Marijuana Legalization and Educational Outcomes: Evidence from Oregon

Rachel Jarrold-Grapes*
Syracuse University

October 28, 2021

Abstract

In the past decade, 19 states have legalized recreational marijuana for adults ages 21 and older. This paper examines the extent to which there are negative spillovers on underage utilization and educational outcomes. I use two complementary identification strategies that rely on plausibly exogenous spatial and temporal variation in access to marijuana in Oregon. In November of 2014, Oregon passed Measure 91, a referendum to legalize recreational marijuana. Unlike other legal states, Oregon allowed counties that voted against the legalization measure by at least 55% to opt out. Difference-in-differences estimates suggest that self-reported access to marijuana from the Oregon Student Wellness and Oregon Healthy Teens surveys did not change in counties above versus below the vote-share threshold after legalization. However, utilization increased, particularly for 11th-grade girls. Girls were 4 percentage points more likely to use marijuana, and used it 0.3 more times, in the past month after legalization. Additionally, using data on high schools from the Oregon Department of Education, I find that chronic absenteeism increased by 3 percentage points across all students, dropout rates increased by 1 percentage point for girls, and the proportion of girls proficient in ELA fell by over 3 percentage points. As an alternative method of identification that considers the within-county variation in access to marijuana, I estimate how the drive-time between high schools and pre-existing marijuana dispensaries affects outcomes. The results generally align with those from the standard difference-in-differences models, though I do find an additional statistically significant increase in self-reported access to marijuana and a decrease in math proficiency for girls.

*Job market paper. Contact rcjarrol@syr.edu. I am grateful for the support and guidance of my advisors Gary Engelhardt, Amy Ellen Schwartz, and Maria Zhu. I also thank the participants of the Education and Social Policy Workshop and Graduate Student Workshop at Syracuse University for their comments and suggestions. Finally, I thank my many correspondents at the Oregon Department of Education and Oregon Health Authority.

1 Introduction

In the past decade, a green wave began rolling over the nation. Colorado and Washington were the first states to legalize recreational marijuana in 2012, and since then, 17 other states have followed suit (see Figure 1). So far in 2021, Connecticut, New Mexico, New York, and Virginia have all passed measures legalizing marijuana for recreational use. All legal states have established, or are planning to establish, a retail market for marijuana where sales are taxed, allowing states to tap into a new source of revenue and generate new employment opportunities. For instance, between 2013 and 2019, Colorado raised over 1.2 billion dollars in marijuana tax revenues. In 2019, these revenues accounted for roughly 2% of the state's total revenues and 1% of its budget.

However, recreational marijuana legalization may also have negative spillovers on crime, traffic fatalities, workplace injuries, and substance use. From a policy perspective, it is important to know the magnitude of these spillovers to understand the effects of marijuana legalization. This paper provides novel evidence on the effects of recreational marijuana legalization on educational outcomes. Existing studies on the relationship between substances and educational outcomes have primarily focused on alcohol and tobacco use. Given the rapid shift towards recreational marijuana legalization in the U.S., this paper fills an important knowledge gap by looking at the effects of recreational marijuana legalization on both underage marijuana utilization and educational outcomes.

The primary challenge in identifying the effects of marijuana legalization is that places that legalize potentially have a higher latent demand for marijuana than places that do not. Additionally, there could be unobserved heterogeneity in attitudes toward underage utilization and education that are related to the decision to legalize. Either of these would render traditional

estimates of legalization biased. Thus, I use two complementary identification strategies that rely on spatial and temporal variation in access to marijuana resulting from recreational marijuana legalization in Oregon.

Oregon passed Measure 91, a referendum to legalize recreational marijuana for adults ages 21 and older, in November of 2014. Oregon is unique because it allowed counties that voted against the legalization measure by at least 55% to opt out. Using a difference-in-differences estimation strategy, I compare the counties that opted out with those that did not before versus after legalization. The key identifying assumption is that legalization created plausibly exogenous variation in access to marijuana across the vote-share threshold that is unrelated to the latent demand for marijuana as well as unobserved attitudes toward underage use and education. As a robustness check, I assess for parallel trends and find that outcomes follow similar trends in counties above and below the 55% threshold in the pre-legalization period.

I find that self-reported access to marijuana from the Oregon Student Wellness and Oregon Healthy Teens surveys did not change in a statistically significant or economically meaningful way after legalization. However, I do find that marijuana utilization increased, particularly for 11^{th}-grade girls. The probability of past-month marijuana use increased by 4.1 percentage points for girls, which is a 22% increase from the pre-legalization average of 19%. Not only are girls more likely to use marijuana, but they also use it more frequently. The number of times they used marijuana in the past month increased by 0.27. This is a 26% increase from the average of 1.04.

One might expect the increase in marijuana use to feed into students' behavioral and performance outcomes, particularly for girls. This is largely the case. Using data on high schools from the Oregon Department of Education, I find that chronic absenteeism increased by 2.92 percentage points across all students after legalization, which is a 12% increase from the pre-

legalization average of 24%. I also find that dropout rates increased by about 1 percentage point for girls, a one-third increase from the base. Additionally, while proficiency in math did not change, the proportion of 11th-grade girls proficient in ELA fell by 3.22 percentage points. This is a 4% decrease from the 72% average.[1]

As an alternative identification strategy, I use within-county variation in the proximity of high schools to pre-existing marijuana dispensaries to estimate the effects of legalization. Specifically, I collect the addresses of public high schools and medical marijuana dispensaries with licenses that were approved before Measure 91 was put on the ballot. Using the Google Distance-Matrix API, which computes the drive-time between two locations using Google Maps, I find the drive-time between each of these schools and dispensaries. For each school, I calculate the minimum time it takes to get to a dispensary, which I use as a proxy for marijuana accessibility. I estimate the effects on marijuana access and utilization and educational outcomes using a difference-in-differences model with this continuous treatment measure.

My estimation results using this strategy generally align with those from the difference-in-differences models that use county-level variation in the vote-share, with a couple of exceptions. Unlike the estimates from the traditional model, estimates from this drive-time model show that 11th-grade girls find marijuana easier to access after legalization. Specifically, if the average minimum drive-time from schools to dispensaries were to fall by 1 hour and 18 minutes, which is the average difference in drive-time between opt-out and non-opt-out counties, then the probability that girls think getting marijuana is easy would increase by 2.5 percentage points. This a 4% increase from the pre-period average of 63%. In addition, I find that the proportion of girls

[1] I do find a small, statistically significant effect on dropout rates for boys.

proficient in math would fall by 2.4 percentage points after legalization for the same decrease in drive-time, an 8% decrease from the 29% base.

Overall, the weight of the evidence suggests that the legalization of recreational marijuana in Oregon leads to more utilization and worse educational outcomes for high school girls. Girls are more likely to use marijuana and use it more frequently after legalization. Chronic absenteeism and dropout rates rise, while fewer girls reach proficiency levels in ELA. There is also some evidence suggesting that girls both find marijuana more accessible and perform worse in math after legalization.

The rest of the paper is organized as follows. In the next section, I discuss previous research and my conceptual framework. In section 3, I describe recreational marijuana legalization in Oregon and the variation I leverage for identification. I discuss the data on marijuana access and use and student outcomes in section 4. In section 5, I present my empirical model. Results are in section 6, robustness in section 7, and extensions in section 8. Section 9 discusses mechanisms. Finally, I end with a discussion of caveats and conclusions.

2 Literature and Conceptual Framework

2.1 Health, Human Capital, and Marijuana Legalization

Most research on health behaviors can be traced back to Grossman's model of health capital. The canonical model treats health as both a consumption and an investment good, where people enjoy good health directly and use time, goods, and services to produce more healthy days. The focus is typically on the investment component: individuals maximize utility where the marginal return on their investment in their health equals the marginal cost of their investment. Sometimes people choose to *negatively* invest in their health, i.e., participate in risky or unhealthy behaviors like substance use, unsafe sex, or binge eating. The returns on investing in unhealthy

behaviors could be the instant gratification one feels or the social experience of participating. The costs include both monetary costs of substances, food, etc., and non-monetary costs, like poorer health outcomes later in life or less success in the labor market.[2]

Indeed, there is a large body of research on the relationships between risky behaviors and human capital accumulation and labor market outcomes. Most of this literature focuses on the effects of substance use, particularly cigarette smoking and alcohol use. A smaller section examines the effect of marijuana use. Relevant to this paper is the work on teen marijuana use and educational outcomes, which generally finds that smoking marijuana decreases educational attainment. For example, Chatterji (2006) finds that past-month marijuana use in 10th and 12th grades decreases the number of years of education completed by age 26, and McCaffrey, et al. (2010) find that marijuana use is associated with higher dropout rates.[3] Other work includes Yamada, Kendix, and Yamada (1996), Bray, et al. (2000), Register, Williams, and Grimes (2001), and Roebuck, French, and Dennis (2004), among others.[4]

More recently, economists have started to examine the effects of medical and recreational marijuana legalization on access to marijuana and teen utilization. Findings are mixed. For instance, Anderson, Hansen, and Rees (2015) find a slight, insignificant decrease in the probability of marijuana use after medical marijuana legalization, while Wen, Hockenberry, and Cummings

[2] Grossman (1972) and Cawley and Ruhm (2011).

[3] McCaffrey, et al. (2010), however, find that much of this effect is explained away by family influence and peer effects in grade 8-10, as well as cigarette use. Similarly, Mokrysz, et al. (2016) finds that cigarette use mitigates the effect of marijuana on the IQ and educational performance of English students.

[4] A negative relationship is also documented in the sociology and public health literatures: Lynskey and Hall (2000) suggests that marijuana use is negatively related to grade point average, attitudes toward school, attendance, performance, and retention; Ryan (2010) finds that frequent use is associated with lower educational attainment; and Beverly, Castro, and Opara (2019) find that late marijuana users were 1.67 times more likely than early users to graduate from high school. International studies also find negative relationships between marijuana use and a variety of educational outcomes (Duarte, Escario, and Molina (2006); Fergusson and Boden (2008); Silins, et al. (2014); Thompson, et al. (2019)).

(2015) find an increase.[5] In regard to recreational marijuana legalization, Cerda, et al. (2017) find an increase in marijuana use in Washington (but not Colorado), while Dilley, et al. (2019) show that teen marijuana use fell after legalization in Washington. Additionally, Rusby, et al. (2018) find that marijuana use in a small sample of Oregon schools increased after legalization.

2.2 Potential Mechanisms

I contribute to this literature by analyzing the effects of recreational marijuana legalization in Oregon. There are numerous mechanisms that could lead to more marijuana use, and subsequently worse educational outcomes, after legalization. First, legalization could make marijuana easier for teens to access, which could increase the likelihood of use. In the following section I provide some context for Oregon's decision to legalize and discuss what, when, and where marijuana is potentially available to teens.

Second, a large body of research in cognitive development shows that using marijuana in adolescence has negative effects on cognition, short-term memory, attention, overall and verbal IQ, and abstract reasoning skills, and that the effects are more pronounced for those who start using earlier.[6] Additionally, neuroscientists have found that girls' and boys' brains have different reactions to tetrahydrocannabinol (THC), the psychoactive ingredient in marijuana that produces the drug's high. The amygdala, the part of the brain that regulates emotion, fear response, and memory, is shown to have a larger volume for girls who use marijuana, but not boys. This leads to increased anxiety, depression, and short-term memory loss, particularly for girls. Estrogen also plays a role in how girls react to THC. Females are more sensitive to the pain-relieving effects of

[5] There are also conflicting results about access, use, and perceived riskiness in work by Khatapoush and Hallfors (2004), Wall, et al. (2011), Lynne-Landsman, Livingston, and Wagenaar (2013), Harper, Strumpf, and Kaufman (2012), Choo, et al. (2014), Schuermeyer, et al. (2014), and Cerda, et al. (2018).
[6] Pope, Gruber, and Yurgelun-Todd (1995) and Lisdahl, et al. (2013).

THC and develop a tolerance to the drug faster than males, leading to a greater probability of addiction to marijuana for females. The sensitivity to THC is particularly strong during ovulation when estrogen levels have peaked.[7]

Third, the peer effects literature suggests that teens with peers who use substances or approve of using substances are more likely to use than teens with disapproving peers. Whether girls and boys react differently to peer substance use is ambiguous.[8] Fourth, girls may be more likely to be rule-followers and boys more likely to be risk-takers, meaning that boys might take the risk and use marijuana before it is legal while girls might wait. Indeed, research in psychology shows that girls are more risk-averse than boys.[9] Fifth, legalization leads to higher quality marijuana products. As I discuss in the following section, products are subject to testing for quality assurance purposes, which could lead to increased utilization, particularly for girls.

Finally, an increase in marijuana use after legalization could negatively affect educational outcomes not only directly, as discussed above, but also indirectly. Research suggests that marijuana is a gateway drug to alcohol and other illicit substances that are known to have negative effects on educational outcomes. In addition, there is evidence that marijuana use leads to worse mental health and greater participation in deviant and criminal behaviors.[10]

Lack of data leaves me unable to distinguish between these potential mechanisms, though I can comment somewhat on accessibility and risk-taking behavior, which I do in section 9. Thus, in this paper, I identify the *net* effects of legalization on marijuana use and educational outcomes.

