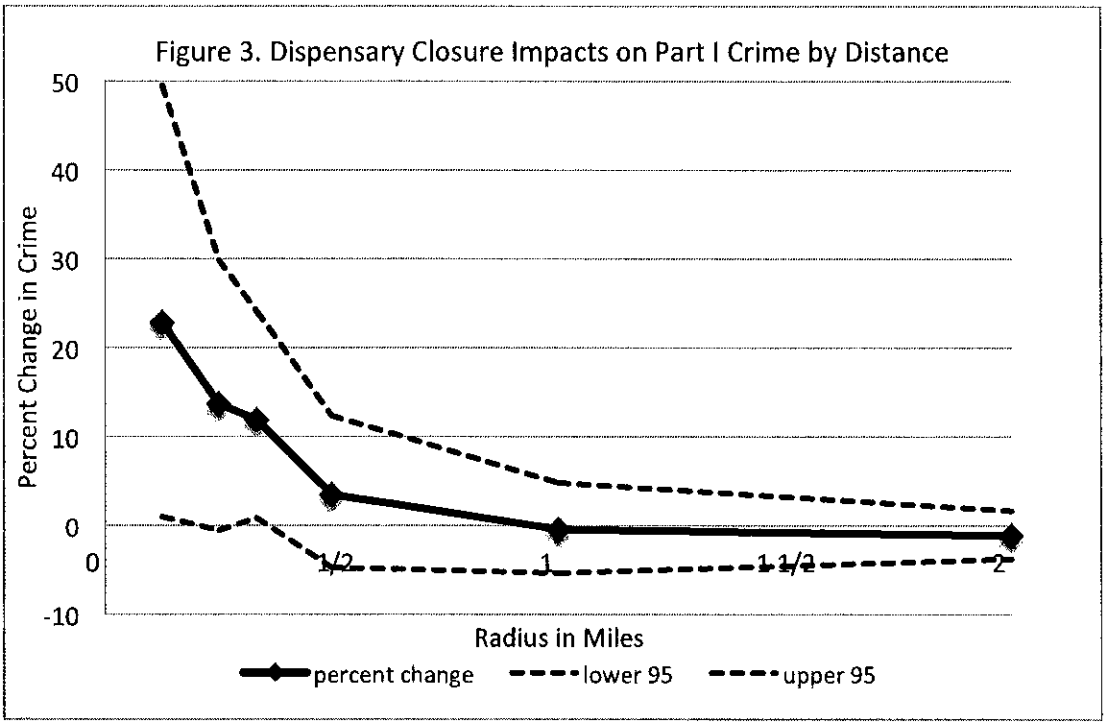


Figure 3. Dispensary Closure Impacts on Part I Crime by Distance
50
40
30
20
10
0
0
-10
Percent Change in Crime
1/2
1
1 1/2
2
Radius in Miles
percent change
lower 95
upper 95

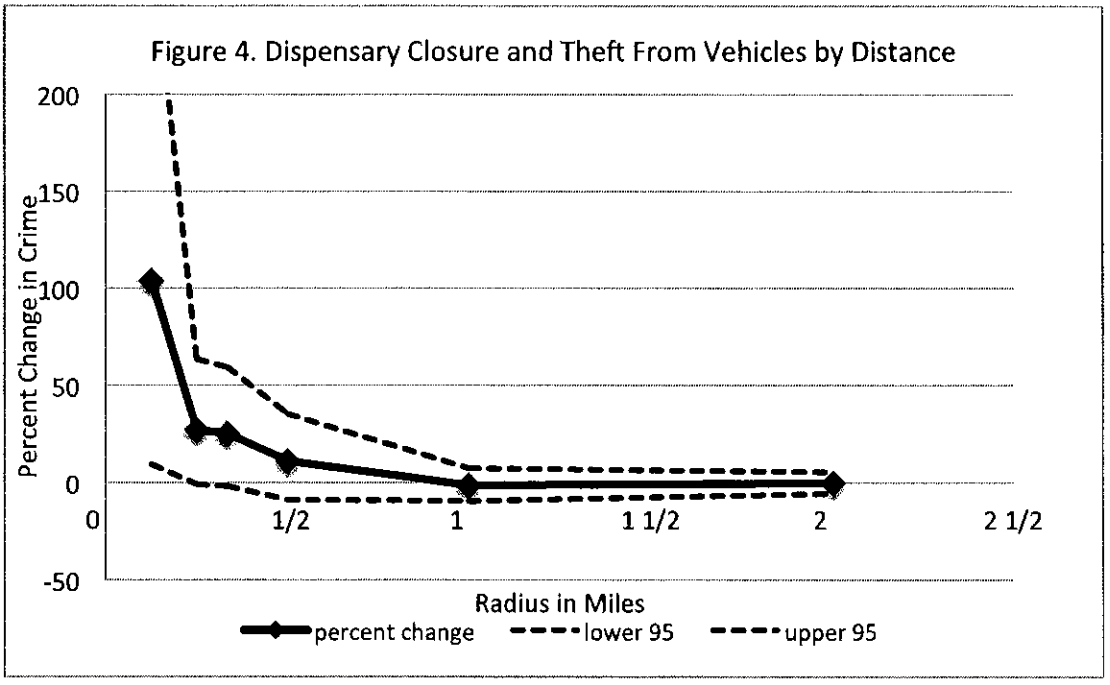


Figure 4. Dispensary Closure and Theft From Vehicles by Distance
200
150
100
50
0
0
-50
Percent Change in Crime
1/2
1
1 1/2
2
2 1/2
Radius in Miles
percent change
lower 95
upper 95

Table 1. Dispensary Summary Statistics Pre versus Post June 7, 2010

	Dispensaries ordered to clos, Pre-June 7	Dispensaries allowed to remain open, Pre-June 7	p-value
Daily Crimes			
Part I Crimes < 1 Mile	3.12	3.24	0.122
Part I Property Crime <1 Mile	2.47	2.56	0.117
Part I Violent Crime < 1 Mile	0.657	0.679	0.466
Part I Crimes < 1/3 Mile	0.466	0.479	.563
Part I Property Crime <1/3 Mile	0.356	0.362	0.751
Part I Violent Crime < 1/3 Mile	0.104	0.106	0.813
Daily Part I subcategories < 1/3 mile			
Aggravated assault	0.049	0.054	0.535
Auto Theft	0.061	0.054	0.276
Burglary	0.052	0.054	0.713
Homicide	0.0014	0.0017	0.835
Rape	0.0046	0.0044	0.957
Robbery	0.048	0.046	0.724
Larceny Theft	0.243	0.254	0.480
Theft	0.144	0.145	0.960
Theft from Vehicles	0.099	0.109	0.254
Zip Code Characteristics			
Population	41960	41947	0.994
Households	15414	15669	0.609
Median Household Income	54621	54900	0.867
Median Age	35.5	35.7	0.480
Occupancy Rate	0.930	0.930	0.772
Share Foreign born	0.376	0.381	0.592
Other			
Walkscore	74.9	77.2	0.056
Closest Neighbor Allowed Open	0.326	0.354	0.514

The p-value is for a two-sided test of differences in means for dispensaries ordered to close vs. allowed to remain open. We compare crime counts in radii of 1 and 1/3 mile around dispensaries in the 10 days prior to June 7, 2010. Zip Code characteristics are from the 2010 Census and the 2011 American Community Survey. Walkscores are from walkscore.com and are matched to dispensaries by exact address. Walkscore.com categorizes its scores as followss: (1) 0-49 = Car Dependent; (2) 50-69= Somewhat Walkable; (3) 70-89 = Very Walkable and (4) 90-100 = Walker's Paradise.

Table 2. Effect of Dispensary closures on Total Part 1 crime

		Treatment of Defiant Dispensaries		
Radius (miles)	Pre-closure Mean	Intent to Treat	Recoded	Dropped
1/8	0.097	0.206*	0.207*	0.213+
		(0.1)	(0.097)	(0.115)
1/4	0.286	0.128+	0.150*	0.137*
		(0.068)	(0.063)	(0.068)
1/3	0.466	0.112*	0.131*	0.121*
		(0.053)	(0.057)	(0.055)
1/2	0.938	0.0341	0.073	0.047
		(0.042)	(0.031)	(0.043)
1	3.12	-0.004	0.004	-0.001
		(0.026)	(0.017)	(0.026)
2	10.6	-0.011	-0.008	-0.010
		(0.014)	(0.01)	(0.013)
N	4170	11940	11940	11760

Notes: + $p<0.10$, * $p<0.05$, ** $p<0.01$.

Pre-closure means are for crime around dispensaries ordered to close at each distance are shown in col (1). All other cols show point estimates from Poisson regression models. Standard errors, shown in parenthesis, allow for twoway clustering by dispensary and by date. All regressions include date and dispensary fixed effects. We include 10 days of data pre and post-closure but drop the actual closure date. To handle dispensaries known to be defiant col (2) does nothing and estimates the intent to treat, col (3) recodes dispensaries known to be defiant and col (4) drops known defiers.

Table 3. Placebo Checks of Dispensary closures on Total Part 1 crime

	Dispensaries			
	Period Relative to June 7th Closure Orders			
Radius (miles)	Actual	-1 month	-2 months	- 3 months
1/8	0.206*	-0.086	0.093	0.105
	(0.1)	(0.142)	(0.106)	(0.137)
1/4	0.128+	-0.034	0.078	-0.045
	(0.068)	(0.077)	(0.067)	(0.076)
1/3	0.112*	-0.039	0.008	-0.037
	(0.053)	(0.043)	(0.053)	(0.047)
1/2	0.0341	-0.028	0.076+	-0.050+
	(0.042)	(0.020)	(0.044)	(0.026)
1	-0.004	0.004	0.014	-0.001
	(0.026)	(0.015)	(0.024)	(0.014)
2	-0.011	.0126+	0.000	0.003
	(0.014)	(0.007)	(0.011)	(0.01)
N	11940	11940	11940	11940

Notes: + p<0.10, * p<0.05, ** p<0.01.

The table shows point estimates from Poisson regression models. Standard errors, shown in parenthesis, allow for twoway clustering by dispensary and by date. All regressions include date and dispensary fixed effects. Column (1) is from Table 2. It shows our main results for the June 7th closure orders. Placebo results are in colums 2 - 4. Column 2 assumes a May 10 closure date; column 3 assumes an April 12 closure date and column 4 a March 15 closure data. In all cases, we drop the data from the closure day (actual or placebo) and use 10 days of data on either side of thise date.

Table 4. Effect of Dispensary Closures by Crime Type

	Radius Around Dispensaries (miles)					
	1/8	1/4	1/3	1/2	1	2
Property	0.209+	0.107	0.112*	0.050	-0.005	-0.018
	(0.113)	(0.07)	(0.05)	(0.034)	(0.022)	(0.014)
Burglary	-0.518+	0.106	0.160	0.006	-0.013	-0.056*
	(0.284)	(0.199)	(0.195)	(0.142)	(0.053)	(0.022)
Auto Theft	0.617	-0.071	0.061	-0.072	-0.036	0.016
	(0.509)	(0.318)	(0.2)	(0.136)	(0.065)	(0.029)
Larceny	0.288+	0.145	0.126*	0.091*	0.002	-0.017
	(0.159)	(0.09)	(0.063)	(0.052)	(0.033)	(0.023)
Thefts from Vehicle	0.712*	0.241+	0.224+	0.106	-0.014	-0.003
	(0.318)	(0.128)	(0.123)	(0.101)	(0.044)	(0.028)
Theft	N/A	0.080	0.057	0.079	0.016	-0.030
		(0.13)	(0.078)	(0.067)	(0.035)	(0.024)
Violent	0.188	0.177	0.099	-0.024	0.002	0.020
	(0.274)	(0.162)	(0.147)	(0.106)	(0.062)	(0.035)
Agg. Assault	N/A	0.257	0.200	-0.130	-0.014	-0.000
		(0.245)	(0.241)	(0.166)	(0.083)	(0.065)
Robbery	N/A	-0.001	-0.040	0.072	-0.004	0.030
		(0.214)	(0.194)	(0.126)	(0.088)	(0.042)
N	11940	11940	11940	11940	11940	11940

Notes: + $p<0.10$, * $p<0.05$, ** $p<0.01$.

The table shows point estimates from Poisson regression models as well as standard errors, in parenthesis, that allow for twoway clustering by dispensary and by date. All regressions include date and dispensary fixed effects. Standard errors allow for twoway clustering by dispensary and by date. Regressions are estimated using 10 days pre and post the June 7th closure orders. June 7th is not included in the sample. Arson is included in total property crime and rape and murder are included in total violent crime; we do not estimate separate count models for these 3 types of crimes because they are too rare to allow for convergence. Aggravated assault and robbery do not convege at 1/8 mile.

Table 5. Spatial Displacement of Crime due to Dispensary Closures

Crime Within Rings of...	1/4-1/3	1/3-1/2	1/2-1	1/2-2	1-2
All Part 1	0.080	-0.036	-0.019	-0.015	-0.014
	(0.115)	(0.065)	(0.029)	(0.014)	(0.014)
Property	0.120	-0.010	-0.028	-0.025+	-0.023
	(0.117)	(0.06)	(0.025)	(0.014)	(0.015)
Violent	-0.085	-0.149	0.014	0.024	0.028
	(0.188)	(0.126)	(0.085)	(0.037)	(0.048)
N	11940	11940	11940	11940	11940

Notes: + $p<0.10$, * $p<0.05$, ** $p<0.01$.