[7] Jacobus, J. and Tapert, S. (2014), Washington State University (2014), Weir, K. (2015), and Frontiers (2018).
[8] Guo, J., Hill, K., Hawkins, J., Catalano, R., Abbott, R. (2002), Eisenberg, D. (2004), Kawaguchi, D. (2004), Lundborg, P. (2006), Moriarty, J., McVicar, D., and Higgins, K. (2012), Mason, M., Mennis, J., Linker, J., Bares, C., and Zaharakis, N. (2014), and Henneberger, A., Mushonga, D., and Preston, A. (2021).
[9] Byrnes, J., Miller, D., and Schafer, W. (1999) and Harris, C., Jenkins, M., and Glaser, D. (2006).
[10] Ellickson, Hays, and Bell (1992), Kandel, Yamaguchi, and Chen (1992), DeSimone (1998), Brook, et al. (1999), Green and Ritter (2000), Brook, et al. (2011), Brook, et al. (2013), and Epstein, et al. (2015).

3 Background on Marijuana Legalization in Oregon

Oregon has a long legislative history related to marijuana. In 1973, Oregon decriminalized the possession of small amounts of marijuana. Namely, it removed the felony charge associated with public possession of one ounce and at-home possession of eight ounces of marijuana. Then, in 1998, voters passed Measure 67, a referendum to legalize the cultivation, possession, and use of marijuana for medical purposes statewide. Under this new law, people could use marijuana if recommended by their doctor to alleviate symptoms from the following conditions: cancer; glaucoma; degenerative or pervasive neurological conditions; HIV/AIDS; post-traumatic stress disorder (PTSD); and any medical condition that produces cachexia, severe pain, severe nausea, seizures, and/or persistent muscle spasms. Measure 67 also established the Oregon Medical Marijuana Program (OMMP). People could apply for permits from the OMMP to grow marijuana for medicinal use and were allowed to have seven plants (only three mature) and possess one ounce of dried marijuana.

While Measure 67 legalized possession, use, and cultivation, it did not legalize the *sale* of medical marijuana. As such, Oregonians tried to legalize the sale of medical marijuana twice in the early 2000s and 2010s. In 2004, they voted on Measure 33, which would have established marijuana distribution centers, and in 2010, they voted on Measure 74, which would have created medical marijuana dispensaries. Neither of these measures passed. Then, in 2012, Oregon lawmakers approved medical marijuana sales out of medical dispensaries, though they also passed a law the following year allowing localities to put moratoria on dispensaries for a year. Thus, the first medical marijuana dispensary licenses were approved in March of 2014. Only medical marijuana card holders could make purchases from these dispensaries. Patients over the age of 18 could apply for medical marijuana cards through the OMMP as long as they supplied proof of a

qualifying medical condition from their physician. Effective June 30, 2015, people under 18 years old could apply for medical marijuana cards with parental consent. Parents or legal guardians are required to be primary caregivers and speak to their child's physician about the possible side effects of using marijuana and are responsible for the acquisition and administration of marijuana to their child. The number of medical marijuana patients under 18 years old in Oregon was 214 in January 2015, which was about 0.3% of all patients. This number peaked at 298 (0.4%) in January 2017 and has since been declining. As of July 2021, there were 123 (0.5%) patients under 18. Most young patients use medical marijuana for severe pain and/or seizure disorders, though the number using marijuana for neurological disorders has steadily increased over the past two years.

Like Oregon, Washington state, on Oregon's northern border, legalized medical marijuana in 1998 and did not allow sales until later. Medical marijuana was first sold out of dispensaries in Washington in 2016. Additionally, Washington legalized marijuana for recreational use in 2012 and opened its first recreational dispensaries in July of 2014.

Oregonians originally voted to legalize marijuana for recreational use in 1986 (Measure 5) and again in 2012 (Measure 80), but the measures were unsuccessful. Then, in November of 2014, they voted on Measure 91, a referendum for recreational marijuana legalization, that passed with a 56% majority. Measure 91 legalized the possession, use, and sale of recreational marijuana for adults ages 21 and older. Beginning in July 2015, users could possess eight ounces of usable (dried) marijuana, one ounce of cannabinoid extracts or concentrates, 16 ounces of cannabinoid products in solid form and 72 ounces in liquid form, ten marijuana seeds, and four plants at home. These limitations apply to public possession as well, though dried marijuana is limited to one ounce in public instead of eight.

Measure 91 also gave regulatory power to the Oregon Liquor Control Commission, which has since been renamed the Oregon Liquor and Cannabis Commission (OLCC). The OLCC is responsible for the running the OMMP; distributing licenses to recreational producers, processers, wholesalers, and retailers; developing a taxing structure and tracking sales; developing packaging for products that discourage use by minors; and ensuring product quality. All marijuana products undergo testing for microbiological contaminants, pesticides, solvents, and THC and cannabidiol concentration. The amount of THC allowed in a serving size or a container depends on the product. For instance, the maximum concentration of THC per serving of edible marijuana is 5mg and the maximum concentration per container is 50mg.

Recreational marijuana sales began in October 2015 out of existing medical marijuana dispensaries and were subject to a 25% sales tax starting in January 2016. This tax only applied to recreational sales out of medical dispensaries; medical sales remained tax free. The OLCC began to accept applications for recreational dispensaries at the beginning of 2016, and recreational sales out of these new dispensaries began in October 2016. Sales from recreational dispensaries are taxed at 17%. In addition, cities and counties can institute a 3% tax with voter approval. Beginning in December 2016, medical dispensaries were required to apply for recreational licenses if they intended to keep selling to recreational customers.

The state sales tax revenue from marijuana is distributed to several entities: 40% of revenues are earmarked for education, 20% go to the Mental Health Alcoholism and Drug Services Account, 15% are for state law enforcement, 10% each to cities and counties based on their population and number of licensees, and 5% for alcohol and drug abuse prevention, intervention, and treatment services. The 40% for education goes to the State School Fund, which is distributed to school districts in the form of several grants: facility, transportation, high-cost disabilities, and

general purpose. Grant amounts are calculated using the state's school funding formula. Marijuana tax revenues help fund the general-purpose grant, which flows into school districts' general funds and can be used for any legal purpose.[11]

Though Measure 91 legalized marijuana statewide, localities were given the option to ban licensed producers, processors, wholesalers, and retailers from operating within their borders. Before 2016, counties with at least 55% of votes against legalization could opt out without putting it on a ballot. Cities within these counties could also implement bans. 15 of the 36 counties in Oregon opted out and 48 cities within these counties did as well.[12] Figure 2 shows the counties that voted against legalization with at least 55% of votes and decided to opt out in white. All counties that could opt out did so. The counties with a 50% majority against legalization, but that were not allowed to opt out, are in light green. Counties with less than 50% against legalization are in dark green. Starting in 2016, any locality, regardless of how it voted on Measure 91, could vote to opt out or back into legalization. Currently, there are 15 counties and 81 cities banning marijuana retail businesses.[13] Importantly, only localities that allow marijuana sales receive tax revenues.

Total marijuana sales have steadily increased since legalization, which is shown by the dark green line in Figure 3. Sales were roughly $2.5 million in October of 2016 and peaked in July 2020 at roughly $99 million. Recreational sales follow a similar trend. The medium green line

[11] Information is from my correspondence with the Assistant Superintendent for Research for the Oregon Department of Education's Office of Child Nutrition, Research, Accountability, Fingerprinting, and Transportation.
[12] These counties are Baker, Crook, Gilliam, Grant, Harney, Jefferson, Klamath, Lake, Malheur, Morrow, Sherman, Umatilla, Union, Wallowa, and Wheeler. 48 cities within these counties banned as well (League of Oregon Cities, Local Government Regulation of Marijuana in Oregon).
[13] Marion and Douglas counties voted to ban in 2016, while Gilliam voted to remove its ban (Oregon Liquor Control Commission, Record of Cities/Counties Prohibiting Licensed Recreational Marijuana Facilities). 28 cities in counties that had voted in favor of Measure 91 decided to ban in 2016, and another 5 banned in 2018 (The Oregonian, Oregon Marijuana Measures; Withycombe, "Six Oregon Cities Vote to Allow Marijuana Business"). Grant County repealed its ban on marijuana in 2018 (Hanners, "Recreational Marijuana Industry to Expand in Grant County").

shows that recreational sales went from $2 million in October 2016 to over $88 million in April 2021. Medical sales are given by the light green line.[14] These stayed relatively constant at about $5 million through 2019, increased to just over $10 million by June 2020, then slowly declined to about $7 million by September 2021. Assuming that sales are a good proxy for consumption, these data suggest that recreational marijuana use increased significantly since legalization. However, these trends are not necessarily indicative of *teen* marijuana use. I use data from two surveys of Oregon youth to shed light on their marijuana consumption both before and after legalization.

4 Data

4.1 Marijuana Acquisition, Access, and Use

Illegal substance use is notoriously difficult to measure. Before states decided to legalize marijuana, researchers had to rely solely on self-reported illicit marijuana use, which is subject to measurement error. People may not be truthful when answering questions about their drug use when the drug is illegal. After legalization, sales records can be used to proxy for marijuana utilization, though sales are not necessarily good measures of *underage* marijuana use, which remains illegal. Because I am examining the effects of legalization on underage marijuana use, I have to rely on self-reported data.

These data, which include measures of marijuana accessibility and utilization, come from the Oregon Student Wellness (OSWS) and Oregon Healthy Teens (OHTS) surveys. Both surveys are administered by the Oregon Department of Education (ODE) in conjunction with the Oregon Health Authority (OHA) to assess overall student health and school climate. They are given to

[14] Medical sales are purchases made with medical marijuana cards issued through the OMMP. Note that distinguishing sales as recreational or medical does not necessarily indicate the purpose for which an individual consumer uses marijuana, i.e., marijuana purchased with a medical marijuana card could be used for recreational purposes and marijuana purchased without a medical marijuana card could be used for medical purposes.

students in school by their teachers in the spring semester. The OSWS is given in even years and the OHTS in odd years, so I pool the data to have a more continuous time series that includes the 2009-10 school year and the 2011-12 through the 2018-19 school years. Additionally, the OSWS is administered to 6th, 8th, and 11th graders, while the OHTS is given to 8th and 11th graders. In this paper, I focus only on 11th graders. Doing so allows me to better capture the cumulative effects of using marijuana. In addition, 11th-grade marijuana use is probably more closely related to student drop-out decisions, one of my outcomes of interest, than utilization in 8th grade. My sample includes about 126,000 11th graders across the entire sample period.

Students are asked questions about how easy it is for them to get marijuana, whether they used marijuana in the past month, and how many times they used it in the past month. They also record their ethnicity and gender, which I use as controls in my model. The questions about marijuana use are identical, and those about access are similar, to those used in the Monitoring the Future (MTF) survey sponsored by the National Institute on Drug Abuse (NIDA) and the questionnaires used in the Centers for Disease Control and Prevention's (CDC) Youth Risk Behavior Surveillance System (YRBSS). Numerous validation studies have been conducted to assure that the questions in the YRBSS provide reliable information on teen substance use.[15] Additionally, each Oregon study conducts internal honesty and logic checks and discards surveys where students are likely not telling the truth. See the appendix for more detailed information on the survey methodologies, response rates, and honesty checks.

[15] Morbidity and Mortality Weekly Report: Methodology of the Youth Risk Behavior Surveillance System, Centers for Disease Control and Prevention

4.2 Educational Outcomes

The ODE provides publicly available, school-level data on dropout rates and chronic absenteeism. Dropouts are students who either dropped out of school and did not re-enroll at any point during the year or who completed the previous school year but did not enroll in the current year though they were expected to do so. The dropout rate is defined as the ratio of dropouts to the number of students enrolled in high school in the fall of the current school year. The chronic absenteeism rate is the percentage of students who missed 10% or more of the days they were enrolled in school. Both outcomes are available from the 2012-13 through the 2018-19 school years, and dropout rates are available by gender.

Student test score data is also available at the school level from the ODE. The proportions of 11th-grade students who did not meet, nearly met, met, and exceeded standards in math and ELA are available by gender from 2014-15 through 2017-18. Additionally, the ODE has information on student race, ethnicity, disability status, and free-or-reduced-price lunch eligibility, which serves as a proxy for student economic disadvantage. I use these student characteristics to control for differences within schools over time.[16]

The analysis sample includes over 200 high schools each year. I exclude charter schools because they typically draw students from multiple counties, especially if they are virtual, which makes it unclear whether they were treated by legalization.

[16] To preserve student confidentiality, some variables are suppressed for schools with fewer than ten students and are coded as "less than 1%," "less than 5%," "greater than 95%," or "greater than 99%." I recode these as exactly 1%, 5%, 95%, or 99%.

5 Empirical Methodology

If marijuana use among teens was randomly assigned, then its causal effect on student outcomes would be given by the OLS estimate of β_1 in the following equation:

$$Y_{it} = \beta_0 + \beta_1 M_{it} + \varepsilon_{it} \quad (1)$$

where *i* is students, *t* is time, *Y* is the student outcome of interest, *M* is marijuana use, and ε is a random error term. However, there is likely unobserved heterogeneity in marijuana use across students, potentially in terms of risk aversion and time preferences, that could be correlated with educational outcomes and yields $cov(M, \varepsilon) \neq 0$. The OLS estimate of β_1 in this case is biased and no longer has a causal interpretation.

One way to deal with this challenge to identification is to find a situation that creates random variation in marijuana use and use this as an instrument for *M* in equation (1). One such instrument is recreational marijuana legalization, assuming that this policy changes the accessibility of marijuana, which then changes utilization. Since legalization varies across counties and time in Oregon, I consider *Legal x Post* as an instrument for marijuana use. *Legal* is a binary variable equal to one for counties that voted in favor of Measure 91 by over 45%, and *Post* indicates years after the marijuana sales market opened.

However, the data on marijuana use and educational outcomes come from two separate data sets that are at different units of analysis, so I cannot use this exact estimation method. Instead, I estimate the effects of legalization on marijuana use (the "first stage") and educational outcomes (the "reduced form"). The ratio of the reduced form to the first stage provides an approximation of the IV estimate of β_1 from equation (1).[17]

[17] As an extension, I use a two-sample instrumental variables strategy to estimate the effects of marijuana use on educational outcomes in section 8.

The first stage is given by the following equation:

$$M_{ict} = \delta_0 + \delta_1(Legal\ x\ Post)_{ct} + \delta_2 X_{it} + \alpha_c + \theta_t + \mu_{ict} \quad (2)$$

where *i*, *c*, and *t* index students, counties, and years, respectively. The dependent variable, *M*, is either a binary variable indicating whether the student thinks it is easy to access marijuana, a binary indicator for whether the student used marijuana in the past month, or the number of times a student used marijuana in the past month. *Legal* is 1 for counties with over 45% of votes in favor of legalization, and 0 for those with at least 55% against it. *Post* is 1 after marijuana sales began in October 2015 and 0 before. The interaction of *Legal* and *Post* is my variable of interest. *X* is a vector of time-varying student characteristics, which includes gender and ethnicity. α_c and θ_t are fixed effects to control for idiosyncrasies across counties and time, respectively, and μ_{ict} is the random student-by-county-by-year error term. Standard errors are clustered by county. Since I am pooling data from the OSW and OHT surveys, I use the provided county enrollment weights. Assuming that the $cov[\mu_{ict}, (Legal\ x\ Post)_{ct} | X_{it}, \alpha_c, \theta_t] = 0$, $\widehat{\delta_1}$ is the causal estimate of the effect of recreational marijuana legalization on 11th-grade marijuana access and use.

The reduced form regression of legalization on educational outcomes is the following:

$$Y_{sct} = \beta_0 + \beta_1(Legal\ x\ Post)_{ct} + \beta_2 X_{st} + \gamma_s + \theta_t + \omega_{sct} \quad (3)$$

where *s*, *c*, and *t* index schools, counties, and years, respectively. *Y* represents dropout rates, chronic absenteeism, and proficiency rates. Again, *Legal* is 1 for counties with over 45% of votes in favor of legalization, and 0 for those with at least 55% against it, and *Post* is 1 after marijuana sales began in October 2015 and 0 before. *X* is a vector of school-level student characteristics that possibly change over time, such as the proportion of students who are considered disabled, economically disadvantaged, Hispanic, Black, or Asian. The fixed effects γ_s and θ_t control for unobserved differences across schools and time, respectively. ω_{sct} is the random school-by-

county-by-year error term. Standard errors are clustered by county. Like equation (2), the interaction of *Legal* and *Post* is my variable of interest, and assuming that the $cov[\omega_{sct}, (Legal\ x\ Post)_{ct} | X_{st}, \gamma_s, \theta_t] = 0$, the estimate of β_1 is the causal effect of recreational marijuana legalization on student outcomes.

The primary identifying assumption of these difference-in-differences models is that marijuana use and educational outcomes would have followed the same trends in counties that opted out and counties that did not if recreational marijuana had not been legalized. Though I cannot test this assumption directly because I do not observe outcomes in absence of legalization, I assess for parallel trends prior to the sales market opening in my robustness checks. Parallel trends would suggest that outcomes in counties above and below the 55% vote-share threshold would have continued along similar trends if Measure 91 had not been passed.

6 Main Results

It is well-documented in the public health literature that substance utilization varies by gender. Generally, more males than females tend to use substances, and this pattern holds true for teenage marijuana use.[18] In addition, male and female brains react differently to THC, as shown in the neuroscience literature I discussed previously. As such, I present my estimation results disaggregated by student gender.

6.1 Marijuana Access and Utilization

When I estimate equation (2) separately by gender, I find that girls think it is somewhat easier to get marijuana after legalization while boys think it is slightly more difficult. The marginal

[18] National Institute on Drug Abuse Report on Sex and Gender Differences in Substance Use (2021); Cuttler, et al. (2016), Schepis, et al. (2011); and Butters (2005).

effect for girls is 0.0248 (0.0222), and the one-sided p-value is 0.133, as shown in Table 1, column (1). This is an increase of about 4% from the pre-legalization average of 63%. For boys, the marginal effect is -0.0198 (0.0221) with a one-sided p-value of 0.185 (column (2)). Relative to the pre-legalization average, 67%, this is a decrease of 3%.

Though access to marijuana did not increase in a statistically significant or economically meaningful way after legalization, marijuana use did. The likelihood that 11th-grade girls used marijuana in the past month increased by 4.1 percentage points on a base of 19%, which is a 22% increase (Table 1, column (3)). For boys, the probability of past-month marijuana use only increased by 0.41 percentage points relative to the 22% average (column (4)). This is less than a 2% increase. I can reject the null hypothesis that marijuana use does not change after legalization in favor of the alternative that it increases at the 1.1% level for girls and the 41% level for boys.

Not only are 11th-grade girls more likely to use marijuana after it is legalized, but they also choose to use it more frequently. Column (5) of Table 1 shows that girls used marijuana 0.2749 (0.1232) more times after legalization, which is a 25% increase from the pre-period average of 1.04. Boys used it 0.0338 (0.1236) more times, which is a 2% increase relative to a base of 1.59 (column (6)). One-sided p-values are 0.013 and 0.392 for girls and boys, respectively.

6.2 Student Behavior

Given that marijuana use increased after legalization, I examine whether legalization changed student behavior. Specifically, I estimate equation (3) for dropout rates and chronic absenteeism. Table 2 shows results for chronic absenteeism across all students, as absenteeism data is not available by gender, and dropout rates for boys and girls separately. Column (1) shows that the marginal effect of legalization on chronic absenteeism is 0.0292 (0.0134), which is statistically greater than zero at the 1.8% level. This is a 12% increase from the pre-period average

of 24%. To put this in perspective, before legalization the average high school had 715 students, 171 of whom were chronically absent. A 12% increase means that an additional 20 students were chronically absent from school after legalization.

Column (2) shows that the dropout rate for girls increased by 0.97 percentage points from the 3% average, which is a 32% increase. For boys, the dropout rate increased by 0.69 percentage points relative to the pre-legalization average of 4%, a 17% increase (column (3)). Both effects are statistically greater than zero at the 5% level of significance. Again, to put this in perspective, consider the average high school cohort, which had about 170 students – 83 girls and 87 boys. On average, 2 girls and 3 boys dropped out prior to legalization. A 32% increase for girls and a 17% increase for boys means that at most 1 additional girl and 1 additional boy dropped out after legalization.

6.3 Academic Performance

I also estimate the effect of legalization on student performance in math and ELA. Given the results for behavioral outcomes, I focus on students at the bottom of the test score distribution. These students either "did not meet" or "nearly met" grade-level standards on end-of-grade tests. In other words, they are "not proficient."

Table 2, column (4) shows that the marginal effect of legalization on the proportion of 11^{th}-grade girls who are not proficient in math is 0.0152 (0.0151). The one-sided p-value is 0.161 and I cannot reject the null hypothesis that the effect is zero. The proportion of 11^{th}-grade boys who are not proficient in math fell by 0.0027 (0.0260), which is also statistically insignificant at the standard levels (column (5)). In column (6), the marginal effect on the proportion of 11^{th}-grade girls who are not proficient in ELA is 0.0322 (0.0160). This is a 12% increase from the pre-legalization average of 28%. I can reject that the null is zero in favor of the alternative hypothesis

that the effect is positive at the 2.6% level. For 11th-grade boys, the same proportion fell by 0.0136 (0.0296), which is a 4% increase from the pre-period average of 38% (column (7)). The one-sided p-value is 0.324. Overall, performance in math did not change in a statistically significant way after legalization, while performance in ELA worsened, particularly for girls.

7 Robustness

7.1 Parallel Trends

The identifying assumption in these models is that the outcomes in counties that opted out and did not opt out would have followed parallel trends in absence of legalization. Though this is not directly testable, I can examine the outcomes across counties before legalization for parallel trends. If the outcomes did *not* follow similar trends in the pre-period, then the changes I saw after legalization may be due to underlying factors across opt-out and non-opt-out counties instead of legalization. Figure 4 shows average marijuana access and use for counties where marijuana businesses were banned (black) and allowed (green). For all outcomes, the figures indicate that counties followed similar trends in the pre-period. Figure 5 shows average dropout rates and chronic absenteeism over time. The trends before legalization were somewhat similar, though not as convincing as those in Figure 4. Since the proficiency data is only available in one year during the pre-period, I cannot check parallel trends visually for those outcomes.

Thus, I do a more formal check for pre-existing parallel trends. Specifically, I randomly assign vote-shares to counties and then re-estimate the models with *Legal* defined using these placebo vote-shares. A statistically significant result far from zero would indicate that the placebo treatment explains the differences I see after legalization, suggesting that the effects I find could be attributed to underlying differences in opt-out and non-opt-out counties rather than legalization. The results of these placebo tests are in Table 3. Column (1) shows that the marginal effect of the

placebo treatment on marijuana access is 0.0007 and is not statistically positive at the standard levels. In column (2), the effect on the probability of past-month marijuana use is -0.0027 and is not statistically significant. The effect on marijuana use on the intensive margin is farther from zero (-0.0448), but is not statistically significant, as shown in column (3). Column (4) shows that the effect on chronic absenteeism is 0.0168, which is not particularly close to zero, but is also not statistically significant. The effect on dropout rates is 0.0009 and insignificant (column (5)). The marginal effects of the placebo on the proportions of students not proficient in math and ELA are 0.0104 and 0.0089, as shown in columns (6) and (7), respectively. Neither are statistically positive. Overall, the weight of the evidence suggests that the differences in marijuana use and educational outcomes after marijuana legalization are not due to underlying differences in the counties that opted out or did not opt out.

7.2 County Time Trends

It is possible that there are underlying trends in marijuana use within individual counties that my model is attributing to legalization. For example, marijuana use might be increasing over the sample period within counties generally, and not have anything to do with legalization. One way to test this is to include a county-specific linear time trend and see if the results remain the same. However, when I do this, there is too little variation left to identify the effect of legalization. The R-squared from a regression of *Legal x Post* on the other covariates in equation (2) and the time trend is 0.9819, indicating that there is only $1 - 0.9819 = 0.0181$ residual variation left for identification.

7.3 Multiple Hypothesis Testing

Since I use the same model to estimate the effects of legalization on several outcomes, I determine whether my results are robust to multiple hypothesis testing. To do so, I implement the Romano-Wolf correction for multiple hypotheses and compute the corresponding p-values. I calculate Romano-Wolf p-values for the marijuana access and use outcomes and the educational outcomes separately because the data come from two datasets at different levels of aggregation. For the marijuana outcomes, I include the six specifications in Table (1) when I calculate the p-values. For the educational outcomes, I do two separate calculations, one for the three specifications of the behavioral outcomes (columns (1)-(3) of Table 2) and a second for the four specifications of the performance outcomes (columns (4)-(7) of Table 2). In all three cases, I do 100 bootstrap replications. The resulting p-values are in curly brackets in Tables 1 and 2. The effects of legalization on marijuana use for girls on both the extensive and intensive margins, as well as the effects on dropout rates, chronic absenteeism, and the proportion of 11^{th}-grade girls who are not proficient in ELA, all remain statistically significant after implementing the correction.

8 Extensions of the Main Analysis

8.1 Effects of Legalization Over Time

The effects of legalization could either increase over time as the marijuana market grows, or they could dissipate as the market becomes less novel. To examine whether the effects are concentrated in the short run or the medium run, I re-estimate equations (2) and (3) without *Legal x Post*, but with interactions of the post-legalization years with *Legal*. Specifically, I interact *Legal* with one indicator for whether the year is 2016 or 2017 (the "earlier" or "short-run" years), and a second indicator for whether the year is 2018 or 2019 (the "later" or "medium-run" years). Results are presented in Tables 4 and 5.

For girls, access to marijuana did not change right after legalization, but increased by 6.2 percentage points in the medium run (Table 4, column (1)). Boys found it harder to get marijuana in the short run (4.09 percentage point decrease), but not in the medium run (column (2)). The probability of using marijuana in the past month did not change for anyone in the earlier years but increased in the later years: in column (3), girls were 7.27 percentage points more likely to use marijuana in the medium run, and in column (4), boys were 3.19 percentage points more likely to do so. Finally, girls used marijuana more days in both the earlier and later years after legalization. They used 0.2377 more days in the short run and 0.3102 more days in the medium run (column (5)).