The table shows point estimates from Poisson regression models as well as standard errors, in parenthesis, that allow for twoway clustering by dispensary and by date. All regressions include date and dispensary fixed effects. Standard errors allow for twoway clustering by dispensary and by date. Regressions are estimated using 10 days pre and post the June 7th closure orders. June 7th is not included in the sample.

Table 6. Effect of restaurant closures on Total Part 1 crime

		Restaurants Treatment of Missing Re-Open Date		
Radius (miles)	Pre-closure Mean	Use Median Closure Period	Assume Ongoing Closure	Drop Those with Missings
1/4	0.234	0.061 (0.063)	0.013 (0.053)	0.003 (0.043)
1/3	0.331	0.110* (0.045)	0.094* (0.038)	0.094+ (0.049)
1/2	0.803	0.053* (0.027)	0.052+ (0.027)	0.050 (0.031)
1	2.75	0.000 (0.018)	0.013 (0.015)	-0.003 (0.02)
2	9.52	0.014 (0.01)	0.002 (0.009)	0.018 (0.011)
N	8880	17760	17760	14600

Notes: + $p<0.10$, * $p<0.05$, ** $p<0.01$.

Pre-closure means are for crime at each distance are shown in col (1). The table shows point estimates from Poisson regression models. Standard errors, shown in parenthesis, allow for twoway clustering by restaurnt and by date. All regressions include date and business fixed effects. Standard errors allow for twoway clustering by business and by date. We include 10 days pre and post-closure. To handle missing reopen dates, col (2) codes them as closed through the rest of the sample period, col (3) uses the median number of days closed and col (4) drops these cases. Poisson regression for restaurants for distance of <1/8 mile do not converge.

Table 7. Effect of Restaurant Closures by Crime Type

	Radius Around Restaurants (miles)				
	1/4	1/3	1/2	1	2
Property	0.082	0.096+	0.046	0.000	0.018
	(0.07)	(0.051)	(0.028)	(0.02)	(0.011)
Burglary	0.021	-0.038	0.007	-0.031	0.039
	(0.196)	(0.139)	(0.097)	(0.05)	(0.024)
Auto Theft	-0.008	0.038	0.024	-0.011	0.007
	(0.208)	(0.156)	(0.103)	(0.042)	(0.025)
Larceny	0.096	0.128*	0.067+	0.012	0.016
	(0.08)	(0.064)	(0.038)	(0.026)	(0.015)
Thefts from Vehicle	0.255*	0.227*	0.100	0.007	0.007
	(0.124)	(0.096)	(0.066)	(0.04)	(0.022)
Theft	0.012	0.054	0.050	0.022	0.024
	(0.105)	(0.086)	(0.055)	(0.032)	(0.018)
Violent	0.001	0.157	0.078	-0.002	0.004
	(0.146)	(0.101)	(0.067)	(0.039)	(0.018)
Agg. Assault	-0.209	0.181	0.016	-0.007	-0.026
	(0.228)	(0.166)	(0.127)	(0.068)	(0.03)
Robbery	N/A	N/A	0.097	-0.005	0.026
			(0.084)	(0.05)	(0.026)
N	17760	17760	17760	17760	17760

Notes: + $p<0.10$, * $p<0.05$, ** $p<0.01$.

The table shows point estimates from Poisson regression models. Standard errors, shown in parenthesis, allow for twoway clustering by restaurant and by date. All regressions include date and restaurant fixed effects.. The regressions us e10 days of datat pre and post-closure. We use the median number of days closed to handle missing reopen dates. Poisson regression for restaurants for distance of <1/8 mile do not converge. Robbery does not converage at 1/4 or 1/3 of a mile. While arson is included in property crime and rape and murder are included in violent cime counts, these crimes are too few to separately estimate changes due to business closures.

Table 8. Spatial Displacement of Crime due to Restaurant Closures

Panel A: Spatial Displacement	1/4-1/3	1/3-1/2	1/2-1	1/2-2	1-2
All Part 1	0.172*	0.002	-0.021	0.011	0.020+
	(0.086)	(0.041)	(0.023)	(0.011)	(0.012)
Property	0.109	0.005	-0.018	0.016	0.025+
	(0.096)	(0.043)	(0.027)	(0.012)	(0.013)
Violent	N/A	0.007	-0.038	-0.004	0.005
		(0.103)	(0.103)	(0.021)	(0.023)
N	17760	17760	17760	17760	17760

Notes: + p<0.10, * p<0.05, ** p<0.01.

Notes: The table shows point estimates from Poisson regression models. Standard errors, shown in parenthesis, allow for twoway clustering by business and by date. All regressions include date and restaurant fixed effects. We include 10 days pre and post-closure. We use the median number of days closed to handle restaurants with no reopen date.

Table 9. Temporal Displacement of Crime at 1/3 Mile around Restaurant Closures

	All	Property			Violent
		All	Larceny	Vehicle	All
closed	0.111*	0.096+	0.128*	0.233*	0.161
	(0.045)	(0.052)	(0.065)	(0.1)	(0.099)
re-open	0.034	-0.006	0.063	-0.005	0.157
	(0.061)	(0.081)	(0.093)	(0.176)	(0.12)
re-open + 1	-0.021	0.002	-0.058	0.086	-0.113
	(0.062)	(0.083)	(0.097)	(0.153)	(0.127)
N	17760	17760	17760	17760	17760

Notes: + p<0.10, * p<0.05, ** p<0.01.

Notes: The table shows point estimates from Poisson regression models. Standard errors, shown in parenthesis, allow for twoway clustering b ybusiness and by date. For both datasets - restaurants and dispensaries - we include 10 days pre and post-closure. We use the median number of days closed to handle restaurants with no reopen date. For dispensary regressions, we exclude June 7 from the data. Re-open and re-open + 1 are dummies equal to one on the day a restaurant is allowed to re-open and the day after a restaurant is allowed to re-open respectively.

Table 10. Dispensary or Restaurant Closures and Walkscores: Crime at 1/3 of a Mile Around Establishments

Panel A: Dispensary Closures

	Part I Crime		Property			Violent
			Total Property	Larceny	Theft from Vehicle	Total Violent
Closed (Low Walk Score)	0.194*		0.180+	0.285*	0.367+	0.284
	(0.083)		(0.094)	(0.106)	(0.203)	(0.236)
Closed (High Walk Score)	0.083		0.091	0.085	0.176	0.022
	(0.069)		(0.058)	(0.071)	(0.146)	(0.157)
Closed * Car-dependent		-0.063				
		(0.197)				
Closed * Somewhat Walkable		0.233*				
		(0.092)				
Closed * Very Walkable		0.104				
		(0.077)				
Closed * Walker's Paradise		0.042				
		(0.11)				
N	11940	11940	11940	11940	11940	11940

Panel B: Restaurant Closures

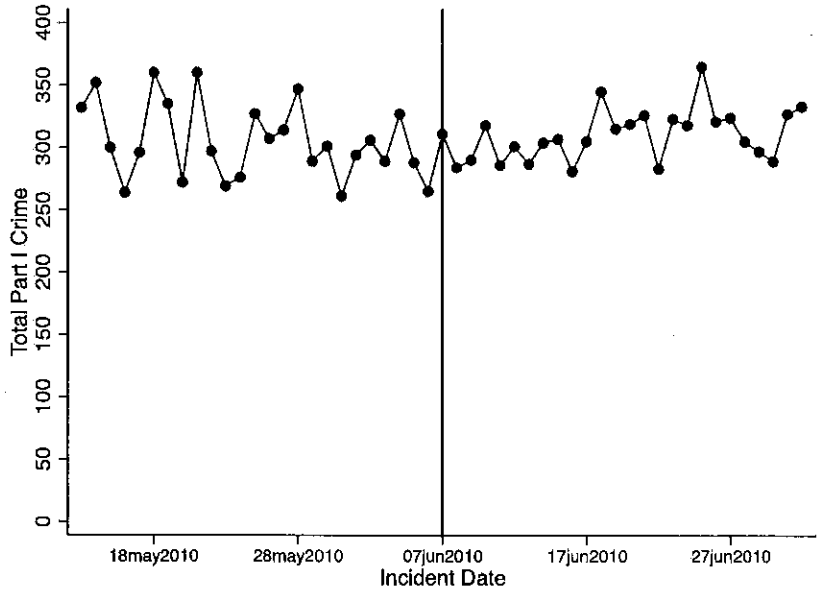
	Part I Crime		Property			Violent
			Total Property	Larceny	Theft from Vehicle	Total Violent
Closed * Low Walk Score	0.187+		0.180	0.347*	0.513*	0.194
	(0.103)		(0.114)	(0.152)	(0.212)	(0.207)
Closed * High Walk Score	0.083		0.068	0.071	0.135	0.141
	(0.051)		(0.056)	(0.069)	(0.108)	(0.155)
Closed * Car-dependent		-0.155				
		(0.241)				
Closed * Somewhat Walkable		0.244*				
		(0.114)				
Closed * Very Walkable		0.084				
		(0.069)				
Closed * Walker's Paradise		0.082				
		(0.073)				
N	17760	17760	17760	17760	17760	17760

Notes: + p<0.10, * p<0.05, ** p<0.01.

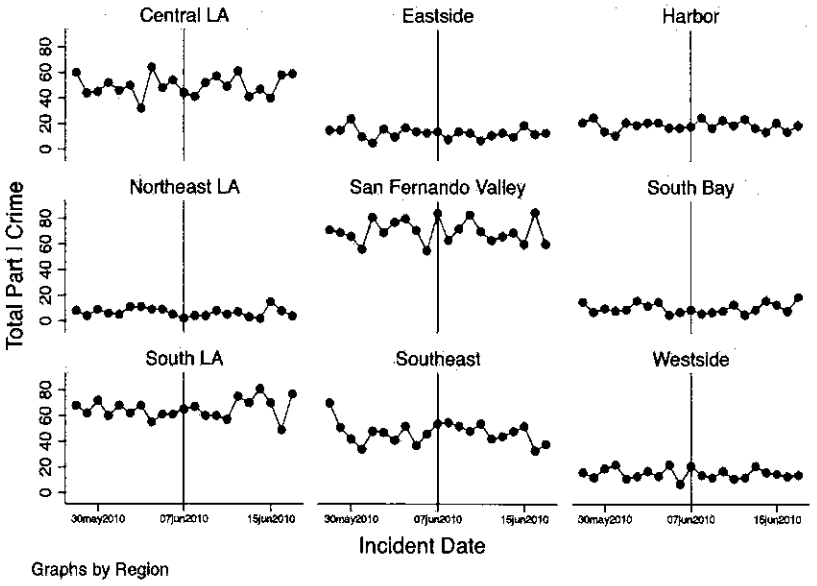
Notes: The table shows point estimates from Poisson regression models. Standard errors, shown in parenthesis, allow for twoway clustering by business and by date. For both datasets - restaurants and dispensaries - we include 10 days pre and post-closure. We use the median number of days closed to handle restaurants with no reopen date. For dispensary regressions, we exclude June 7 from the data. Low Walk Scores are those that are defined as either "Car-dependent" or "Somewhat Walkable", while High Walk Scores are those defined as "Very Walkable" and "Walker's Paradise". Dividing the sample into businesses above and below the median Walk Score generate qualitatively similar results.

Online Appendix

Appendix Figure 1a. Trends in Part I Crimes

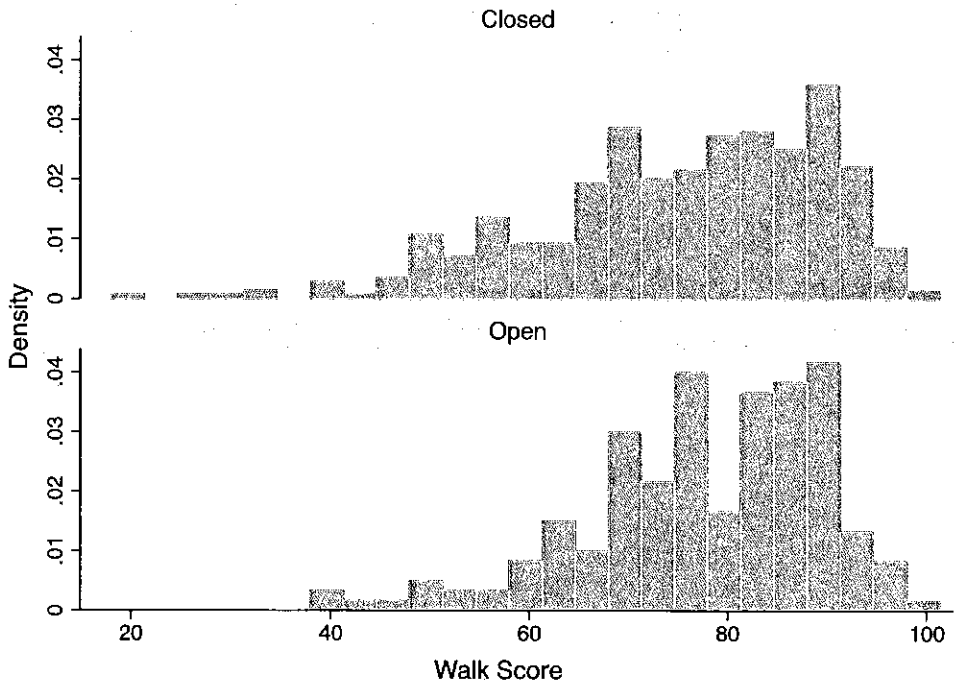


Appendix Figure 1b. Trends in Part I Crimes by Region



Notes: Data are from the LA Times Crime L.A. Project. The overall trends are restricted to the regions, as defined here http://maps.latimes.com/neighborhoods/, listed in Figure 1b. Excluded are crimes committed in the Angeles Forest, Antelope Valley, Northwest County, Pomona Valley, San Gabriel Valley, Santa Monica Mountains, Verdugos. We excluded them based on proximity to city dispensaries.