The effects on educational outcomes over time are given in Table 5. In column (1), the marginal effect on chronic absenteeism is 0.0274 (0.0133) right after legalization and 0.0313 (0.0175) in the medium run. For girls, the effect on dropout rates is about 1 percentage point in both the short and medium runs, while the effect is concentrated in the short run for boys, as shown in columns (2) and (3).

The proportion of 11th-grade girls who are not proficient in math increased by 0.0077 (0.0158) in the short run and by 0.0302 (0.0252) in the medium run (column (4)). Similarly, the effect for boys is concentrated in the medium run. As shown in column (5), the marginal effect for boys in math is 0.0082 (0.0246) right after legalization and -0.0229 (0.0309) in the later years. Column (6) shows that the proportion of 11th-grade girls who are not proficient in ELA increased by 0.0152 (0.0227) in the short run and 0.0671 (0.0254) in the medium run. The latter is statistically greater than zero at the 1% level of significance. The same proportion for boys decreased by 0.0289 (0.353) right after legalization and increased by 0.0163 (0.0310) in the medium run (column (7)). Note that these test score models only include 2018 in the medium run because of data availability.

Overall, the medium-run effects of legalization appear larger than the short-run effects. As the market expanded, access to marijuana and marijuana use increased, which subsequently drove educational outcomes down over time.

8.2 Two-Sample Instrumental Variables Estimation

A natural next step is to take the ratio of the reduced form effect of legalization on educational outcomes to the first stage effect on marijuana utilization to see how marijuana use affects educational outcomes. I do this formally by estimating the effect of marijuana use on educational outcomes using a two-sample instrumental variables strategy. Since the data on marijuana use and educational outcomes are at different levels, I aggregate both datasets up to the county level. Using this county-year panel, I then estimate the effect of marijuana use on chronic absenteeism, dropout rates, and proficiency rates with legalization as my instrument for marijuana use (the IV is specifically *Legal x Post*), and county and year fixed effects. Results are in Table 5. Panel A shows the effects of the probability of using marijuana on educational outcomes and Panel B shows the effects of the frequency of marijuana use on educational outcomes. For each educational outcome and marijuana use pair, I report marginal effects, standard errors clustered at the county level, standard 95% confidence intervals, and 95% confidence intervals adjusted for weak instruments.

In column (1) of Panel A, the proportion of chronically absent students increases by 0.8022 (0.2387) when the probability of using marijuana in the past month goes from 0 to 1. If the probability of using marijuana increases by 0.023, which is the effect of legalization on marijuana use across all students from the first stage, then chronic absenteeism would increase by 0.018. On the intensive margin, using marijuana one more time in the past month leads to a 0.1373 (0.0486) increase in the proportion of chronically absent students, as shown in column (1) of Panel B. If

marijuana use increased by 0.16 times, as it did in the first stage across all students, then chronic absenteeism would increase by 0.023. Both effects on absenteeism are statistically significant at the 1% level after adjusting for weak instruments. Columns (2)-(7) of Panels A and B show that dropout rates and performance in math and ELA fall for girls and boys with both measures of marijuana use, but not in statistically significant ways.

8.3 School Heterogeneity

From a policy perspective, it is important to know which students are most affected by recreational marijuana legalization. While I have already considered heterogenous effects by student gender, it is possible that there are differences across student academic achievement levels and socioeconomic status. I do not have student-level data on these measures, so I look instead at differences in these characteristics across schools. In addition, I ask whether there is heterogeneity by school location, i.e., urban, suburban, and rural schools. I will discuss the estimation results for differences across school economic disadvantage and location, but not academic performance because the results are ambiguous.[19]

8.3.1 Economic Disadvantage

The school-level data from the ODE includes the percentage of students who are eligible for free-or-reduced-price lunch. I use this to proxy for school economic disadvantage. Specifically, I calculate terciles of the percentage of free-or-reduced-price lunch eligible students across all schoolyears in my sample. Thus, schools are grouped into three categories, which I call "less poor", "poor," and "more poor," and these designations can change over time. I re-estimate equation (3)

[19] I grouped schools by terciles of the proportion of students who are not proficient in math and re-estimated equation (3) for all outcomes for each tercile. I did the same for the proportion not proficient in ELA. The results are ambiguous for both subjects.

for each of the behavioral and performance outcomes for each tercile of economic disadvantage. The results are presented in Table 7. Panel A includes behavioral outcomes while Panel B includes academic performance outcomes. Each column shows the regression coefficients of *Legal x Post* for each outcome by tercile. Standard errors clustered by county are in parentheses and one-sided p-values are in square brackets.

The marginal effects of legalization on chronic absenteeism in less poor and poor schools are 0.0140 and 0.0115, as shown in columns (1) and (2) of Panel A, respectively. Neither effect is statistically significant. The effect on chronic absenteeism in poorer schools, however, is 0.0381, which is statistically positive at the 10% level (column (3)). A similar pattern emerges for dropout rates for both girls and boys. Columns (1) and (2) show that there is no change in dropout rates in less poor and poor schools after legalization. Column (3) shows that dropout rates increase by 0.0329 for girls and 0.0234 for boys in poorer schools. I can reject the null hypothesis that these effects are less than or equal to zero at the 1% level of significance.

The effects on the proportion of girls and boys not proficient in math are ambiguous. None of the coefficients in columns (1)-(3) of Panel B are statistically significant at the standard levels. The effects of legalization on the proportion of girls not proficient in ELA, however, seem to be driven by poorer schools. In column (1), the coefficient is -0.0480 and in column (2) it is 0.0182. Neither are significant. Column (3) shows that the proportion of girls not proficient in ELA increases by 0.0488, which is statistically positive at the 5% level. Unlike girls, the proportion of boys not proficient in ELA does not change across schools of different economic disadvantage.

Overall, schools with more poor students are those most impacted by legalization. The effects on chronic absenteeism for all students, dropout rates for girls and boys, and ELA

performance for girls are larger in magnitude and statistically significant for poorer schools compared to schools that are less poor or poor.

8.3.2 School Location

To estimate the effects of legalization for schools in different locations, I use information from the Common Core of Data (CCD). The CCD classifies schools as being in one of the following locations based on U.S. Census Bureau definitions of urban and rural: small, midsize, or large cities; small, midsize, or large suburbs; remote, distant, or fringe towns; and remote, distant, or fringe rural areas. I create three categories of location based on these classifications: city schools, suburban or town schools, and rural schools. Then, I re-estimate equation (3) for each behavioral and performance outcome for these three locations separately. The results are presented in Table 8, and like Table 7, Panel A shows results for behavioral outcomes while Panel B shows results for academic performance outcomes. The columns include the coefficients of *Legal x Post*, standard errors clustered by county in parentheses, and one-sided p-values in square brackets for each outcome by location.

The marginal effect of legalization on chronic absenteeism in city schools is 0.0596, as shown in Panel A, column (1). The coefficient is statistically positive at the 1% level of significance. Columns (2) and (3) show smaller, but positive and statistically significant effects of legalization on chronic absenteeism in suburban or town schools and rural schools. The effect for suburban or town schools is 0.0371 while the effect for rural schools is 0.0200. Interestingly, the effects on dropout rates appear to be driven by schools in suburbs and towns. Column (2) shows that the dropout rate increases by 0.0113 for girls and by 0.0084 for boys after legalization. I can reject the null hypothesis that these are less than or equal to zero at the 10% level. Panel B shows

that the effects on math and ELA performance across school location are more ambiguous, though it does appear that boys do better in ELA in city schools after legalization (-0.0524 in column (1)).

Overall, chronic absenteeism increases in all schools, but the most in city schools; dropout rates for girls and boys increase in suburban or town schools; and academic performance does not change across school location.

8.4 Drive-Time Model

So far in this paper, I have used a county-level measure of marijuana accessibility – the vote-share in favor of Measure 91 – to estimate the effects on marijuana use and educational outcomes. In doing so, I have treated everyone in a county that voted for legalization as having the same level of access to marijuana. However, this is not the case. Take Lane County for instance. As shown in Figure 2, Lane County voted for Measure 91. Map (a) in Figure 6 shows that Eugene, the county seat, has several marijuana dispensaries, making it easy for people who live in or near the city to get marijuana, but more difficult for those farther away. In this section, I develop a different measure of marijuana access that utilizes this within-county variation and estimate the effects on marijuana use and educational outcomes using this measure.

8.4.1 Drive-Time Data and Measures

Using the Google Distance-Matrix API, I find the drive-time between schools and marijuana dispensaries. The API allows me to input starting and ending addresses and it uses Google Maps to calculate seconds of drive-time and meters of drive-distance between the two locations. The sample of schools includes the public high schools that appear in the ODE data from my previous analyses, while the sample of dispensaries includes *pre-existing* medical marijuana dispensaries. Specifically, I use the 110 medical marijuana dispensaries that had licenses approved

prior to July 22, 2014, the day that Measure 91 was officially put on the ballot. These medical dispensaries were allowed to participate in the early sale of recreational marijuana beginning in October 2015 and could convert to selling recreational marijuana after October 2016, making them a relevant set of dispensaries to consider. Though they could sell recreational marijuana, these dispensaries are not the full set of recreational marijuana dispensaries that opened after legalization. Thus, the effects of drive-time on marijuana use and educational outcomes are intention-to-treat rather than total average treatment effects. The main benefit of using the already-established dispensaries is that their location choice is plausibly exogenous rather than a response to recreational legalization, which allows me to identify causal effects. Figure 6 shows the distribution of pre-existing dispensaries (pink squares) and public high schools (black circles) in map (a) relative to a snapshot of recreational dispensaries active at the start of 2020 in map (b). There are fewer medical than recreational dispensaries, though they are concentrated in similar areas within counties.[20]

For each school, I calculate the minimum amount of time it takes to get to one of these dispensaries, which I use as a proxy for marijuana accessibility. While high schoolers are not necessarily driving themselves to dispensaries to purchase marijuana illegally, it is possible that they are able to get marijuana more easily from dealers, older friends, family members, etc. if their school is closer to a dispensary. To estimate the effects on marijuana access and use, I aggregate the drive-time up to the county level. Specifically, I take the weighted average of the minimum drive-times across schools in a county, where the weights are 11^{th}-grade school enrollment. I keep the drive-time at the school level to estimate the effects on educational outcomes since those data are already at the school level. Figure 7 shows the weighted average of the minimum drive-time

[20] I am currently waiting on a request for a full directory of recreational dispensaries over time from the OLCC so I can use an IV strategy and estimate total average treatment effects.

by county, where the darker shades of green indicate shorter drive-times. Not surprisingly, it generally takes less time to get to dispensaries in counties that did not opt out after legalization than in those that did.

8.4.2 Results

I re-estimate equations (2) and (3) with the minimum drive-time to a dispensary in place of *Legal*. Instead of presenting the marginal effects, I present the marginal effects evaluated at the difference-in-means between counties that did and did not opt out. Specifically, I compute the weighted average of the minimum drive-time across counties above and below the 55% vote-share threshold and take the difference, then multiply this difference by the marginal effects. The weighted average in opt-out counties is 1 hour and 43 minutes while it is 25 minutes in non-opt-out counties, so I evaluate the marginal effects at the difference of 1 hour and 18 minutes. Tables 9 and 10 show the results. Note that the drive-time is measured in hours in the tables and that a positive effect indicates an increase in the outcome when the drive-time *decreases* by an hour and 18 minutes. I interpret these results as what would have happened to marijuana use and educational outcomes in counties that opted out after legalization if the drive-time from schools to dispensaries was as short as that in counties that did not opt out.

The results for marijuana access and use are presented in Table 9. Column (1) shows that the probability that girls think getting marijuana is easy after legalization increases by 0.0246 (0.0137) when the drive-time to a dispensary decreases by an hour and 18 minutes. This effect is statistically positive at the 10% level. The probability that boys think getting marijuana is easy increases by 0.0099 (0.0137), which is not significant at the standard levels (column (2)). Decreasing the average minimum drive-time increases the likelihood of past-month marijuana use by 0.0155 for girls and 0.0085 for boys, as shown in columns (3) and (4). The one-sided p-value

is 0.129 for girls and 0.267 for boys. Column (5) shows that girls use marijuana 0.1441 (0.0750) more times in the past month when the drive-time falls. This effect is statistically greater than zero at the 10% level of significance. Column (6) shows that boys use marijuana 0.1094 (0.803) in the past month, which is not significant at the standard levels. None of the estimates remain statistically significant when I apply the Romano-Wolf correction for multiple hypothesis testing.

Table 10 shows the results for educational outcomes. Column (1) shows that chronic absenteeism increases by 0.0190 (0.0085) when average minimum drive-time between schools and dispensaries decreases by an hour and 18 minutes. This effect is statistically greater than zero at the 5% level and is robust to multiple hypothesis testing. In columns (2) and (3), dropout rates for both girls and boys increase by about 0.002 with a decrease in the drive-time. Neither effect is statistically significant at the standard levels.

Column (4) shows that girls perform worse in math when the drive-time decreases. Specifically, the proportion of girls not reaching proficiency levels in math increases by 0.0241 (0.0099) when the drive-time falls by an hour and 18 minutes. This is statistically significant at the 5% level and remains significant after I implement the Romano-Wolf correction. The effect on math proficiency for boys is slightly smaller (0.0204) and not significant, as shown in column (5). The proportion of girls who do not reach proficiency in ELA increases by 0.0255 (0.0084) while the same proportion for boys only increases by 0.0030 (0.0126), as shown in columns (6) and (7), respectively. The former is statistically positive at the 5% level and is robust to multiple hypothesis testing while the latter is not statistically significant.

Overall, the results from these drive-time models align with those from the standard difference-in-differences estimates, with a few exceptions. While the difference-in-differences estimates show no change in access to marijuana for girls or boys after legalization, the drive-time

models show that girls find marijuana more accessible the closer they are to dispensaries after legalization. Both sets of estimates suggest that 11th-grade girls use more marijuana after recreational marijuana legalization while boys do not. Additionally, they both suggest that high school chronic absenteeism and dropout rates increase, though the effects from the drive-time models are smaller and not statistically significant for the latter. ELA proficiency declines for girls in both models, while math proficiency declines for girls only in the drive-time models. Both models show that boys' proficiency in either subject does not change after legalization.

9 Mechanisms

While I cannot test every possible mechanism that could be contributing to the changes in marijuana use and educational outcomes after recreational marijuana legalization, I can examine student risk-taking behavior, where students acquire marijuana, and school spending.

9.1 Risk-Taking Behavior

Previous research in psychology suggests that boys are more prone to taking risks than girls, which could help explain why boys are typically more likely to use substances than girls.[21] Indeed, the data from the OSWS and OHTS show that boys are less likely to perceive marijuana as risky and more likely to use marijuana, while girls are more likely to perceive it as risky and less likely to use it. Legalization could change how teens perceive the risk associated with using marijuana. If girls think using marijuana is less risky after legalization while boys' perceptions do not change, then this could explain why marijuana use increases for girls but not boys after legalization.

[21] Byrnes, J., Miller, D., and Schafer, W. (1999) and Harris, C., Jenkins, M., and Glaser, D. (2006).

To test this hypothesis, I use data on the perceived risk of marijuana from the OSW and OHT surveys. Specifically, the surveys ask students how much they think people risk harming themselves (physically or in other ways) if they use marijuana at least once or twice a week.[22] I create a binary variable equal to zero if students say using marijuana regularly is not risky or slightly risky and one if students say it is moderately or greatly risky. Before legalization, the average probability that girls thought using marijuana was moderately or greatly risky was 56%, while it was 46% for boys. To determine whether risk perceptions changed after legalization in non-opt-out counties, I re-estimate equation (2) with the risk measure as the dependent variable. The results are in Table 11. Column (1) shows that legalization leads to a decrease in the probability of perceived riskiness of 0.0365 for girls, which is about a 7% decrease from the pre-legalization average. This is statistically different from zero at the 10% level of significance. Column (2), however, shows that boys' risk perceptions do not change. The coefficient on *Legal x Post* is 0.0037 and the two-tailed p-value is 0.864. These findings suggest that changing perceptions of risk are contributing to the differential changes in marijuana use for girls and boys after legalization.

9.2 Acquisition and Product Safety

It is possible that girls are less comfortable buying marijuana on the black market prior to legalization than boys. Buying from a dealer could be less safe than, say, getting marijuana from an older sibling after legalization, particularly for girls. Not only could the act of getting marijuana be safer after legalization, but the product itself is almost certainly better. As I discussed earlier in the paper, marijuana products are required to be tested for contaminants and are much less likely

[22] The SWS asks about smoking specifically, while the HTS asks about *using* marijuana. I treat these as the same questions for this analysis.

to be laced with other drugs and harmful substances, like alcohols, acetone, pesticides, and other chemicals. It is possible that boys are more likely to take the risk and get marijuana before it is legal while girls are less likely to do so. If girls decide that getting marijuana is safer and/or the quality of the marijuana is better after it is legalized, then this could help explain why they use more marijuana after legalization.

I cannot test this hypothesis directly because I do not have information on whether teens think getting marijuana is safe or whether they think the products they use are high-quality. However, starting in 2012, the OSWS asked students where they got marijuana if they used it in the past month. The choices given in the survey include the following: a public event like a sporting event or concert, a party, friends 18 or older, friends under 18, a family member, a medical marijuana cardholder or grower, I gave someone money to buy it for me, I grew it, I got it some other way. They are allowed to choose more than one option. On average, prior to legalization, girls and boys were most likely to get marijuana from their friends and at parties. I re-estimate equation (2) for each source separately to see if girls and boys change where they get marijuana after legalization. The results are in Table 12. There are no statistically significant changes in where girls get marijuana after legalization, and only a couple significant changes for boys. Column (4) shows that boys are about 4 percentage points more likely to get marijuana from a public event 12 percentage points less likely to get marijuana from older friends after legalization. Overall, it does not appear that differences in where boys and girls get marijuana after legalization are contributing to the differential changes in marijuana use.

9.3 Marijuana Tax Revenue for Schools

As I discussed earlier in the paper, early marijuana sales out of medical marijuana dispensaries are taxed at 25% by the state. Sales out of new recreational dispensaries are taxed at

17% by the state and can be taxed another 3% by counties and cities. Figure 8 shows marijuana tax receipts over time. The solid green line represents revenues from the state tax, while the green dashed line represents revenues from local taxes that are collected by the state on behalf of localities. Tax revenues increased from $2.5 to $8 million between February 2016 and October 2016, when the 25% tax rate was in place. Revenues dipped at the end of 2016 when the 17% tax was applied. Since then, revenues have steadily climbed and reached almost $16 million by August 2021.

Part of the sales tax revenues are allocated to schools located in places that did not opt out after legalization. Specifically, 40% of revenues from the state tax flow into the State School Fund, where it is then used to fund general purpose grants. This money goes into school district general funds, where it is spent on a number of items. The general fund is spent on instruction, support services, enterprise and community services, facilities acquisition and construction, and other uses. Most of the general fund is spent on instruction and support services. Instructional services include regular elementary, middle, and high school programs; special education programs to support English language learners, talented and gifted students, students with disabilities, and many others; continuing education programs; and summer school programs. Support services include student support programs like counseling, speech pathology, attendance services, and school nurses; support services for instructional staff and administrators; business services like financial accounting, student transportation, maintenance, and security services; and other services to support central activities like recruitment and technology. Enterprise and community services include food service, community recreation and public library services, and support for the custody and care of children. Facilities acquisition and construction is self-explanatory, and other uses include short- and long-term debt service.

I estimate the effect of legalization on total general fund expenditures and spending from each of these five categories to see if marijuana tax revenue is being used for a particular purpose. The data come from the ODE at the school-district-level and are available from the 2012-13 through the 2018-19 school years. There are 1,358 school districts across the sample period. The model is analogous to the reduced form given in equation (3) except I include school district fixed effects in the place of school fixed effects. The dependent variables are the natural logarithms of per pupil expenditures, so the marginal effects are interpreted as percentage changes. The results are in Table 13.

Column (1) shows that spending from the general fund increased by about 5.6% after legalization. This is about a $700 increase in per pupil spending from the pre-legalization average of $12,508. I can reject the null hypothesis that the effect is equal to zero at the 10.8% level. In column (2), legalization leads to a 7% increase in instructional spending, though this is not a statistically significant effect (two-sided p-value is 0.209). This is a $466 increase in per pupil spending relative to the average. Spending on support services goes up by 3.8%, as shown in column (3), but the effect is not statistically different from zero (two-sided p-value is 0.321). Enterprise and community services spending, facilities spending, and spending on other things, including debt service, do not change in statistically significant ways after legalization, as shown in columns (4)-(6).

To put these results in perspective, I compare them to estimates in the education production function and school finance literatures. The meta-analysis in Greenwald, Hedges, and Laine (1996) finds that the median effect of a one-dollar increase in per pupil expenditures on reading and math achievement is 0.0001-0.0003 standard deviations. The $700 increase in per pupil spending from the general fund that I find translates to about a 0.07-0.21 standard deviation increase in

achievement using these estimates. In Card and Krueger (1996), they summarize estimated effects on earnings and wages: a 10% increase in per pupil spending leads to a 1.3% increase in adult earnings and a 0.7% increase in wages. My estimates thus suggest that earnings will increase by 0.73% and wages by 0.39% when per pupil general fund expenditures increases after legalization. More recently, Jackson, Johnson, and Persico (2015) estimate the effects of increasing spending during each year of public-school education. They find that a 10% increase in per pupil spending for twelve years results in 0.31 more years of education completed, a 7-percentage-point increase in the probability of graduating from high school, and a 7.7% increase in wages. If spending from the general fund were to increase by 5.6% each year for twelve years, then the number of years of completed schooling would increase by 0.17, the probability of high school graduation would increase by 3.92 percentage points, and wages would increase by 4.3%.

Given that increasing spending likely leads to better educational outcomes, it is possible that my estimated effects of legalization on chronic absenteeism, dropout rates, and proficiency rates are lower bounds of the true effects. In other words, if schools had not received tax revenues from marijuana, then their students might have been even worse off after legalization.

10 Conclusion

This paper examines the effects of recreational marijuana legalization on underage marijuana utilization and educational outcomes in Oregon. Overall, the results suggest that legalization leads to an increase in marijuana consumption for 11^{th}-grade girls, which subsequently leads to higher rates of high school chronic absenteeism, higher dropout rates for high school girls, and worse performance in math and ELA for 11^{th}-grade girls.

These results are tempered by the following three caveats. First, since cities and counties can hold local elections to ban marijuana businesses every two years, the estimates in this paper

should be thought of as intention-to-treat rather than total average treatment effects. Second, since I only have data on marijuana use for 11th graders, the first stage estimates may not be representative of high schoolers in general. Thus, the reduced form effects can only be explained by the change in marijuana use from the first stage to the extent that a change in 11th grade use is indicative of a change in marijuana use across all high school grades.

Finally, these findings cannot necessarily be generalized to other states that have legalized recreational marijuana because they have different regulatory structures, taxes, and ways of distributing revenue. Washington, for instance, put a quota on the number of retail licenses that it would distribute and used a lottery system to determine which potential businesses would receive a license. I am currently examining the effect of legalization on educational outcomes using this exogenous variation in dispensary location. In addition, Colorado differs from Oregon in how it utilizes marijuana tax revenues. Schools still receive revenues, but Colorado uses them to help fund school construction grants instead of general grants. I am currently working to identify the demand for capital investment in Colorado using a windfall of marijuana tax revenue from 2016 and changes in the state matching contributions on capital expenditures.

References

Attendance and Absenteeism. Retrieved from Oregon Department of Education: https://www.oregon.gov/ode/reports-and-data/students/Pages/Attendance-and-Absenteeism.aspx.

Beverly, H.K., Castro, Y., & Opara, I. (2019). Age of First Marijuana Use and Its Impact on Educational Attainment and Employment Status. *Journal of Drug Issues*, 1-10.

Bray, J.W., Zarkin, G.A., Ringwalt, C. & Qi, J. (2000). The Relationship Between Marijuana Initiation and Dropping Out of High School. *Health Economics, 9*, 9-18.

Brook, J. S., Balka, E. B., & Whiteman, M. (1999). The Risks for Late Adolescence of Early Adolescent Marijuana Use. *American Journal of Public Health, 89*, 1549-1554.

Brook, J. S., Lee, J. Y., Brown, E. N., Finch, S. J., & Brook, D. W. (2011). Developmental Trajectories of Marijuana Use from Adolescence to Adulthood: Personality and Social Role Outcomes. *Psychological Reports, 108*, 339-357.

Brook, J. S., Lee, J. Y., Finch, S. J., Seltzer, N., & Brook, D. W. (2013). Adult Work Commitment, Financial Stability, and Social Environment as Related to Trajectories of Marijuana Use Beginning in Adolescence. *Substance Abuse, 34*, 298-305.

Butters, J.E. (2005). Promoting Healthy Choices: The Importance of Differentiating Between Ordinary and High-Risk Cannabis Use Among High-School Students. *Substance Use & Misuse, 40*(6), 845-855.

Byrnes, J., Miller, D., and Schafer, W. (1999). Gender Differences in Risk Taking: A Meta-Analysis. *Psychological Bulletin, 125*(3), 367-383.

Card, D. and Krueger, A. (1996). School Resources and Student Outcomes: An Overview of the Literature and New Evidence from North and South Carolina. *Journal of Economic Perspectives, 10*(4), 31-50.

Cawley, J. & Ruhm, C.J. (2011). "The Economics of Risky Health Behaviors," in M. Pauly, T. McGuire, & P. Barros, eds., *Handbook of Health Economics, Volume 2* (North Holland: Elsevier), pp. 95-199.

Cerda, M., Wall, M., Feng, T., Keyes, K. M., Sarvet, A., Schulenberg, J., & Hasin, D. S. (2017). Association of State Recreational Marijuana Laws with Adolescent Marijuana Use. *JAMA Pediatrics, 171*, 142-149.