Appendix Figure 2. Distribution of Walk Scores by Dispensary Closure Orders



Notes: The figure above plots the distribution of Walk Scores by exact dispensary address for those dispensaries ordered to close (top panel) and those dispensaries allowed to remain open.

Appendix Table 1. Timeline of Events Impacting Medical Marijuana Dispensaries in Los Angeles

Date	Law/Event	Key Details
14-Dec-06	LAPD fact sheet released	Details the explosion of medical marijuana dispensaries in the City of Los Angeles, shows statistics to support the view that the dispensaries increase crime, and recommends a moratorium on new dispensaries and regulations for existing dispensaries
14-Sep-07	ICO:L.A. Ordinance 179027	Placed a temporary moratorium on the opening of new medical marijuana dispensaries in the City of Los Angeles. Allows for a hardship exemption.
13-Nov-07	ICO registration deadline	Deadline for dispensary registration under the ICO
24-Jun-09	ICO amended via L.A. Ordinance 180749	Eliminates hardship exemption
26-Jan-10	L.A. Ordinance 181069 to regulate medical marijuana collectives passes	Caps the number of dispensaries at 70. Allows dispensaries in excess of 70 to remain operational provided that they comply with the ICO and abide by new requirements. Dispensaries must be geographically distributed across L.A. community plan areas in proportion to the population; must be at least 1,000 feet from "sensitive use" buildings, such as schools and parks; and must not be located on a lot "abutting, across the street or alley from, or having a common corner with a residentially zoned area."
7-Jun-10	L.A. Ordinance 181069, Chapter IV, Article 5.1, takes effect	The city shuts down the more than 400 dispensaries that had not registered by November 13, 2007. Offenders face civil penalties of $2,500 per day and may receive up to six months in jail . The remaining dispensaries have 180 days to comply with the new zoning requirements, which, in many cases, means moving.
25-Aug-10	Villaraigosa memo	City states that 128 of the remaining 169 dispensaries must shut down because they had changes in management, which were precluded under the ICO. City allows these dispensaries to remain open until the courts can rule on the decision's legality.
24-Nov-10	Koretz-Hahn and other amendments to L.A. Ordinance 181069	City Council adopts amendments that clarify and effectively eliminate the "same ownership and management" requirements and extend the timeline for full compliance for "qualifying" dispensaries. Mayor has until December 6, 2010, to decide on the amendments.
10-Dec-10	Mohr injunction	Los Angeles County Superior Court Judge Anthony J. Mohr grants an injunction that bars the city from enforcing key aspects of L.A. Ordinance 181069, including closures based on the moratorium.
25-Jan-11	L.A. Ordinance 181530 takes effect	Amends L.A. Ordinance 181069 to cap the number of dispensaries at 100 among those continuously operating since September 14, 2007. Allocates permits by lottery.

SOURCES: Brown (2008), California Senate Bill 420 (2003), Compassionate Use Act of 1996, Council of the City of Los Angeles (2007), Council of the City of Los Angeles (2009), Council of the City of Los Angeles (2010), Hoeffel (2010a), Hoeffel (2010b), Hoeffel (2011d), Johnston and Lewis (2009), LACityClerk Connect (undated[b]), Lagmay (2010), and Los Angeles County Department of Regional Planning (2009), Los Angeles Police Department, Narcotics Division (2006), and United States Department of Justice (2009).

Appendix Table 2. Alternative Models of the Effect of Dispensary Closures on Total Part 1 crime

	Negative Binomial			Zero-inflated Poisson		
	Treatment of Defiant Dispensaries			Treatment of Defiant Dispensaries		
Radius (miles)	ITT	Recoded	Dropped	Ongoing	Recoded	Dropped
1/8	0.206+	--	--	0.205+	0.217+	0.216+
	(0.109)			(0.111)	(0.127)	(0.119)
1/4	0.127+	0.150*	0.137*	0.130+	0.156*	0.141*
	(0.068)	(0.063)	(0.067)	(0.07)	(0.066)	(0.070)
1/3	0.114*	0.134*	0.123*	0.116*	0.135*	0.123*
	(0.055)	(0.057)	(0.056)	(0.054)	(0.057)	(0.056)
1/2	0.036	0.073	0.049	0.038	0.071	0.049
	(0.042)	(0.046)	(0.043)	(0.041)	(0.044)	(0.042)
1	-0.005	0.004	-0.002	--	--	-0.001
	(0.027)	(0.026)	(0.026)			(0.026)
2	-0.011	-0.008	-0.010	-0.011	-0.009	-0.010645
	(0.014)	(0.013)	(0.013)	(0.013)	(0.012)	0.0132143
N	11940	11940	11760	11940	11940	11760

Notes: + $p<0.10$, * $p<0.05$, ** $p<0.01$.

Models in the first three columns are negative binomial and in the last three are zero-inflated poisson models. All regressions include date and business fixed effects. Standard errors allow for twoway clustering by business and by date. For both datasets - restaurants and dispensaries - we include 10 days pre and post-closure. To handle dispensaries known to be defiant cols (1) and (4) do nothing and estimate the intent to treat, cols (2) and (5) recode dispensaries known to be defiant and cols (3) and (6) drop known defiers. Negative Binomial Regressions do not converge at 1/8 mile if we recode or drop defiers (col(2) or col(3)). Zero-inflated Poisson models don't converge at 1 mile in the intent to treat and the recoded analysises (col(4) and col(5)).

Appendix Table 3. Effect of lengthening the study window to 60 Days

	Total Part I Crimes		
Radius (miles)	Days 1-10	Days 11-20	Days 21-30
1/8	0.263**	0 .048	0.146
	(0.09)	(0.114)	(0.145)
1/4	0.115+	0.057	-0.052
	(0.059)	(0.043)	(0.054)
1/3	0.089*	0.054+	-0.005
	(0.042)	(0.03)	(0.045)
1/2	0.024	0.014	0.004
	(0.026)	(0.028)	(0.027)
1	-0.003	-0.012	-0.001
	(0.018)	(0.021)	(0.012)
2	-0.003	-0.015	-0.010
	(0.012)	(0.014)	(0.011)

Notes: + $p<0.10$, * $p<0.05$, ** $p<0.01$.

All regressions include date and dispensary fixed effects and use 60 days of data -- 30 days on either side of June 7, 2010. The total number of observations in each regression is 35820 = 60 days * 597 dispensaries. Standard errors allow for twoway clustering by dispensary and by date. Within a crime category, each row represents a separate regression. For each crime, column (1) provides the coefficient on the first, column (2) the second and column (3) the third and last 10 days in the full 30 day post closure period.

Appendix Table 4. Effect of Dropping June 6-8 in Estimation of Closues on Total Part 1 crime

		Dispensaries Length of Window		
Radius (miles)	Pre-closure Mean	+/- 9 days	+/- 19 days	+/- 29 days
1/8	0.097	0.176	0.204+	0.230*
		(0.119)	(0.105)	(0.1)
1/4	0.286	0.145+	0.101+	0.130*
		(0.075)	(0.06)	(0.06)
1/3	0.466	0.144**	0.092**	0.105**
		(0.053)	(0.038)	(0.037)
1/2	0.938	.043156	.030805	.0341048
		(0.044)	(0.027)	(0.025)
1	3.12	-.0003429	.0043993	.0014057
		(0.028)	(0.021)	(0.02)
2	10.6	-.0123588	-.0009354	.0000517
		(0.015)	(0.012)	(0.012)
N	4170	10,746	22,686	34,626

Notes: + p<0.10, * p<0.05, ** p<0.01.

Pre-closure means are for crime around dispensaries ordered to close at each distance are shown in col (1). All other cols show point estimates from Poisson regression models. Standard errors, shown in parenthesis, allow for twoway clustering by dispensary and by date. All regressions include date and dispensary fixed effects. In all regressions, we drop the day of as well as the day before and day after the closure order took effect, i.e., June 6-Jun 8, 2010. In col (1), we include 9 days, in col (2) 19 and col (3) 29 days on either side of the closure orders. Thus, for the 597 dispensaries, col (1) captures 18 days (N=18*597=10746), col (2) 38 days (N=22686 = 38* 597) and col (3) 58 days (N=34626 = 58*597).

Appendix Table 5. Effect of limiting overlap - Total Part 1 crime

	Restricting to dispensaries with nearest neighbor more than…	
Radius (miles)	1/3 mile away	1/2 mile away
1/8	0.293	0.412
	(0.222)	(0.589)
1/4	0.382*	0.660*
	(0.178)	(0.319)
1/3	0.325**	0.491+
	(0.131)	(0.26)
1/2	0.196*	0.342
	(0.098)	(0.227)
1	0.035	0.045
	(0.049)	(0.094)
2	-0.006	0.023
	(0.024)	(0.033)
N	3160	1580

Notes: + p<0.10, * p<0.05, ** p<0.01.

All regressions include date and dispensary fixed effects. Standard errors allow for twoway clustering by business and by date. For both datasets - restaurants and dispensaries - we include 10 days pre and post-closure. Column (1) restricts to dispensaries with a nearest neighbor more than 1/3 of a mile away while column (2) restricts to dispensaires with a nearest neighbor more than 1/2 mile away.

Appendix Table 6. Pre-closure Summary Statistics for Dispensaries Ordered to Close

	Radius Around Dispensaries (miles)					
	1/8	1/4	1/3	1/2	1	2
Property	0.072	0.219	0.357	0.734	2.47	8.35
Burglary	0.011	0.032	0.052	0.111	0.418	1.47
Auto Theft	0.011	0.039	0.061	0.120	0.396	1.30
Larceny	0.050	0.148	0.243	0.502	1.65	5.58
Thefts from Vehicle	0.016	0.059	0.099	0.219	0.762	2.63
Theft	0.034	0.088	0.144	0.284	0.891	2.95
Violent	0.025	0.066	0.104	0.204	0.657	2.23
Agg. Assault	0.011	0.032	0.049	0.095	0.314	1.01
Robbery	0.013	0.031	0.048	0.096	0.306	1.08
Rape	0.0014	0.0026	0.0046	0.0094	0.0283	0.1053
Homicide	0.0002	0.0007	0.0014	0.0034	0.0084	0.0367
N	4170	4170	4170	4170	4170	4170

This table shows mean crime counts by type in the 10 days prior to June 7, 2010 for dispensaries ordered to close. Means are generally indistinguishable for those allowed to remain open.

Appendix Table 7. Effect of Dispensary Closures by Crime Type - Dropping Defiers

	Radius Around Dispensaries (miles)					
	1/8	1/4	1/3	1/2	1	2
All Part 1	0.213+	0.137*	0.121*	0.047	-0.001	-0.010
	(0.115)	(0.068)	(0.055)	(0.043)	(0.026)	(0.013)
Property	0.206+	0.110	0.116*	0.059+	-0.004	-0.017
	(0.114)	(0.069)	(0.051)	(0.034)	(0.022)	(0.014)
Burglary	-0.518+	0.102	0.117	0.013	-0.016	-0.057**
	(0.284)	(0.193)	(0.195)	(0.141)	(0.054)	(0.021)
Auto Theft	0.617	-0.072	0.069	-0.057	-0.031	0.022
	(0.509)	(0.324)	(0.204)	(0.139)	(0.067)	(0.031)
Larceny	0.281+	0.152+	0.126*	0.098+	0.003	-0.018
	(0.165)	(0.087)	(0.062)	(0.051)	(0.032)	(0.022)
Thefts from Vehicle	0.714*	0.241+	0.218+	0.111	-0.014	-0.004
	(0.323)	(0.128)	(0.123)	(0.101)	(0.044)	(0.027)
Theft	N/A	0.092	0.062	0.087	0.019	-0.030
		(0.132)	(0.076)	(0.064)	(0.034)	(0.024)
Violent	0.229	0.212	0.130	0.007	0.002	0.022
	(0.29)	(0.17)	(0.15)	(0.108)	(0.062)	(0.035)
Agg. Assault	N/A	0.279	0.235	-0.099	-0.012	-0.002
		(0.351)	(0.242)	(0.167)	(0.082)	(0.064)
Robbery	N/A	0.053	-0.007	0.105	0.014	0.034
		(0.215)	(0.197)	(0.131)	(0.088)	(0.042)
N	11760	11760	11760	11760	11760	11760

Notes: + p<0.10, * p<0.05, ** p<0.01.