Cerdá M., Sarvet A., Wall M., Feng T., Keyes K., Galea S., Hasin D. (2018). Medical Marijuana Laws and Adolescent Use of Marijuana and Other Substances: Alcohol, Cigarettes, Prescription Drugs, and Other Illicit Drugs. *Drug and Alcohol Dependence, 183*, 62-68.

Chatterji, P. (2006). Illicit Drug Use and Educational Attainment. *Health Economics, 15*, 489-511.

Choo, E.K., Benz, M., Zaller, N., Warren, O., Rising, K.L. & McConnell, K.J. (2014). The Impact of State Medical Marijuana Legislation on Adolescent Marijuana Use. *Journal of Adolescent Health 55,* 160-166.

Cook, P. J. & Moore, M. J. (1993). Drinking and Schooling. *Journal of Health Economics, 12*(4), 411-429.

Cuttler, C., Mischley, L.K., & Sexton, M. (2016). Sex Differences in Cannabis Use and Effects: A Cross-Sectional Survey of Cannabis Users. *Cannabis and Cannabinoid Research*, *1*(1), 166-175.

Dee, T., & Evans, W.N. (2003). Teen Drinking and Educational Attainment: Evidence from Two-Sample Instrumental Variables (TSIV) Estimates. *Journal of Labor Economics, 21*(1), 178-209.

DeSimone, J. (1998). Is Marijuana a Gateway Drug? *Eastern Economic Journal, 24*, 149-164.

Dropout Rates in Oregon High Schools. Retrieved from Oregon Department of Education: https://www.oregon.gov/ode/reports-and-data/students/Pages/Dropout-Rates.aspx.

Duarte, R., Escario, J. J., & Molina, J. A. (2006). Marijuana Consumption and School Failure among Spanish Students. *Economics of Education Review, 25*(5), 472-481.

Eisenberg, D. (2004). Peer Effects for Adolescent Substance Use: Do they Really Exist? *Health Outcomes Group.* San Francisco, CA: Health Outcomes Group.

Ellickson, P. L., Hays, R. D., & Bell, R. M. (1992). Stepping Through the Drug Use Sequence: Longitudinal Scalogram Analysis of Initiation and Regular Use. *Journal of Abnormal Psychology, 101*, 441-451.

Epstein, M., Hill, K. G., Nevell, A. M., Guttmannova, K., Bailey, J. A., Abbott, R. D., & Hawkins, J. D. (2015). Trajectories of Marijuana Use from Adolescence into Adulthood: Environmental and Individual Correlates. *Developmental Psychology, 51,* 1650-1663.

Fergusson, D.M. and Boden, J.M. (2008). Cannabis Use and Later Life Outcomes. *Addiction, 103*, 969-976.

Frontiers. (2018). Sex, drugs and estradiol: Why cannabis affects women differently. ScienceDaily. Retrieved from www.sciencedaily.com/releases/2018/10/181026102627.htm.

Green B. and Ritter C. (2000). Marijuana Use and Depression. *Journal of Health and Social Behavior, 41*(1), 40-49.

Greenwald, R., Hedges, L., and Laine, R. (1996). The Effect of School Resources on Student Achievement. *Review of Educational Research, 66*(3), 361-396.

Grossman, M. (1972). On the Concept of Health Capital and the Demand for Health. *Journal of Political Economy, 80*(2), 223-249.

Guo, J., Hill, K., Hawkins, J., Catalano, R., Abbott, R. (2002). A Developmental Analysis of Sociodemographic, Family, and Peer Effects on Adolescent Illicit Drug Initiation. *Journal of the American Academy of Child & Adolescent Psychiatry, 41*(7), 838-845.

Hanners, R. "Recreational Marijuana Industry to Expand in Grant County." *Blue Mountain Eagle*. 20 Dec 2018. https://www.bluemountaineagle.com/news/recreational-marijuana-industry-to-expand-in-grant-county/article_fe21baff-725f-51bf-beea-e7cb2bd6a51e.html.

Harper, S., Strumpf, E.C. & Kaufman, J.S. (2012). Do Medical Marijuana Laws Increase Marijuana Use? Replication Study and Extension. *Annals of Epidemiology, 22*, 207-212.

Harris, C., Jenkins, M., and Glaser, D. (2006). Gender Differences in Risk Assessment: Why do Women Take Fewer Risks than Men? *Judgement and Decision Making, 1*(1), 48-63.

Henneberger, A., Mushonga, D., and Preston, A. (2021). Peer Influence and Adolescent Substance Use: A Systematic Review of Dynamic Social Network Research. *Adolescent Research Review, 6*, 57-73.

House Bill 2041. (2015). Retrieved from Oregon State Legislature: https://olis.leg.state.or.us/liz/2015R1/Downloads/MeasureDocument/HB2041.

Jackson, C., Johnson, R., and Persico, C. (2015). The Effects of School Spending on Educational and Economic Outcomes: Evidence from School Finance Reforms. *The Quarterly Journal of Economics,* 157-218.

Jacobus, J. and Tapert, S. (2014). Effects of Cannabis on the Adolescent Brain. *Current Pharmaceutical Design, 20*(13), 2186-2193.

Kandel, D. B., Yamaguchi, K., & Chen, K. (1992). Stages of Progression in Drug Involvement from Adolescence to Adulthood: Further Evidence for the Gateway Theory. *Journal of Studies on Alcohol, 53*, 447-457.

Kawaguchi, D. (2004). Peer Effects on Substance Use Among American Teenagers. *Journal of Population Economics, 17*, 351-367.

Kerr, D. C., Bae, H., Phibbs, S., & Kern, A. C. (2017). Changes in Undergraduates' Marijuana, Heavy Alcohol, and Cigarette Use Following Legalization of Recreational Marijuana Use in Oregon. *Addiction.*

Khatapoush S., Hallfors D. 2004. Sending the Wrong Message: Did Medical Marijuana Legalization in California Change Attitudes About and Use of Marijuana*? Journal of Drug Issues, 34,* 751-770.

Lisdahl, K. M., Gilbart, E. R., Wright, N. E., & Shollenbarger, S. (2013). Dare to Delay? The Impacts of Adolescent Alcohol and Marijuana Use Onset on Cognition, Brain Structure, and Function. *Frontiers in Psychiatry, 4*(53), 1-19.

Local Government Regulation of Marijuana in Oregon. (2015). Retrieved from League of Oregon Cities: https://bend.granicus.com/MetaViewer.php?view_id=9&clip_id=352&meta_id=12747.

Lundborg, P. (2006). Having the Wrong Friends? Peer Effects in Adolescent Substance Use. *Journal of Health Economics, 25*(2), 214-233.

Lynne-Landsman, S.D., Livingston, M.D. & Wagenaar, A.C. (2013). Effects of State Medical Marijuana Laws on Adolescent Marijuana Use. *American Journal of Public Health, 103*, 1500-1506.

Lynskey, M. and Hall, W. (2000). The Effects of Adolescent Cannabis Use on Educational Attainment: A Review. *Addiction, 95*, 1621-1630.

Marijuana Taxes. (2018). Retrieved from Oregon Department of Revenue: https://www.oregon.gov/dor/press/Documents/marijuana_fact_sheet.pdf.

Mason, M., Mennis, J., Linker, J., Bares, C., and Zaharakis, N. (2014). Peer Attitudes Effects on Adolescent Substance Use: The Moderating Role of Race and Gender. *Prevention Science, 15*, 56-64.

Measure 91. (2014). Retrieved from Oregon Liquor Control Commission: https://www.oregon.gov/olcc/marijuana/Documents/Measure91.pdf.

Metric Cannabis Tracking System. (2021). Retrieved from the Oregon Liquor Control Commission: https://data.olcc.state.or.us/#/site/OLCCPublic/views/MarketDataTableau/MainScreen?:iid=1.

McCaffrey, D. F., Liccardo Pacula, R., Han, B., & Ellickson, P. (2010). Marijuana Use and High School Dropout: The Influence of Unobservables. *Health Economics, 19*, 1281-1299.

Mokrysz, C., Landy, R., Gage, S. H., Munafò, M. R., Roiser, J. P., & Curran, H. V. (2016). Are IQ and Educational Outcomes in Teenagers Related to their Cannabis Use? A Prospective Cohort Study. *Journal of Psychopharmacology, 30,* 159-168.

Morbidity and Mortality Weekly Report: Methodology of the Youth Risk Behavior Surveillance System. (2013). Retrieved from the Centers for Disease Control and Prevention: https://www.cdc.gov/mmwr/pdf/rr/rr6201.pdf.

Moriarty, J., McVicar, D., and Higgins, K. (2012). Peer Effects in Adolescent Cannabis Use: It's the Friends, Stupid. *Melbourne Institute Working Paper Series: Working Paper No. 27/12*.

Oregon Healthy Teens Survey. Retrieved from Oregon Health Authority: https://www.oregon.gov/oha/PH/BIRTHDEATHCERTIFICATES/SURVEYS/OREGONHEALTHYTEENS/Pages/index.aspx.

Oregon Marijuana Measures. (2016). Retrieved from The Oregonian: https://gov.oregonlive.com/election/2016/general/marijuana-results/.

Oregon Student Wellness Survey. Retrieved from Oregon Health Authority: https://oregon.pridesurveys.com/.

ORS 327.008 State School Fund: State School Fund Grants. (2020). Retrieved from Oregon Laws: https://www.oregonlaws.org/ors/327.008.

Pope, H. G., Gruber, A. J., & Yurgelun-Todd, D. (1995). The Residual Neuropsychological Effects of Cannabis: The Current Status of Research. *Drug and Alcohol Dependence, 38,* 25-34.

Program Budgeting and Accounting Manual: For School Districts and Education Service Districts in Oregon. (2019). Retrieved from the Oregon Department of Education: https://www.oregon.gov/ode/schools-and-districts/grants/Documents/Program%20Budgeting%20and%20Accounting%20Manual%20(PBAM)%20-%202019%20Edition%20(Effective%20as%20of%20July%201,%202020).pdf.

Record of Cities/Counties Prohibiting Licensed Recreational Marijuana Facilities. (2021). Retrieved from Oregon Liquor Control Commission: https://www.oregon.gov/olcc/marijuana/Documents/Cities_Counties_RMJOptOut.pdf.

Register, C. A., Williams, D. R. & Grimes, P. W. (2001). Adolescent Drug Use and Educational Attainment. *Education Economics, 9*(1), 1-18.

Renna, F. (2007). The Economics Cost of Teen Drinking: Late Graduation and Lowered Earnings. *Health Economics, 16*(4), 407-419.

Report on Adequacy of Public Education Funding. (2018). Retrieved from Oregon Legislature: https://www.oregonlegislature.gov/citizen_engagement/Reports/JISPEA_2018EducationBudget_EdFunding.pdf.

Roebuck, M. C., French, M. T., & Dennis, M. L. (2004). Adolescent Marijuana Use and School Attendance. *Economics of Education Review, 23*(2), 133-141.

Rusby, J. C., Westling, E., Crowley, R., & Light, J. M. (2018). Legalization of Recreational Marijuana and Community Sales Policy in Oregon: Impact on Adolescent Willingness and Intent to Use, Parent Use, and Adolescent Use. *Psychology of Addictive Behaviors, 32*, 84-92.

Ryan, A. K. (2010). The Lasting Effects of Marijuana Use on Educational Attainment in Midlife. *Substance Use and Misuse, 45*(4), 554-597.

Schepis, T.S., Desai, R.A., Cavallo, D.A., Smith, A.E., McFetridge, A., Liss, T.B., Potenza, M.N., & Krishnan-Sarin, S. (2011). Gender Differences in Adolescent Marijuana Use and Associated Psychosocial Characteristics. *Journal of Addiction Medicine, 5*(1), 65-73.

Schuermeyer, J., Salomonsen-Sautel, S., Price, R.K., Balan, S., Thurstone, C., Min, S-J., & Sakai, J. T. (2014). Temporal Trends in Marijuana Attitudes, Availability and Use in Colorado Compared to Non-Medical Marijuana States: 2003-11. *Drug and Alcohol Dependence, 140*, 145-155.

Senate Bill 460. (2015). Retrieved from Oregon State Legislature: https://olis.leg.state.or.us/liz/2015R1/Downloads/MeasureDocument/SB460/A-Engrossed.

Sex and Gender Differences in Substance Use. (2021). *National Institute on Drug Abuse*. https://www.drugabuse.gov/publications/research-reports/substance-use-in-women/sex-gender-differences-in-substance-use.

Silins, E., Horwood, L. J., Patton, G. C., Fergusson, D. M., Olsson, C. A., Hutchinson, D. M., & Coffey, C. (2014). Young Adult Sequelae of Adolescent Cannabis Use: An Integrative Analysis. *The Lancet Psychiatry, 1*, 286-293.

State School Fund: School District and ESD Payment Statements. Retrieved from Oregon Department of Revenue: https://www.oregon.gov/ode/schools-and-districts/grants/Pages/School-District-and-ESD-payment-Statements.aspx.

Statistics from Oregon Marijuana Tax Returns. (2016). Retrieved from Oregon Department of Revenue: https://www.oregon.gov/dor/programs/gov-research/Documents/marijuana-tax-report_2016.pdf.

Stroup, K. "Oregon Ballot Measure 91: Will Third Time Be The Charm?" *NORML*, 6 Oct. 2014. https://norml.org/blog/2014/10/06/oregon-ballot-measure-91-will-third-time-be-the-charm/.

Subbaraman, M. S. (2016). Substitution and Complementarity of Alcohol and Cannabis: A Review of the Literature, *Substance Use and Misuse, 51*(11), 1399-1414.

Thompson, K., Leadbeater, B., Ames, M., & Merrin, G. J. (2019). Associations Between Marijuana Use Trajectories and Educational and Occupational Success in Young Adulthood. *Prevention Science, 20,* 257-269.

Wall, M.M., Poh, E., Cerda, M., Keyes, K.M., Galea, S. & Hasin, D.S. (2011). Adolescent Marijuana Use from 2002 to 2008: Higher in States with Medical Marijuana Laws, Cause Still Unclear. *Annals of Epidemiology, 21*, 714-716.

Washington State University. (2014). Estrogen increases cannabis sensitivity, study shows. ScienceDaily. Retrieved from www.sciencedaily.com/releases/2014/09/140903092153.htm.

Weir, K. (2015). Marijuana and the Developing Brain. *American Psychological Association: Monitor on Psychology, 46*(10), 48.

What's Legal Oregon. Retrieved from What's Legal Oregon: http://whatslegaloregon.com/#!.

Withycombe, C. "Six Oregon Cities Vote to Allow Marijuana Business." *Salem Reporter*. 7 Nov. 2018. https://www.salemreporter.com/posts/184/six-oregon-cities-vote-to-allow-marijuana-business.

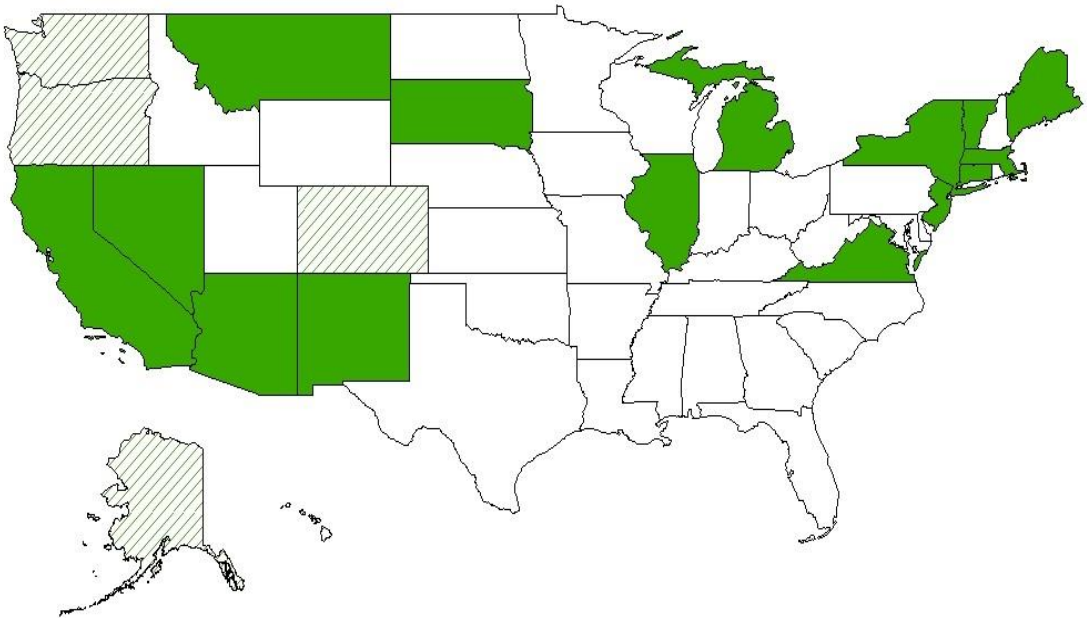
Yamada, T., Kendix, M. & Yamada, T. (1996). The Impact of Alcohol Consumption and Marijuana Use on High School Graduation. *Health Economics, 5*, 77-92.

2017 ORS 161.125: Drug or Controlled Substance Use or Dependence or Intoxication as Defense. (2018). Retrieved from Oregon Laws: https://www.oregonlaws.org/ors/161.125.

2017 ORS 475B.785: Findings. (2018). Retrieved from Oregon Laws: https://www.oregonlaws.org/ors/475B.785.

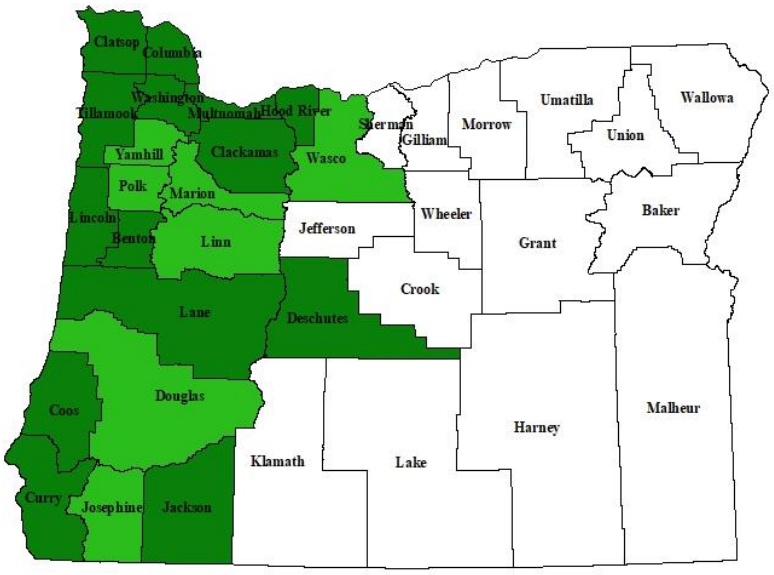
Figures

Figure 1: Legality of Recreational Marijuana Across the United States



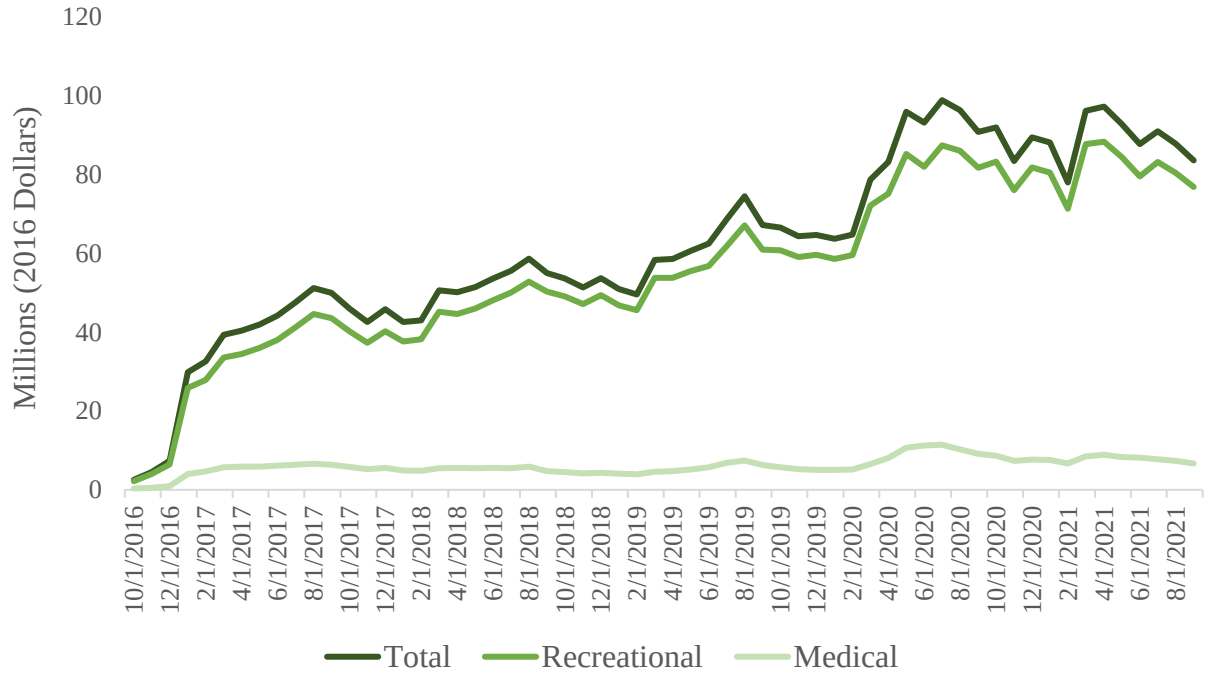
Notes: This figure shows which states legalized recreational marijuana by September 2021. The states with stripes legalized recreational marijuana by 2014, including Oregon. The solid green states are those that have legalized marijuana since 2014.

Figure 2: Legality of Recreational Marijuana by County in Oregon



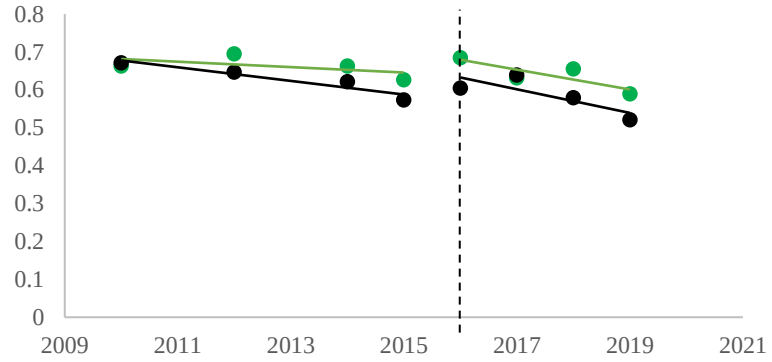
Notes: This figure shows which counties in Oregon were able to opt-out after legalization. The counties in white had a 55% majority against Measure 91 and were allowed to (and did) opt out. Those in light green had a 50% majority against legalization but were not allowed to opt out. Counties in dark green had less than 45% of votes against marijuana and were unable to opt out.

Figure 3: Monthly Marijuana Sales in Oregon

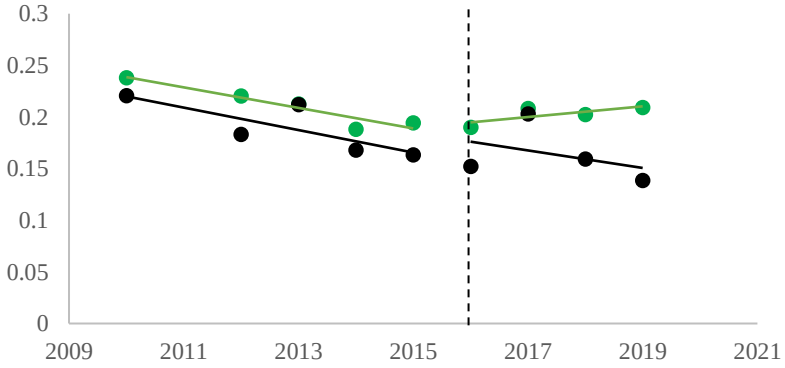


Notes: This figure shows trends in total, recreational, and medical marijuana sales in Oregon from October 2016 through September 2021. The data was extracted from the Oregon Liquor and Cannabis Commission's Metric Cannabis Tracking System.