All regressions include date and dispensary fixed effects. Standard errors allow for twoway clustering by dispensary and by date. Regressions are estimated using 10 days pre and post the June 7th closure orders. June 7th is not included in the sample and dispensaries known to have defied closure orders are dropped. Arson is included in total property crime and rape and murder are included in total violent crime; we do not estimate separate count models for these 3 types of crimes because they are too rate to allow for convergence. Theft, aggravated assault and robbery do not convege at 1/8 mile.

Appendix Table 8. Effect of Dispensary Closures by Crime Type with Defiers Recoded

	Radius Around Dispensaries (miles)					
	1/8	1/4	1/3	1/2	1	2
All Part 1	0.207+	0.150*	0.131*	0.073	0.004	-0.008
	(0.118)	(0.064)	(0.057)	(0.046)	(0.025)	(0.012)
Property	0.180	0.112+	0.116*	0.073*	-0.002	-0.016
	(0.111)	(0.065)	(0.051)	(0.035)	(0.022)	(0.014)
Burglary	-0.357	0.088	0.130	0.027	-0.021	-0.058**
	(0.301)	(0.173)	(0.189)	(0.134)	(0.054)	(0.019)
Auto Theft	0.479	-0.073	0.086	-0.019	-0.020	0.036
	(0.474)	(0.326)	(0.209)	(0.139)	(0.07)	(0.033)
Larceny	0.235	0.156*	0.117*	0.105*	0.004	-0.018
	(0.165)	(0.078)	(0.056)	(0.048)	(0.031)	(0.021)
Thefts from Vehicle	0.696**	0.235+	0.192	0.116	-0.017	-0.006
	(0.318)	(0.124)	(0.124)	(0.098)	(0.043)	(0.025)
Theft	-0.027	0.107	0.067	0.097*	0.023	-0.028
	(0.207)	(0.112)	(0.067)	(0.058)	(0.032)	(0.024)
Violent	0.308	0.277	0.196	0.079	0.034	0.025
	(0.311)	(0.179)	(0.153)	(0.115)	(0.064)	(0.033)
Agg. Assault	N/A	0.257	0.285	-0.005	0.026	0.020
		(0.329)	(0.231)	(0.163)	(0.082)	(0.057)
Robbery	0.043	0.164	0.068	0.176	0.052	0.043
	(0.276)	(0.219)	(0.197)	(0.145)	(0.088)	(0.041)
N	11940	11940	11940	11940	11940	11940

Notes: + $p<0.10$, * $p<0.05$, ** $p<0.01$.

All regressions include date and dispensary fixed effects. Standard errors allow for twoway clustering by dispensary and by date. Regressions are estimated using 10 days pre and post the June 7th closure orders. June 7th is not included in the sample. Dispensaries known to have defied closure orders are recoded as open. Arson is included in total property crime and rape and murder are included in total violent crime; we do not estimate separate count models for these 3 types of crimes because they are too rate to allow for convergence. Aggravated assault do not convege at 1/8 mile.

Appendix Table 9. Effect of Dispensary Closures by Crime Type including Closure Date

	Radius Around Dispensaries (miles)					
	1/8	1/4	1/3	1/2	1	2
All Part 1	0.163	0.101	0.094+	0.021	-0.007	-0.009
	(0.109)	(0.07)	(0.054)	(0.042)	(0.025)	(0.013)
Property	0.193+	0.081	0.099+	0.033	-0.012	-0.017
	(0.109)	(0.071)	(0.052)	(0.037)	(0.023)	(0.014)
Burglary	-0.484+	0.066	0.072	-0.008	-0.005	-0.043+
	(0.285)	(0.199)	(0.194)	(0.137)	(0.052)	(0.024)
Auto Theft	0.484	-0.118	0.019	-0.084	-0.037	0.017
	(0.459)	(0.302)	(0.193)	(0.132)	(0.063)	(0.029)
Larceny	0.273+	0.128	0.125*	0.070	-0.009	-0.021
	(0.156)	(0.086)	(0.063)	(0.051)	(0.033)	(0.022)
Thefts from Vehicle	0.657*	0.217+	0.240*	0.099	-0.013	-0.032
	(0.303)	(0.123)	(0.116)	(0.091)	(0.041)	(0.026)
Theft	0.027	0.066	0.045	0.048	-0.005	-0.028
	(0.227)	(0.125)	(0.074)	(0.068)	(0.041)	(0.024)
Violent	0.015	0.139	0.081	0.021	0.013	0.026
	(0.294)	(0.159)	(0.135)	(0.099)	(0.059)	(0.063)
Agg. Assault	N/A	0.193	0.181	-0.106	0.018	0.020
		(0.31)	(0.221)	(0.158)	(0.082)	(0.057)
Robbery	N/A	-0.018	0.054	0.059	-0.011	0.026
		(0.2)	(0.172)	(0.114)	(0.08)	(0.04)
N	12537	12537	12537	12537	12537	12537

Notes: + $p<0.10$, * $p<0.05$, ** $p<0.01$.

All regressions include date and dispensary fixed effects. Standard errors allow for twoway clustering by dispensary and by date. Regressions are estimated using 10 days pre and post the June 7th closure orders. June 7th is not included in the sample. Dispensaries known to have defied closure orders are recoded as open. Arson is included in total property crime and rape and murder are included in total violent crime; we do not estimate separate count models for these 3 types of crimes because they are too rare to allow for convergence. Aggravated assault and robbery do not convege at 1/8 mile.

Appendix Table 10. Restaurant Summary Statistics

	Restaurants, 10-days pre-closure
Daily Crimes	
Part I Crimes < 1 Mile	2.75
Part I Property Crime <1 Mile	2.08
Part I Violent Crime < 1 Mile	0.674
Part I Crimes < 1/3 Mile	0.383
Part I Property Crime <1/3 Mile	0.285
Part I Violent Crime < 1/3 Mile	0.098
Daily Part I subcategories < 1/3 mile	
Aggravated assault	0.042
Auto Theft	0.048
Burglary	0.043
Homicide	0.0015
Rape	0.0030
Robbery	0.051
Larceny Theft	0.194
Theft	0.119
Theft from Vehicles	0.074
Zip Code Characteristics	
Population	44040
Households	13579
Median Household Income	50472
Median Age	34.6
Occupancy Rate	0.939
Share Foreign born	0.403
Other	
Walkscore	71.1
Closest Neighbor Allowed Open	N/A

Appendix Table 11. Restaurant Closure Placebo Checks

	Placebo based on Actual Closure Length			Placebo Based on Fixed Periods	
Radius (miles)	Assume Ongoing Closure	Use Median Closure Period	Drop Those with Missings	1 day prior	2 days prior
1/4	0.020	-0.003	0.013	-0.090	-0.006
	(0.054)	(0.052)	(0.061)	(0.09)	(0.065)
1/3	-0.007	-0.043	-0.012	-0.076	-0.009
	(0.043)	(0.042)	(0.05)	(0.074)	(0.05)
1/2	0.021	0.003	0.027	-0.007	0.020
	(0.032)	(0.031)	(0.035)	(0.051)	(0.035)
1	-0.004	-0.013	-0.003	-0.030	0.006
	(0.017)	(0.015)	(0.018)	(0.023)	(0.019)
2	-0.001	0.004	-0.006	0.001	-0.001
	(0.009)	(0.008)	(0.009)	(0.012)	(0.01)
N	17760	17760	14600	17760	17760

Notes: + p<0.10, * p<0.05, ** p<0.01.

All regressions include date and business fixed effects. Standard errors allow for twoway clustering by business and by date. Placebo closures indicators reverse the date of closures around the closure date. That is if a restaurant was closed for 2 days (the median closure length), then the placebo closure would be a dummy equal to one for the to days prior to the restaurant closure. Cols (2)-(4) use actual closure periods but vary in how they treat missing reopen dates. Cols (5) and (6) use fixed pre-closure periods.

Appendix Table 12. Effect of lengthening the study window - Total Part 1 crime

	Restaurant Closures		
Radius (miles)	+/-15 days	+/-20 days	+/-30 days
1/4	0.045	0.018	0.016
	(0.057)	(0.056)	(0.054)
1/3	0.094*	0.043	0.073+
	(0.042)	(0.047)	(0.041)
1/2	0.051+	0.032	0.044+
	(0.026)	(0.025)	(0.026)
1	0.001	-0.004	-0.005
	(0.016)	(0.015)	(0.016)
2	0.012	0.007	0.006
	(0.009)	(0.008)	(0.008)
N	26573	36696	52031

Notes: + p<0.10, * p<0.05, ** p<0.01.

All regressions include date and restaurant fixed effects. Standard errors allow for twoway clustering by restaurant and by date. We include either 15, 20 or 30 days on either side of the closure period (in contrast to the 10 on either side in the main tables). To handle missing reopen dates, we use the median number of days closed. Poisson regression for restaurants for distance of <1/8 mile do not converge.

Appendix Table 13. Effect of Restaurant Closures by Crime Type including Closure Date

	Radius Around Restaurants				
	1/4	1/3	1/2	1	2
All	0.040	0.082*	0.037	-0.004	0.008
	(0.051)	(0.037)	(0.024)	(0.015)	(0.008)
Property	0.066	0.098*	0.029	-0.000	0.013
	(0.059)	(0.043)	(0.026)	(0.018)	(0.009)
Burglary	0.114	0.031	-0.016	-0.020	0.026
	(0.162)	(0.11)	(0.077)	(0.041)	(0.019)
Auto Theft	0.109	0.149	0.040	-0.006	0.017
	(0.165)	(0.119)	(0.076)	(0.035)	(0.02)
Larceny	0.046	0.093+	0.044	0.009	0.009
	(0.068)	(0.052)	(0.035)	(0.022)	(0.012)
Thefts from Vehicle	0.141	0.169*	0.039	0.015	0.013
	(0.106)	(0.078)	(0.054)	(0.033)	(0.019)
Theft	-0.005	0.047	0.055	0.008	0.005
	(0.09)	(0.073)	(0.048)	(0.027)	(0.014)
Violent	-0.047	0.043	0.075	-0.015	-0.007
	(0.122)	(0.085)	(0.054)	(0.03)	(0.014)
Agg. Assault	N/A	0.052	0.064	-0.017	-0.045*
		(0.128)	(0.101)	(0.052)	(0.024)
Robbery	N/A	0.029	0.079	-0.016	0.029
		(0.123)	(0.073)	(0.038)	(0.022)
N	18648	18648	18648	18648	18648

Notes: + p<0.10, * p<0.05, ** p<0.01.

All regressions include date and restaurant fixed effects. Standard errors allow for twoway clustering by restaurant and date. The regressions use 10 days of data pre and post-closure. We also include the closure date even though the restaurant may have closed for only part of the day. We use the median number of days closed to handle missing reopen dates. Poisson regression for restaurants for distance of <1/8 mile do not converge. Robbery does not converage at 1/4 or 1/3 of a mile. While arson is included in property crime and rape and murder are included in violent cime counts, these crimes are too few to separately estimate changes due to business closures.

Appendix Table 14. Effect of Restaurant Closures by Crime Type with Missing Reopen Dates Coded as Continued Closure

	Radius Around Restaurants				
	1/4	1/3	1/2	1	2
All Part 1	0.061	0.110**	0.053**	0.000	0.014
	(0.063)	(0.045)	(0.027)	(0.018)	0.01
Property	-0.003	0.063	0.036	0.012	0.007
	(0.058)	(0.042)	(0.031)	(0.017)	(0.009)
Burglary	-0.185	-0.089	-0.022	-0.029	0.002
	(0.185)	(0.132)	(0.088)	(0.043)	(0.024)
Auto Theft	-0.007	0.110	0.056	0.004	-0.007
	(0.16)	(0.114)	(0.083)	(0.04)	(0.02)
Larceny	0.028	0.086	0.051	0.022	0.013
	(0.068)	(0.054)	(0.037)	(0.022)	(0.013)
Thefts from Vehicle	0.092	0.126	0.054	0.025	0.009
	(0.118)	(0.091)	(0.064)	(0.035)	(0.019)
Theft	-0.026	0.036	0.044	0.021	0.016
	(0.089)	(0.072)	(0.05)	(0.028)	(0.016)
Violent	0.100	0.201**	0.100*	0.014	-0.015
	(0.115)	(0.086)	(0.06)	(0.034)	(0.014)
Agg. Assault	0.001	0.238*	0.146	0.026	-0.025
	(0.178)	(0.14)	(0.107)	(0.059)	(0.025)
Robbery	N/A	N/A	0.047	-0.017	-0.015
			0.072	0.042	0.02
N	17760	17760	17760	17760	17760

Notes: + p<0.10, * p<0.05, ** p<0.01.

All regressions include date and restaurant fixed effects. Standard errors allow for twoway clustering by restaurant and by date. The regressions us 10 days of data pre and post-closure. We treat restaurants with missing re-open dates as permanently closed. Poisson regression for restaurants for distance of <1/8 mile do not converge. Robbery does not converage at 1/4 or 1/3 of a mile. While arson is included in property crime and rape and murder are included in violent cime counts, these crimes are too few to separately estimate changes due to business closures. Restaurants with missing reopen dates are coded as closed for the full post-closure observation period.

Appendix Table 15. Effect of Restaurant Closures by Crime Type, Dropping Restaurants with Missing Reopen Dates

	Radius Around Restaurants				
	1/4	1/3	1/2	1	2
All Part 1	0.000	0.084**	0.047*	-0.007	0.010
	(0.054)	(0.041)	(0.027)	(0.016)	(0.008)
Property	0.008	0.081*	0.032	-0.002	0.015
	(0.06)	(0.047)	(0.028)	(0.018)	(0.011)
Burglary	-0.101	-0.055	-0.043	-0.044	0.017
	(0.174)	(0.128)	(0.086)	(0.046)	(0.021)
Auto Theft	0.078	0.021*	0.046	-0.001	0.018
	(0.168)	(0.12)	(0.081)	(0.038)	(0.023)
Larceny	0.014	0.076	0.056	0.014	0.014
	(0.073)	(0.058)	(0.037)	(0.023)	(0.014)
Thefts from Vehicle	0.072	0.124	0.008	0.019	0.023
	(0.114)	(0.088)	(0.06)	(0.036)	(0.022)
Theft	-0.002	0.057	0.100**	0.015	0.006
	(0.1)	(0.081)	(0.05)	(0.03)	(0.016)
Violent	-0.027	0.096	0.106*	-0.024	-0.000
	(0.131)	(0.097)	(0.061)	(0.036)	(0.016)
Agg. Assault	N/A	N/A	0.089	-0.033	-0.028
			(0.113)	(0.058)	(0.028)
Robbery	N/A	0.101	0.121	-0.017	0.027
		(0.132)	(0.077)	(0.043)	(0.023)
N	15330	15330	15330	15330	15330

Notes: + p<0.10, * p<0.05, ** p<0.01.

All regressions include date and restaurant fixed effects. Standard errors allow for twoway clustering by restaurant and by date. The regressions us 10 days of data pre and post-closure. We drop restaurants that are missing reopen dates. Poisson regression for restaurants for distance of <1/8 mile do not converge. Robbery does not converage at 1/4 or 1/3 of a mile. While arson is included in property crime and rape and murder are included in violent cime counts, these crimes are too few to separately estimate changes due to business closures. Restaurants with missing reopen dates are excluded from the analysis.

Appendix Table 16. Dispensary or Restaurant Closures and Employee Density: Crime at 1/3 of a Mile Around Establishments

Panel A: Dispensary Closures					
	Part I Crime	Total Property	Larceny	Theft from Vehicle	Total Violent
Closed below median density)	0.128	0.21**	0.229	0.265**	-.164
	(0.078)	(0.087)	(0.125)	(0.107)	(0.275)
Closed (above median density)	0.094	0.049	0.064	0.183**	.289
	(0.08)	(0.06)	(0.079)	(0.065)	(0.202)
N	11900	11900	11900	11900	11900
Panel B: Restaurant Closures					
	Part I Crime	Total Property	Larceny	Theft from Vehicle	Total Violent
Closed below median density)	0.198*	0.195*	0.239+	0.17	0.109
	(0.087)	(0.087)	(0.137)	(0.144)	(0.181)
Closed (above median density)	0.048	0.050	0.088	0.261*	0.184
	(0.05)	(0.069)	(0.077)	(0.122)	(0.123)
N	15356	15356	15356	15356	15356

Notes: + p<0.10, * p<0.05, ** p<0.01.

Notes: The table shows point estimates from Poisson regression models. Standard errors, shown in parenthesis, allow for twoway clustering by business and by date. For both datasets - restaurants and dispensaries - we include 10 days pre and post-closure. We use the median number of days closed to handle restaurants with no reopen date. For dispensary regressions, we exclude June 7 from the data. To measure density, we use the number of employees per square mile in a dispensary or restaurant ZIP code.

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TENTH ANNIVERSARY

The Effect of Medical Marijuana Laws on Crime: Evidence from State Panel Data, 1990-2006

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Abstract

Background

Debate has surrounded the legalization of marijuana for medical purposes for decades. Some have argued medical marijuana legalization (MML) poses a threat to public health and safety, perhaps also affecting crime rates. In recent years, some U.S. states have legalized marijuana for medical purposes, reigniting political and public interest in the impact of marijuana legalization on a range of outcomes.

Methods

Relying on U.S. state panel data, we analyzed the association between state MML and state crime rates for all Part I offenses collected by the FBI.

Findings

Results did not indicate a crime exacerbating effect of MML on any of the Part I offenses. Alternatively, state MML *may* be correlated with a reduction in homicide and assault rates, net of other covariates.

Conclusions

These findings run counter to arguments suggesting the legalization of marijuana for medical purposes poses a danger to public health in terms of exposure to violent crime and property crimes.

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Introduction

The social ramifications of marijuana legalization have been hotly debated for at least four decades [1]. Despite a long history of marijuana use for medical purposes, policymakers and in some instances, the scientific community, have been quick to note the potential problematic social outcomes of marijuana legalization [2]. In spite of these political discussions, medical marijuana legalization (MML) has occurred in 20 states and the District of Columbia (between 1996 and the writing of this paper) and its recreational use has now been legalized in Colorado and Washington [3]. An interest in the ramifications of these laws has led to an increase in scholarly activity on the topic [4], [5]. The issue addressed in this article is whether MML has the effect of increasing crime. While there are many mechanisms by which MML might affect crime rates, the most obvious is by increasing the number of marijuana users, which may lead to a broader social acceptance of drug using behaviors and drug users [6]. To the extent that marijuana use serves as a "gateway" to harder drugs such as cocaine and heroin, MML could lead to long-term increases in crime as an ever-growing number of illicit drug users engage in serious predatory crimes to support their habits (but see [7]). But even if MML does not lead to a rise in marijuana use (especially among youth), the laws could still stimulate crime as newly opened medical marijuana dispensaries provide criminals with a highly attractive target with their repository of high quality marijuana and customers carrying large amounts of cash (but see [8]). As a member of the California Chiefs of Police Association stated, "A disturbing and continuing trend is the increasing number of home invasion robberies and associated violence resulting in the

Data on all seven Part I offenses—homicide, rape, robbery, assault, burglary, larceny, and auto theft—for each state between 1990 and 2006 were obtained from the Federal Bureau of Investigation's Uniform Crime Reporting (UCR) Program, published as *Crime in the United States*. The data were obtained using the "data for analysis" tool on the Bureau of Justice Statistics Web site (http://www.ojp.usdoj.gov/bjs/dtd.htm). All data were gathered for each of the 50 U.S. states across the 17 year time span for a total N=850. Values reflect the rate of each crime per 100,000 residents.

Medical Marijuana Legalization (MML).

To determine if and when MML occurred within a state, we searched the official legislative website of each US state. Between 1990 and 2006, the following 11 states legalized marijuana for medical use, with the year the law was passed in parentheses: Alaska (1998), California (1996), Colorado (2000), Hawaii (2000), Maine (1999), Montana (2004), Nevada (2000), Oregon (1998), Rhode Island (2006), Vermont (2004), and Washington (1998). We also ran models based on MML "legislation-effective year" rather than "legislation-passed year" and found no substantive differences in the results. The MML effective dates were also gathered from each State's official legislative website. Only 2 states (Connecticut and Colorado) had an MML effective year different than "passed" year, both being only a 1-year difference. While there are many options in modeling the effects of MML adoption on crime, we opted to use a post-law trend variable. The trend variable represents the number of years the law has been in effect with a value of zero for all years before the law was passed, a value of 1 for the year the law was passed, and a value of $1+k$, where k = number of years after the initial passage of the law, for all subsequent years. Unlike the traditional "dummy variable" approach (i.e., 0 = no MML law, 1 = MML law), which posits a once-and-for-all impact on crime, the post-law trend variable captures any changes in the linear trend of crime that may be observed over time. If opponents of MML are correct that the laws lead to increased marijuana use by teenagers, many of whom are likely to continue illicit hard drug use throughout their adulthood, one might expect a gradual increase in crime over time. Such an effect would be best captured by the post-law trend variable.

Sociodemographic Control Variables.

Sociodemographic variables were included in the analysis to aid in controlling for a vast array of other time-varying influences that might be potential confounding factors over the study period. These variables, and their sources, have been described previously [24]. Specifically, they include each state's percent of the civilian labor force unemployed; the total employment rate; percent of the population living below the poverty line; real per-capita income (divided by the Consumer Price Index); the proportion of residents aged 15–24; the proportion of residents aged 25–34, the proportion of residents aged 35–44 years; the per-capita rate of beer consumption [25]; the proportion of residents with at least a bachelor's degree; and the percent of the state's population that lived in a metropolitan area. State-level unemployment data were obtained from the Bureau of Labor Statistics website (www.bls.gov/sae/home). Data on poverty were acquired via the Bureau of the Census website (www.census.gov/hhes/www/poverty). Personal income and real welfare payments data were taken from the Bureau of Economic Analysis website (www.bea.doc.gov/bea/regional/reis). The age variables were obtained directly from the U.S. Bureau of the Census. Data on beer consumption were taken from the Beer Institute website (www.beerinstitute.org). The percent of the population with college degrees or higher and the percent of the population living in a metropolitan area are linear interpolations of decennial census data, as reported in various editions of the *Statistical Abstracts of the United States*.

Additional measures included the number of prison inmates per 100,000 residents and the number of police officers per 100,000 residents. The number of prisoners was measured as the number of prisoners sentenced to more than a year in custody as of December 31 per 100,000 residents and was obtained from the Bureau of Justice Statistic's website (www.ojp.usdoj.gov/bjs). Data on the total number of police, including civilians, were taken from the Public Employment series prepared by the Bureau of the Census. Louisiana and Mississippi were missing information on this variable for the year 2006, therefore reducing the usable case count by two units. Substantive results were identical when values for this year were imputed with values from the previous year. Summary statistics for these explanatory variables are presented in Table 1.

	Mean	SD
Dependent Variables (prior to log transformation)		
Homicide Rate	5.778	3.347
Rape Rate	36.774	13.212
Robbery Rate	130.346	91.687
Assault Rate	303.573	161.996
Burglary Rate	845.706	304.654
Larceny Rate	2,727.552	687.953
Auto Theft Rate	406.504	208.103
Independent Variable		
Medical Marijuana Law (Post-law Trend)	.393	1.489
Sociodemographic control variables		
Unemployment rate	5.162	1.393
Employment rate	58,568.89	5,043.444
Poverty rate	12.442	3.638
Real per-capita income	5.193	.844
Proportion persons ages 15 to 24	.142	.011
Proportion persons ages 25 to 34	.145	.017
Proportion persons ages 35 to 44	.156	.011
Beer shipments (31-gallon barrels) per 100k	73,670.89	12,003.72
Percent persons with college degree	23.897	4.903
Percent persons residing in metropolitan area	67.654	20.636
Prisoners per 100k	343.072	144.897
Police officers per 100k	278.473	48.917

Note: Descriptive statistics are for the 1990–2006 period. The data sources are noted in the text.
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Table 1. Summary Statistics.
https://doi.org/10.1371/journal.pone.0092816.t001

Analysis Plan

To identify the effect of MML on crime, we use a fixed-effects panel design, exploiting the within state variation introduced by the passage of MML in 11 states over the 17 year observation period. The design allows for the assessment of whether states adopting MML experienced changes in the trend of crime by analyzing within state changes in crime rates over time and comparing those changes to the crime rate trends among states that did not pass an MML law. To carry out this analysis, we estimate fixed-effects ordinary least squares regression models, where the natural log of each crime rate variable (i.e., homicide, rape, robbery, assault, burglary, larceny, and auto theft) is the dependent variable. This model directly accounts for dynamic factors that cause crime to vary from state to state, as well as those stable unmeasured factors that differ between states [26], [27]. In addition, we also include "year fixed-effects," which capture any national influences on crime that are not captured in any of the time-varying explanatory variables. Robust standard errors are clustered at the state level to avoid biased standard errors due to the non-independence of data points over time [28]. Thus, the fixed effects models can be expressed algebraically following the convention set forth by Wooldridge [27] as:

$$\log(\ddot{y}ijt) = bi0 + bi1\ddot{M}Ljt + \ldots + bik\ddot{x}jt + \ddot{e}it$$

where:

the subscripts *i*, *j*, and *t* are used to identify the crime rate variable being used as the dependent variable, the 50 states, and time (1990–2006), respectively;

$\log(\ddot{y}ijt)$ = the time-demeaned (see [27]) logged crime rate outcome variable;

$bi0$ = the crime-specific constant term;

$bi1\ddot{M}Ljt$ = the time-demeaned crime-specific average impact of MML on crime rates;

$+\ldots+bik\ddot{x}jt$ = the time-demeaned crime-specific effect of the various control variables, including year dummies, a linear trend variable, and state fixed effects;

and, $\ddot{e}it$ = the time-demeaned crime-specific error term.

It is important to note that fixed-effects models are not without limitations. While they are well suited to address the issue at hand and account for unobserved time-invariant factors, they are always vulnerable to time-varying factors that are not accounted for that differ between states with MML and those without. However, we have accounted for the bulk of factors that have been shown associated with state crime rates and our models explain a considerable amount of variation in each outcome. It is also important to acknowledge that fixed-effects models do not account for temporal ordering for time-varying predictors within a given observation period. For example, it is unknown whether states adopted MML after experiencing lower crime rates in a given year(s), however, this is unlikely to be an issue here since policy response to crime rates tend to take time and we account for this via operationalization of MML as an additive effect.

Results

Primary Findings

Before consulting the results from the fixed effects regression models, a series of unconditioned crime rates for each offense type were generated and are presented in Figure 1. Note that two crime rate trends are presented in each panel. One trend—the solid line—shows the crime rate, by year, for states that had *not* passed an MML law. Thus, states that eventually did pass an MML law contribute to the solid line up until the year that they passed the MML law. As expected from the overall crime trend during this time period, the solid line reveals that all states experienced a reduction in each of the seven crimes from 1990 to 2006. Important to note is the trend revealed by the dashed line, which shows the crime rate trends for states *after* passing an MML law. With one exception—forcible rape—states passing MML laws experienced reductions in crime and the rate of reduction appears to be steeper for states passing MML laws as compared to others for several crimes such as homicide, robbery, and aggravated assault. The raw number of homicides, robberies, and aggravated assaults also appear to be lower for states passing MML as compared to other states, especially from 1998–2006. These preliminary results suggest MML may have a crime-reducing effect, but recall that these are unconditional averages, meaning that the impact of the covariates and other factors related to time series trends have not been accounted for in these figures.

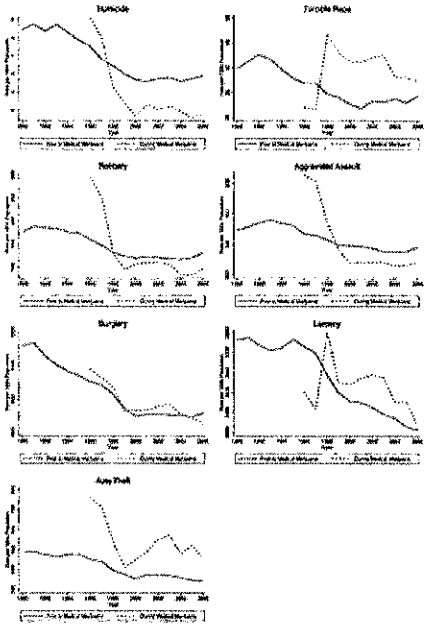

Figure 1. Mean State Crime Rates as a Function of Year, by Medical Marijuana Law (MML).
NOTE: Crime rates for states mandating MML after 1996 remained in the "Prior to Medical Marijuana" line until transition to MML.
https://doi.org/10.1371/journal.pone.0092816.g001

The results of the fixed effects analyses are presented in Table 2. It is important to note that a Hausman test was carried out to determine whether the fixed effects model was preferable over the random effects model; the latter model is more parsimonious and, thus, should be preferred when results do not systematically differ across the two approaches. The results of the Hausman tests (with year fixed effects omitted for both equations because they are inestimable in the random effects model) suggested that the fixed effects model was preferred in each of the seven analyses. For reference, the Hausman χ^2 values were 302.61, 23.64, 102.50, 414.94, 58.87, 34.18, and 31.28 for homicide, rape, robbery, assault, burglary, larceny, and auto theft, respectively.

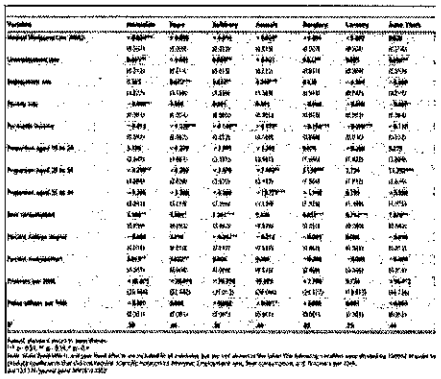

Table 2. The Impact of Medical Marijuana Laws on Crime Rates.
https://doi.org/10.1371/journal.pone.0092816.t002

The key results gleaned from the fixed effects analyses are presented in row 1 of Table 2, which reveals the impact of the MML trend variable on crime rates, while controlling for the other time-varying explanatory variables. Two findings worth noting emerged from the different fixed effects regression analyses. First, the impact of MML on crime was negative or not statistically significant in all but one of the models, suggesting the passage of MML *may* have a dampening effect on certain crimes. The second key finding was that the coefficients capturing the impact of MML on homicide and assault were the only two that emerged as statistically significant. Specifically, the results indicate approximately a 2.4 percent reduction in homicide and assault, respectively, for each additional year the law is in effect. Because log-linear models were estimated, the coefficient must be transformed according to the following formula to generate percentage changes in crime for a one-unit increase in MML: $e^{(b-1)*100}$ [27]. However, it is important to note that the finding for homicide was less variable (i.e., a lower standard error) as compared to assault. One might argue a Bonferroni correction is necessary given the exploratory nature of the study and the multiple models that were analyzed. Once a Bonferroni correction was carried out (i.e., $\alpha/7$), only the effect of MML on homicide remained statistically significant (.05/7=.007).

Perhaps the most important finding in Table 2 is the lack of evidence of any increase in robbery or burglary, which are the type of crimes one might expect to gradually increase over time if the MML-crime thesis was correct. Thus, in the end, MML was not found to have a crime enhancing effect for any of the crime types analyzed.

Sensitivity Analyses

The fixed effects models presented above were subjected to a range of sensitivity tests to determine whether the findings were robust to alternative model specifications. First, and as previously noted, data for the two missing cases were imputed using matched case replacement for Louisiana and Mississippi. Importantly, substantive results were identical when this strategy was carried out. A second sensitivity analysis explored the possibility that the effect of MML on crime rates was non-linear. No evidence emerged to support the hypothesis that MML has a non-linear effect on crime rate trends. Third, a related issue concerns whether the MML effect has *both* a trend effect (shown above) *and* a one-time shock effect. We considered this issue by including the MML trend variable (discussed above) along with a dummy variable coded 0 for years when no MML law was present (by state) and coded 1 in years when an MML law had been passed. The findings were practically identical to those shown above: the MML trend variable was negatively related to homicide (b=−.02, p<.10) and assault (b=−.02, p<.10). A fourth sensitivity analysis re-estimated the original models (shown above), by weighting each state proportional to its population size. When these weighted fixed effects models were estimated, the substantive findings were somewhat different than those presented above. Specifically, the effect of MML on homicide rates was no longer statistically significant (b=−.01, p=.30), MML negatively predicted robbery rates (b=−.02, p<.10), MML negatively predicted assault rates (b=−.03, p<.01), and MML *positively* predicted auto theft rates (b=.03, p<.05). While it is common in the crime policy literature to weight observations by resident population to correct for possible heteroskedasticity, this will be the efficient feasible GLS (generalized least squares) procedure only if the heteroskedasticity takes a particular form, i.e. variance proportional to the square of the population. In the present study, the unweighted results produce findings that are substantively consistent with the weighted results, although they differ slightly quantitatively. The most likely explanation for this discrepancy is that the weighted results are driven by a few large population states. For this reason, we present the unweighted results as the main results and the weighted results as part of our numerous robustness checks.

Discussion and Conclusion

The effects of legalized medical marijuana have been passionately debated in recent years. Empirical research on the direct relationship between medical marijuana laws and crime, however, is scant and the consequences of marijuana use on crime remain unknown. Studies have shown that marijuana use was associated with higher prevalence of subsequent illicit drug use [19] and an increased risk of violence [17]. Yet, other studies have found that once additional factors were controlled for, there was no relationship between marijuana use and later serious drug use [7]. Research has also shown that marijuana use is not related to violent crime when measured at the individual-level [20]. Once drug charges are controlled for, Pedersen and Skardhamar [21] reported that the relationship between marijuana and crime was not significantly different from zero. Unfortunately, no study has examined the effect of legalized medical marijuana on state crime rates across the United States. The current study sought to fill this gap by assessing the effect of legalized medicinal marijuana on the seven Part I UCR offenses. The analysis was the first to look at multiple offenses across multiple states and time periods to explore whether MML impacts state crime rates.

The central finding gleaned from the present study was that MML is not predictive of higher crime rates and *may* be related to reductions in rates of homicide and assault. Interestingly, robbery and burglary rates were unaffected by medicinal marijuana legislation, which runs counter to the claim that dispensaries and grow houses lead to an increase in victimization due to the opportunity structures linked to the amount of drugs and cash that are present. Although, this is in line with prior research suggesting that medical marijuana dispensaries may actually reduce crime in the immediate vicinity [8].

In sum, these findings run counter to arguments suggesting the legalization of marijuana for medical purposes poses a danger to public health in terms of exposure to violent crime and property crimes. To be sure, medical marijuana laws were *not* found to have a crime exacerbating effect on any of the seven crime types. On the contrary, our findings indicated that MML precedes a reduction in homicide and assault. While it is important to remain cautious when interpreting these findings as evidence that MML *reduces* crime, these results do fall in line with recent evidence [29] and they conform to the longstanding notion that marijuana legalization may lead to a reduction in alcohol use due to individuals substituting marijuana for alcohol [see generally 29, 30]. Given the relationship between alcohol and violent crime [31], it may turn out that substituting marijuana for alcohol leads to minor reductions in violent crimes that can be detected at the state level. That said, it also remains possible that these associations are statistical artifacts (recall that only the homicide effect holds up when a Bonferroni correction is made).

Given that the current results failed to uncover a crime exacerbating effect attributable to MML, it is important to examine the findings with a critical eye. While we report no positive association between MML and any crime type, this does not *prove* MML has no effect on crime (or even that it reduces crime). It may be the case that an omitted variable, or set of variables, has confounded the associations and masked the true positive effect of MML on crime. If this were the case, such a variable would need to be something that was restricted to the states that have passed MML, it would need to have emerged in close temporal proximity to the passage of MML in all of those states (all of which had different dates of passage for the marijuana law), and it would need to be something that decreased crime to such an extent that it "masked" the true positive effect of MML (i.e., it must be something that has an opposite sign effect between MML [e.g., a positive correlation] and crime [e.g., a negative correlation]). Perhaps the more likely explanation of the current findings is that MML laws reflect behaviors and attitudes that have been established in the local communities. If these attitudes and behaviors reflect a more tolerant approach to one another's personal rights, we are unlikely to expect an increase in crime and might even anticipate a slight reduction in personal crimes.

Moreover, the present findings should also be taken in context with the nature of the data at hand. They are based on official arrest records (UCR), which do not account for crimes not reported to the police and do not account for all charges that may underlie an arrest. In any case, this longitudinal assessment of medical marijuana laws on state crime rates suggests that these laws do not appear to have any negative (i.e., crime exacerbating) impact on officially reported criminality during the years in which the laws are in effect, at least when it comes to the types of offending explored here. It is also important to keep in mind that the UCR data used here did not account for juvenile offending, which may or may not be empirically tethered to MML in some form or another; an assessment of which is beyond the scope of this study.

Exploring the Ecological Association Between Crime and Medical Marijuana Dispensaries

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ABSTRACT. Objective: Routine activities theory purports that crime occurs in places with a suitable target, motivated offender, and lack of guardianship. Medical marijuana dispensaries may be places that satisfy these conditions, but this has not yet been studied. The current study examined whether the density of medical marijuana dispensaries is associated with crime. **Method:** An ecological, cross-sectional design was used to explore the spatial relationship between density of medical marijuana dispensaries and two types of crime rates (violent crime and property crime) in 95 census tracts in Sacramento, CA, during 2009. Spatial error regression methods were used to determine associations between crime rates and density of medical marijuana dispensaries, controlling for neighborhood characteristics associated with routine activities. **Results:** Violent and property crime rates were positively associated with percentage of commercially zoned areas, percentage of one-person households, and unemployment rate. Higher violent crime rates were associated with concentrated disadvantage. Property crime rates were positively associated with the percentage of population 15–24 years of age. Density of medical marijuana dispensaries was not associated with violent or property crime rates. **Conclusions:** Consistent with previous work, variables measuring routine activities at the ecological level were related to crime. There were no observed cross-sectional associations between the density of medical marijuana dispensaries and either violent or property crime rates in this study. These results suggest that the density of medical marijuana dispensaries may not be associated with crime rates or that other factors, such as measures dispensaries take to reduce crime (i.e., doormen, video cameras), may increase guardianship such that it deters possible motivated offenders. (*J. Stud. Alcohol Drugs, 73,* 523–530, 2012)

WITHIN THE PAST 15 YEARS, a new type of drug outlet has developed in the United States that combines place-based distribution with an illicit substance—medical marijuana dispensaries. At present, 17 states and the District of Columbia have passed legislation legitimizing the use of medical marijuana and its distribution (National Organization for the Reform of Marijuana Laws, 2012). Thus, marijuana distribution in the United States is for the purpose of medical use and only recognized by state-level policies.

Internationally, similar place-based dispensaries have been present since the late 1970s as "coffee houses" or "hash clubs." They are perceived to be a breeding ground for criminal networks, attracting individuals prone to crime and increasing potential for crime around these locations (Asmussen, 2007, 2008; Ministry of Health, Welfare, and Sport, 1995; Møller, 2008). In the United States, the increase in medical marijuana outlets (often referred to as dispensaries or collectives) during the mid to late 2000s has created perceptions that dispensaries support conditions that encourage crime in and around their locations (California Police Chief's Association, 2009). Although the concerns of place-based related crime are consistent across geographic contexts, little is known empirically about medical marijuana dispensaries (Penick, 2006; Reiman, 2007). In fact, only one study has assessed the ecological effects of dispensaries: Jacobson et al. (2011) observed that crime was higher around medical marijuana dispensaries 10 days after their mandated closures compared with 10 days before the closure. Although contrary to previously discussed perceptions, the results cannot be fully evaluated because this technical report was withdrawn after the authors determined that a systematic review of the study's methodology and conclusions was required.

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Routine activity theory of crime

Routine activity theory provides a framework to understand how the presence of medical marijuana dispensaries may contribute to criminal activity. According to this theory, crime occurs when three necessary conditions are met: (a) the presence of a motivated offender; (b) a suitable target defined by its value, visibility, access, and/or likelihood of low resistance to crime; and (c) the absence of guardians against crime, such as place managers (i.e., owners and the agents they hire to monitor and regulate behaviors), inadequate security, and/or low levels of informal social control in the surrounding environment (Clarke and Felson, 1993; Cohen and Felson, 1979; Eck and Weisburd, 1995).

Neighborhood demographic and structural characteristics are not constant over space and thus create opportunities where these three conditions may converge in a geographic area that increase the potential for victimization and encourage crime (Brantingham and Brantingham, 1993; Clarke and Felson, 1993). First, demographic neighborhood characteristics capture the concentration of motivated offenders and potential targets. Various studies have observed that the concentration of potential offenders in neighborhood areas, measured by neighborhood economic deprivation (e.g., concentrated poverty and unemployment rate), is positively associated with neighborhood crime rates (Andresen, 2006; Miethe and McDowall, 1993). The concentration of populations identified as suitable targets has also been observed to be associated with neighborhood crime rates. Neighborhood areas with high concentrations of young males (ages 15–24 years) residing in single-adult households and/or disrupted family (or single-parent) households are likely targets because of the increased likelihood that these neighborhoods are composed of populations who socialize outside of the home and have an increased amount of goods per household (Cohen and Felson, 1979; Sampson and Wooldredge, 1987).

Guardianship of a place or geographic area is related to the presence of individuals or systems that can monitor and regulate behavior to protect against crime, such as place managers, formal authorities (e.g., security guards or police), and/or informal social control provided by individuals within the surrounding environment (e.g., friends or neighbors) (Clarke and Felson, 1993; Cohen and Felson, 1979). Thus, demographic factors can indicate potential guardianship of an area based on informal monitoring and the presence of individuals who may deter crime. For example, a higher percentage of vacant housing units can increase the absence of guardians, such as neighbors and place managers, and thus increase the potential for crime both in and around these vacant locations (Roncek and Maier, 1991; Spelman, 1993). Conversely, high population density may increase the presence of guardians in an area, resulting in the often observed negative association between population density and crime (Andresen, 2006). This additional monitoring of individuals is likely to offset crime expected from the concentration of potential targets and goods within a given amount of space (Cohen et al., 1980).

In addition, structural neighborhood features can contribute to both violent and property crime. Commercially zoned areas are associated with a higher level of street activity and cash flow. These conditions tend to attract crime and/or create opportunities where the three conditions of crime accidentally converge. As a result, there is typically a positive relationship between percentage of a neighborhood area identified as commercially zoned and crime outcomes (Brantingham and Brantingham, 1993; Cohen and Felson, 1979; Sampson and Wooldredge, 1987). Roadway features, such as the presence of highway ramps, may also encourage crime in the general area by easing a potential offender's ability for a quick getaway. Neighborhood areas with highway ramps, then, may be viewed as more suitable for crime through increased access (Felson, 1987). Therefore, those neighborhoods composed of demographic and structural factors associated with crime may create conditions in which both the physical location of a business and the surrounding areas are at risk for higher crime incidents (Brantingham and Brantingham, 1993).

Routine activities approach to medical marijuana dispensaries

Previous work has established the spatial relationships between crime locations and place (Eck and Weisburd, 1995; Greenbaum and Tita, 2004; Gruenewald et al., 2004; Roncek et al., 1991). Places such as medical marijuana dispensaries provide an opportunity where the conditions for crime outlined by routine activities theory can also converge. However, there have been no peer-reviewed studies that explore whether medical marijuana dispensaries are related to crime.

Applying routine activity theory to medical marijuana dispensaries suggests that dispensaries may uniquely contribute to crime even when other contextual factors associated with crime have been controlled. They have on-site stock and sales of marijuana and are a predominantly cash-based business (California Police Chief's Association, 2009). The centralized location of the goods—marijuana and cash—within the dispensaries makes the location a suitable target for a potential offender who might be motivated to seek out ways to obtain the desirable goods, particularly where security appears to be absent.

Based on the conditions described above, dispensaries can be at risk for property crimes, such as burglary. Employees of the dispensaries can be at risk for violent crimes, such as robbery or assault, because they are gatekeepers to both the marijuana products and the cash at the site. Estimates from the western United States and other countries show that users of medical cannabis are primarily male (i.e., two thirds to three fourths of all users) and White, with a wide range of ages (i.e., late teen years to old age; median age between 30 and 50) (Aggarwal et al., 2009; O'Connell and Bou-Matar, 2007; Ogborne and Smart, 2000; Penick, 2006; Reiman, 2007; Ware et al., 2005). The typical clientele for dispensaries (i.e., older White men) are not associated with being at risk for perpetrating crime (Cottle et al., 2001; Hirschi and Gottfredson, 1983). However, they are at risk for being targets of violent crimes, such as robbery, because they are likely carrying cash on entry and some physical amount of marijuana product on exit. In addition, medical marijuana dispensaries have a diverse clientele, with some who are older, frail, and/or diagnosed with chronic, debilitating conditions (O'Connell and Bou-Matar, 2007; Reiman, 2007; Swift et al., 2005; Ware et al., 2003). These more vulnerable

clients may appear to be easier targets for a motivated offender and are at higher risk for victimization (Cohen and Felson, 1979).

Study aims

To date, only preliminary quantitative evidence exists for the relationship between these medical marijuana dispensaries and crime. Thus, the current study investigated the relationship of crime rates in Sacramento, CA, during 2009 to medical marijuana dispensaries to better understand their ecological impact. We hypothesized that medical marijuana dispensaries would be associated with higher crime rates, controlling for other aggregate neighborhood measures of routine activities known to contribute to crime.

Method

Study design

This study used an ecological, cross-sectional design to explore the spatial relationship between the density of medical marijuana dispensaries and crime rates in the City of Sacramento. California recognized distribution of marijuana through collectives in 2004; however, Sacramento did not implement local regulatory policies until 2010. Thus, data are from 2009, a period that represents the longest time for growth before regulations of medical marijuana dispensaries in Sacramento. The sample for the study included all census tracts with centroids within Sacramento City boundaries (N = 95). All data were aggregated to 2000 U.S. Census tract boundaries. Census tracts approximate neighborhood areas with regard to size and composition: (a) average population is 4,000 residents, (b) boundaries align with visible features of the environment, and (c) homogeneous with respect to population characteristics and/or living conditions (U.S. Census Bureau, Geography Division, 2008).

Measures

The dependent variables in the study were violent crime and property crime as measured by police crime incident data obtained from the Sacramento Police Department. Crime incidents were available by crime code and location of incident. Data were recoded into violent crime and property crime categories and geocoded to greater than 99%. Violent crimes were recoded based on the Uniform Crime Reporting definitions, which included homicide, sexual assault, robbery, and aggravated assault. Sexual assaults were excluded from the analysis because address information is confidential to protect the victim; those crimes were not able to be geocoded. Property crimes also were recoded based on the Uniform Crime Reporting definitions, which included burglary, larceny-theft, motor vehicle theft, and arson. For each type of crime category, the number of crime incidents in a census tract was divided by the total population of the tract and multiplied by 1,000 to create the associated crime rate variable. Table 1 provides descriptive statistics for crime rates per census tract. Because of the right-skewed distributions of the dependent variables, violent crime rate and property crime rate were transformed by a natural log. Table 2 provides zero-order correlations between the natural log of each type of crime rate and each continuous independent variable.

TABLE 1. Descriptive statistics for dependent and independent variables across census tracts in Sacramento, CA (N = 95)

Variable	*M*	*SD*
Crime rates		
Violent crime rate per 1,000 population	12.72	22.46
Property crime rate per 1,000 population	67.03	107.98
MMD density		
MMDs per 10 roadway miles	0.41	0.90
Routine activity theory controls		
Total population, in 1,000s	5.07	2.67
% Vacant housing units	6.14	3.97
Population density, in 1,000s	7.07	3.66
Male-to-female ratio	0.99	0.23
% of population 15–24 years old	13.60	4.41
% One-person household	33.49	17.47
% Disrupted family household	11.94	6.06
Unemployment rate	14.84	13.45
Index of concentration at the extremes	-0.25	0.23
% Commercial zoning	12.16	13.71

Note: MMD = medical marijuana dispensary.

The locations of medical marijuana dispensaries were determined by comparing multiple sources: (a) Sacramento City's listing associated with Ordinance No. 2009-033, *An Ordinance Establishing a Moratorium;* (b) news publications; (c) discussion boards on the Internet; (d) trade publications; and (e) survey of dispensary owners/managers. Locations were verified by having at least three sources document that a dispensary was operating on or by June 16, 2009, which provided a midpoint estimate for locations opened during the year. All outlets were geocoded based on point location to 100%. A total of 40 medical marijuana dispensaries were located within 28 of the 95 census tracts (29.5%) in Sacramento. The density of medical marijuana dispensaries was measured by the number of dispensaries per roadway mile in a census tract; this measure was scaled to density per 10 roadway miles. The aggregation to census tracts provided the best variability of density for the smallest areal unit that approximates a neighborhood area. The number of dispensaries ranged from 0 to 3 outlets per tract with density per tract ranging from 0 to 4.95 dispensaries per 10 roadway miles. Figure 1 shows the location of medical marijuana dispensaries mapped onto an unweighted gradient of violent crime rates and property crime rates per 1,000 population by census tract. Those areas with the highest rate of violent or property crime are not necessarily the areas with the greatest population.

TABLE 2. Zero-order correlation coefficients of independent variables with violent crime rate and property crime rate ($N = 95$)

Variable	Violent crime rate (LN)	Property crime rate (LN)
MMD per 10 RWM	.421***	.423***
1,000 population/square mile	-.208*	-.414***
% Vacant housing units	.509***	.425***
Male-to-female ratio (LN)	.523***	.470***
% Population 15–24 years old	-.207*	-.590***
% One-person household	.462***	.656***
% Disrupted family household	.440***	.137
Unemployment rate (LN)	.528***	.161
Index of concentration at the extremes	-.675***	-.367***
% Commercially zoned	.609***	.735***

Notes: LN = natural log; MMD = medical marijuana dispensary; RWM = roadway mile.
*$p < .05$; ***$p < .001$.

To control for neighborhood population and place characteristics that routine activity theory would suggest contribute to observed crime rates, several control variables were created and included in the model. The following variables were selected to control for neighborhood contextual factors commonly associated with aggregate patterns of crime: population density (1,000 population per square mile), male-to-female ratio, percentage of population ages 15–24 years, percentage of one-person households, percentage of disrupted family (or single-parent) households, unemployment rate, and percentage of housing units that were vacant. Data for the measures were from the 2009 estimates of population and housing characteristics obtained from GeoLytics Inc. (2009). Geocoding rates for these census measures are, by definition, 100%. Table 1 provides a summary of descriptive statistics for all control variables. Male-to-female ratio and unemployment rate were transformed using the natural log to address right-skewed distributions.

In addition, neighborhood disadvantage was measured by the index of concentration at the extremes representing concentrated poverty (-1.0) to concentrated affluence (1.0) on a continuous scale. The variable was constructed by subtracting the number of poor households from the number of affluent households and dividing the result by the total number of households (Massey, 2001). Poor households were determined by using 2008 poverty guidelines. Any household composed of two or more individuals and with a combined income less than $26,400 (all dollar values are in

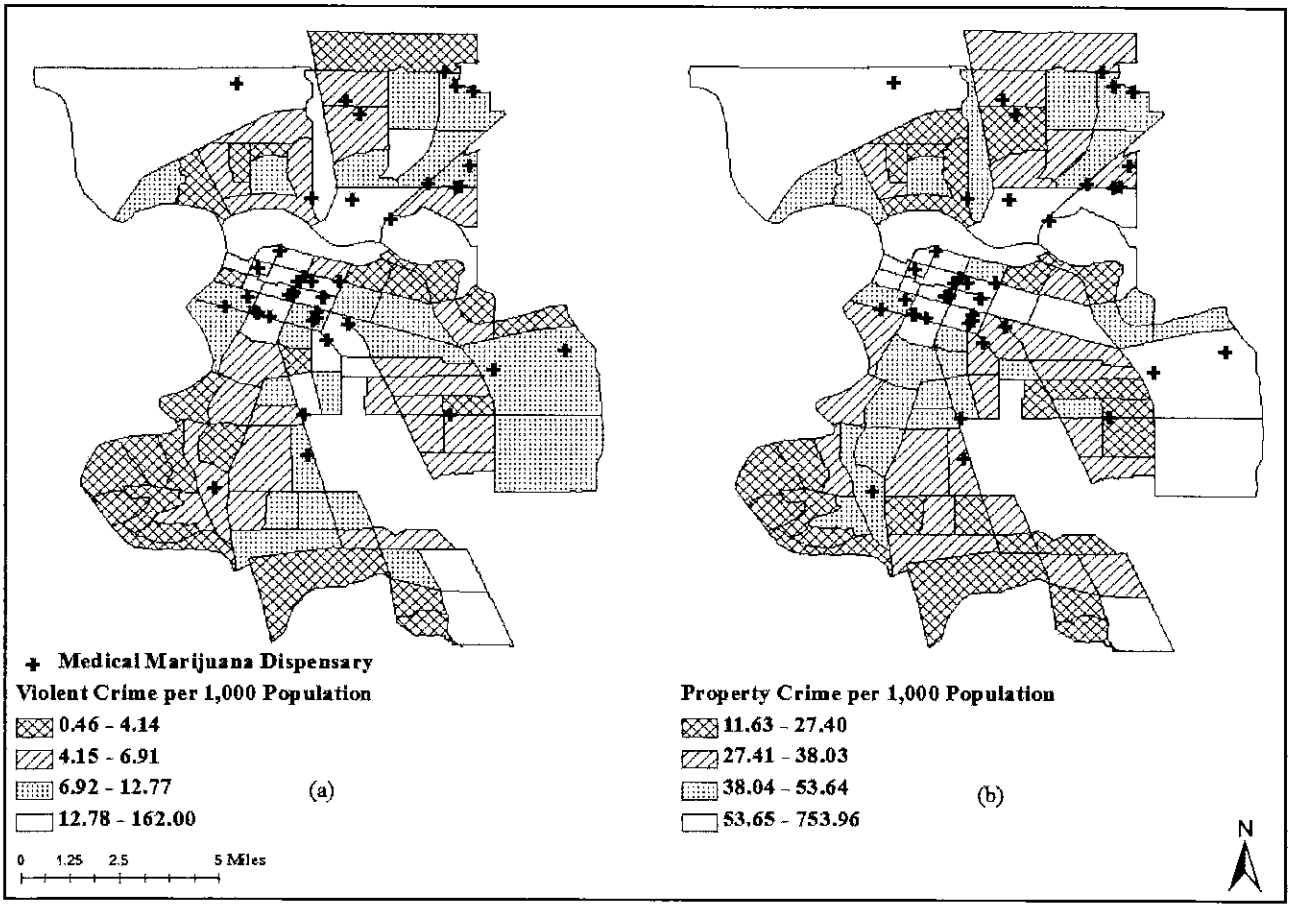

FIGURE 1. Medical marijuana dispensary locations and neighborhood crime rates per 1,000 population ($N = 95$): (a) violent crime rate by census tract, (b) property crime rate by census tract

U.S. dollars) were considered to be below the 200% poverty level. As a result, all households with an income of less than $25,000 were included in the poor household count. Affluent households were determined by any income that was more than two standard deviations above median income, resulting in all households with an income of $100,000 or more being included in the affluent household count.

A categorical variable for the presence of highway on-ramps was created as a proxy measure for physical characteristics that allowed for quick and easy entry and exit into a census tract. We used a categorical measure because of the limited variability in the number of highway ramps per census tract (i.e., 56 of the 95 census tracts had no highway exits; less than 5 census tracts had more than one highway exit). All roadway segments with the Census Feature Class Code (CFCC) A63 (i.e. access ramp) were selected and then aggregated to the census tract; the variable was coded 0 for no highway ramp present and 1 for highway ramp present. ESRI 2008 Streets for United States and Canada (based on 2003 Tele Atlas Dynamap Transportation Version 5.2 product) was used to identify highway ramps (ESRI, 2008). The geocoding rate for highway ramps was 100%; however, the street file is based on 2003 streets and does not account for development in the 5 years between 2004 and 2009.

Finally, all areas defined as commercial zoning for the City of Sacramento (i.e., C1 = limited commercial; C2 = general commercial; C3 = central business district; SC = shopping center; HC = highway commercial; C4 = heavy commercial; ORMU = office/residential mixed use; EC = employment center; OB = office zone) were selected and were parsed into polygons that aligned with census tract boundaries so square mile area could be calculated. The percentage of commercially zoned area was calculated by dividing the aggregate square mile area of commercial zoning by the total square mile area of the census tract and then multiplying by 100. The shapefile for commercially zoned areas from 2010 was obtained from Sacramento County and the City of Sacramento, Geographic Information Systems Division. Geocoding rates for commercially zoned areas were 100% for areas within Sacramento City boundaries.

Statistical analyses

This study used geospatial methods, which have become standard practice for studying ecological relationships between place and crime (Gruenewald et al., 2006). Area units (e.g., census tracts) located next to each other often share similar characteristics that may bias results because they are highly correlated, a phenomenon called *spatial autocorrelation* (Cliff and Ord, 1973). Spatial techniques address this bias by accounting for the spatial autocorrelation. To test if spatial autocorrelation was an issue for these data, the Univariate Moran's *I*, which is a global measure of spatial autocorrelation, was calculated for the dependent variables (Bailey and Gatrell, 1995). Moran's *I* was statistically significant for violent crime rate ($I = 0.3257$, $p < .05$) and property crime rate ($I = 0.4625$, $p < .05$).

Spatial regression models were used to address spatial autocorrelation observed for the dependent variables. This study used a Rook's connection matrix to identify adjacencies between census tracts using an $n \times n$ (in this case 95×95) matrix, where census tracts that shared a boundary were given a 1 and those that did not, a 0 (Bailey and Gatrell, 1995). One challenge to using this approach with smaller geographic areas, such as census tracts, is that the model assumes all areas have the same population. This assumption results in census tracts with small populations and with large populations being weighted equally. To address this, all variables were weighted by the square root of the census tract population to address issues of heteroscedasticity, providing more weight to census tracts with higher population (Greene, 1993). In addition, the condition index was used to test for collinearity in the geographically weighted regressions; any value above 30 indicates problematic collinearity issues within the model (Belsley, 1991; Wheeler, 2007). The condition index for the final models was 21.2 (Table 3), which is not indicative of severe multicollinearity. The fit of the model was examined using the likelihood ratio test, which compared the log-likelihood from the full model (i.e., medical marijuana dispensary density variable plus routine activity variables) with that of the restricted model (i.e., medical marijuana dispensary density variable) to determine if the contribution of routine activity variables improved the overall fit of the model (Greene, 1993).

Results

Table 3 shows the results of the spatial error regression models for violent and property crime rates with the associated condition index, pseudo-R^2, and model-fit statistics. Model I for violent crime rates indicated that medical marijuana dispensaries per 10 roadway miles were not significantly related to violent crime rates. When routine activity theory control variables were added in Model II, the density of medical marijuana dispensaries remained not significantly related to violent crime rates. Model II showed that violent crime rates had a significant positive association with percentage of one-person households, unemployment rate, and percentage of commercial zoning when controlling for other variables. As expected, lower population density was associated with higher levels of violent crime. In addition, lower levels of index of concentration at the extremes (or higher levels of concentrated disadvantage) were significantly associated with higher violent crime rates.

For property crime rates, Model I indicated that medical marijuana dispensaries per 10 roadway miles were not

TABLE 3. Spatial error regression of MMD density on the log of violent crime rate and log of property crime rate by census tract ($N = 95$)

	Violent crime rate (LN)				Property crime rate (LN)			
	Model I MMD density		Model II +RAT controls		Model I MMD density		Model II +RAT controls	
Variable	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
Constant	1.752***	0.167	-0.068	0.259	3.575***	0.144	0.798***	0.198
MMD density								
MMD per 10 RWM	0.214	0.138	0.006	0.093	0.107	0.140	0.002	0.069
RAT controls								
1,000 population/square mile			-0.033*	0.016			-0.019	0.012
% Vacant housing units			0.019	0.021			-0.013	0.016
Male-to-female ratio (LN)			-0.973	0.684			-0.787	0.506
% Population 15–24 years old			0.023	0.018			0.107***	0.013
% One-person household			0.018**	0.006			0.034***	0.005
% Disrupted family household			0.003	0.009			-0.012	0.007
Unemployment rate (LN)			0.291**	0.105			0.211**	0.081
Index of concentration at the extremes			-1.241*	0.537			0.421	0.406
Highway ramp present			-0.098	0.123			0.123	0.092
% Commercially zoned			0.018*	0.007			0.027***	0.006
Spatial autocorrelation								
Λ	0.508***	0.108	0.077	0.145	0.392**	0.121	-0.128	0.151
Model-fit statistics								
Condition index	1.6092		21.2062		1.6092		21.2062	
Pseudo-R^2	.2462		.6944		.1374		.8083	
Log-likelihood	-112.9175		-66.8066		-116.1663		-43.0518	
D (Δdf, p)			92.22 (10,<.001)				146.23 (10,<.001)	

Notes: MDD = medical marijuana dispensary; LN = natural log; RAT = routine activity theory; RWM = roadway mile.
*$p < .05$; **$p < .01$; ***$p < .001$.

significantly related to property crime rates. In Model II, the density of medical marijuana dispensaries remained not statistically significant when routine activity control variables were added to the model. Model II showed a significant positive association with percentage of population ages 15–24 years, percentage of one-person households, unemployment rate, and percentage of commercial zoning when controlling for other variables.

Discussion

In sum, the statistically significant variables for the violent crime rate and property crime rate models were consistent with aggregate neighborhood measures reported within the routine activity theory literature (Andresen, 2006; Cohen and Felson, 1979; Sampson and Wooldredge, 1987). Percentage of a census tract that was commercially zoned, percentage of housing units in a census tract that were one-person households, and unemployment rate were positively related to violent and property crime rates. However, no cross-sectional associations were observed between the density of medical marijuana dispensaries and violent or property crime rates, controlling for ecological variables traditionally associated with routine activity theory.

These findings suggest two possible conclusions. First, the density of medical marijuana dispensaries may not be associated with neighborhood-level crime rates. For example, dispensaries may be associated with crime but no more than any other facility in a commercially zoned area with conditions that facilitate crime. Alternatively, the relationship between density of medical marijuana dispensaries and crime rates is likely more complex than measured here. The study did not measure on-site security or guardianship at the dispensaries. If medical marijuana dispensaries have strong guardianship, such as security and monitoring systems, routine activity theory would suggest that the three necessary conditions for crime are not met. Place-specific guardianship would decrease the accessibility and increase the risk of being caught, decreasing the suitability of a target.

The findings are based on an ecological, cross-sectional study. As a result, no conclusions can be made about causation. First, the study cannot demonstrate whether increasing density of medical marijuana dispensaries is associated with an increase in crime rates over time and space. At an aggregate level, dispensaries in Sacramento are not associated with crime cross-sectionally; however, the introduction of these dispensaries in these areas may have served to increase crime rates from the prior year. This hypothesis can only be tested by examining the changes in medical marijuana dispensary locations and crime rates over time. Second, the ecological design does not allow individual-level variation to be factored into the models, specifically owners' selection of the location of a dispensary. Future studies should address the issue of endogeneity by obtaining information from dispensary owners on their decision-making

processes associated with medical marijuana dispensary locations.

The small sample size of 95 census tracts may have limited the power of the final model. Limited power may have contributed to why variables theorized to affect crime (e.g., percentage of vacant housing, percentage of population ages 15–24 for violent crime rates) were not significant. However, the power was sufficient to establish whether the density of medical marijuana dispensaries would be associated with crime in the univariate models (i.e., Model I).

Other unmeasured ecological factors may also be influencing results. Because of sample size limitations, the current study omitted the locations of illicit drug market activity (Eck, 1995; Gorman et al., 2005; Weisburd and Mazerolle, 2000) and alcohol outlets (Gruenewald et al., 2006; Scribner et al., 1999), both of which are associated with higher crime rates. In addition, dispensaries may be located in areas that reflect the demographics of their clientele (i.e., older White men). The routine activity literature indicates that areas with these local neighborhood characteristics are not likely to have high crime rates (Cohen and Felson, 1979). Exploration of ecological factors associated with location of dispensaries is essential to better understand the role of neighborhood context related to these findings.

The focus on one mid-sized city in California limits the context to which these findings can be generalized. Future studies need to expand spatial methods of this type to other regions of California, other U.S. states, and international regions where marijuana place-based distribution occurs. In addition, the sample size did not allow for the inclusions of variables, such as interaction of place and population characteristics (e.g., Medical Marijuana Dispensary Density × Commercial Zoning) or spatial lags. Finally, measures of premise-based features and operation procedures may provide a better indication of guardianship and employee vulnerabilities that may be associated with findings.

These findings run contrary to public perceptions (California Police Chief's Association, 2009). The cross-sectional results suggest that dispensaries are not associated with crime rates; however, current media and policy efforts have focused their attention on the place-based regulation of these dispensaries to protect the public against crime (California Police Chief's Association, 2009; City of Los Angeles, 2010; Lopez, 2010). Based on the limited evidence presented by this study, it is unclear if place-based policies will be effective. Future studies should address previously described limitations, such as longitudinal studies, to assess the influence of medical marijuana dispensaries on existing crime rates, to gain a better of understanding of the relationship between medical marijuana dispensaries and crime. In addition, future studies should explore specific elements that make dispensaries vulnerable or resistant to crime to better guide future policies.

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