Figure 4: Trends in Average Marijuana Access and Utilization in Oregon for Opt-Out and Non-Opt-Out Counties



(a) Marijuana Access

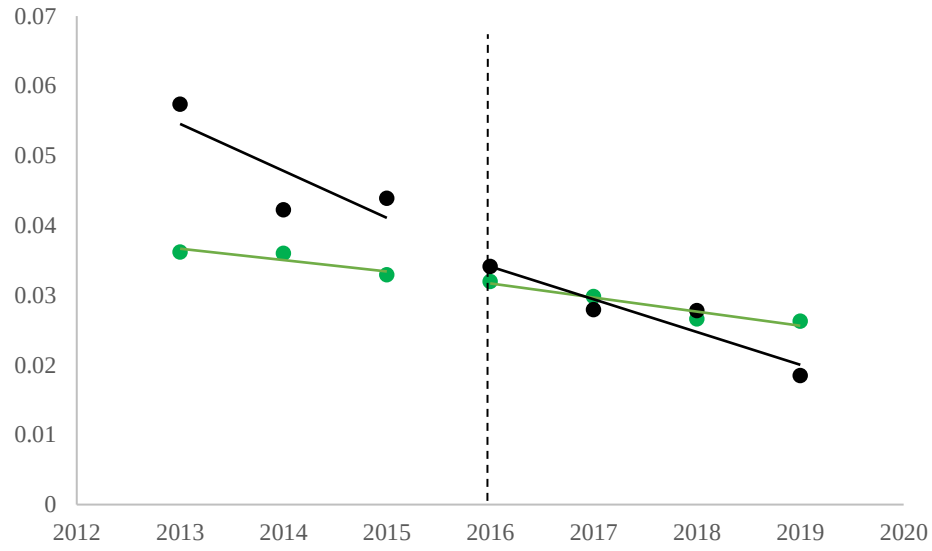


(b) Marijuana Use (Extensive)

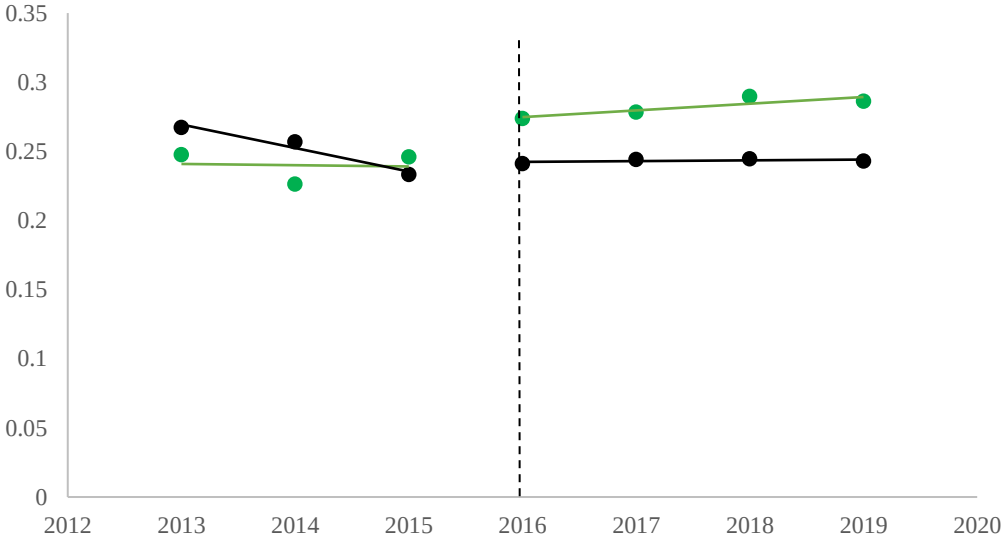
(c) Marijuana Use (Intensive)

Notes: This figure shows trends in 11th-grade average marijuana access (a), marijuana use on the extensive margin (b), and marijuana use on the intensive margin (c) from the OSWS and OHTS. The years on the x-axis are spring semesters. Linear trendlines are fitted to the average outcomes before and after marijuana sales began in the 2015-16 school year (marked by the vertical dashed line). The green lines show trends across counties that did not opt out after legalization, and the black lines show trends across counties that opted out after legalization.

Figure 5: Trends in the Average Dropout Rate and Chronic Absenteeism in Oregon for Opt-Out and Non-Opt-Out Counties



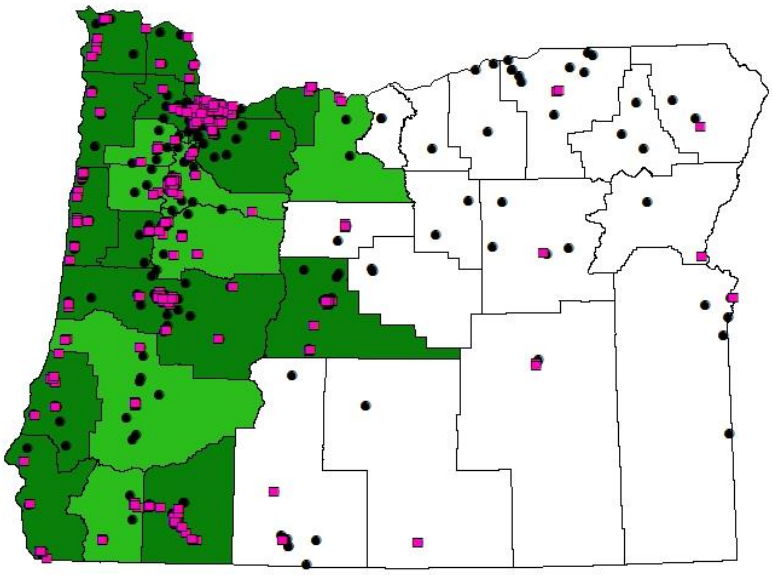
(a) Dropout Rate



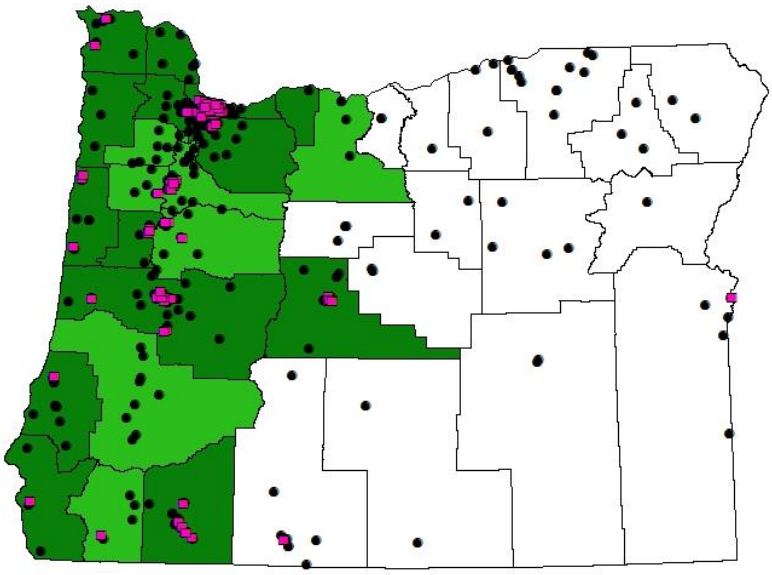
(b) Chronic Absenteeism

Notes: This figure shows the average high school dropout rate (a) and proportion of chronically absent high school students (b) over time. The years on the x-axis are spring semesters. Linear trendlines are fitted to the average outcomes before and after marijuana sales began in the 2015-16 school year (marked by the vertical dashed line). The green lines show trends across counties that did not opt out after legalization, and the black lines show trends across counties that opted out after legalization.

Figure 6: Distribution of Schools and Marijuana Dispensaries Across Oregon



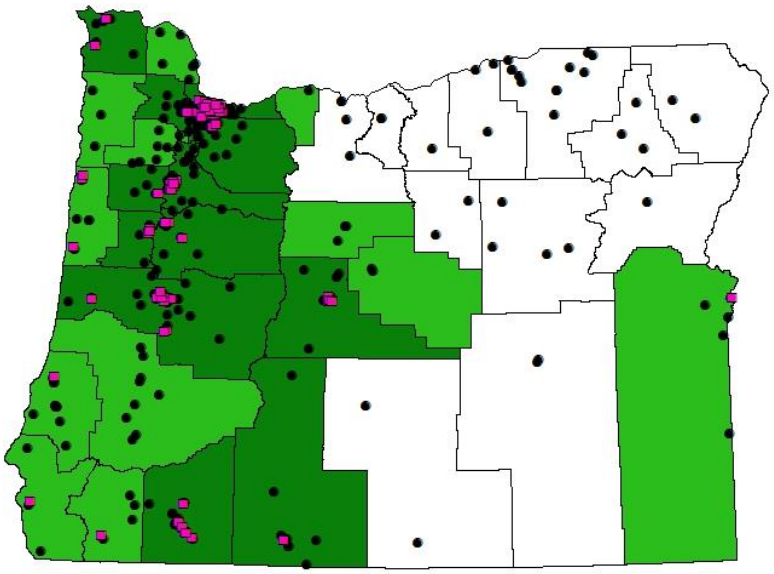
(a) Public High Schools and Recreational Marijuana Dispensaries



(b) Public High Schools and Pre-Existing Medical Marijuana Dispensaries

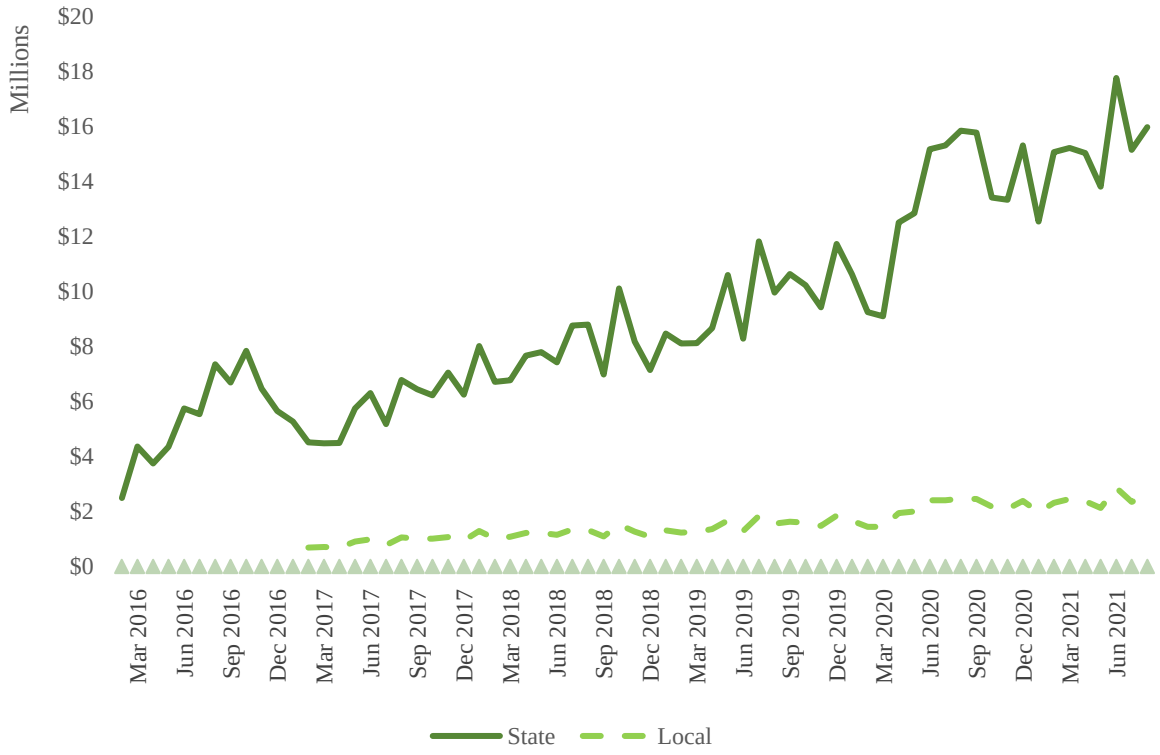
Notes: This figure shows the distribution of public high schools and marijuana dispensaries across Oregon. Map (a) shows public high schools and recreational marijuana dispensaries active at the beginning of 2020. Map (b) shows public high schools and medical marijuana dispensaries licensed before Measure 91 was put on the ballot. The counties in white had a 55% majority against Measure 91 and banned marijuana businesses. Those in light green had a 50% majority against legalization but were not given the option to ban. Counties in dark green were unable to ban. The black circles are public high schools, and the pink squares are marijuana dispensaries. There are some dispensaries located in the white counties because of elections at the county and city levels that subsequently allowed the operation of retail marijuana businesses.

Figure 7: Variation in the Minimum Drive-Time Between Schools and Dispensaries Across Counties in Oregon



Notes: This figure shows the average minimum drive-time between public high schools (black circles) and pre-existing medical marijuana dispensaries (pink squares) weighted by 11th-grade enrollment for each county in Oregon. Drive-time is given in hours. The dark green counties have average minimum drive-times between 0.12 and 0.24 hours (~7 to 14 minutes). The light green counties have average minimum drive-times between 0.24 and 1.02 hours (~14 minutes to an hour). The white counties have average minimum drive-times between 1.02 and 2.97 hours.

Figure 8: Monthly Marijuana Tax Receipts in Oregon



Notes: This figure shows monthly marijuana tax receipts in Oregon from February 2016 through August 2021. The data come from the Oregon Department of Revenue. Starting in 2017, counties and cities can tax marijuana sales at 3%. The dashed line shows the tax receipts from these local taxes that were collected by the state on behalf of localities. The dip in state tax receipts at the end of 2016 reflects the decrease in the tax rate from 25% to 17% as recreational sales transitioned from medical dispensaries to new recreational dispensaries.

Tables

Table 1: Marginal Effects of Recreational Marijuana Legalization in Oregon on 11th-Grade Marijuana Access and Use by Student Gender

	Marijuana Access		Marijuana Use (Extensive)		Marijuana Use (Intensive)	
	Female	Male	Female	Male	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)
Legal x Post	0.0248	-0.0198	0.0409	0.0041	0.2749	0.0338
	(0.0222)	(0.0221)	(0.0178)	(0.0174)	(0.1232)	(0.1236)
	[0.133]	[0.185]	[0.011]	[0.407]	[0.013]	[0.392]
	{0.297}	{0.307}	{0.035}	{0.455}	{0.045}	{0.455}
Dependent Mean	0.63	0.67	0.19	0.22	1.04	1.59
Observations	53,277	52,199	60,541	59,594	60,140	58,950

Notes: This table reports marginal effects from the estimation of equation (2). Probit models are used in columns (1)-(4), while interval regression models are used in columns (5) and (6). There are fewer observations in columns (1) and (2) because data on marijuana access is not available in 2013. All specifications control for student ethnicity and include county and year fixed effects. County-level school enrollment weights are applied in each model. Standard errors clustered by county are in parentheses. One-tailed p-values are shown in square brackets and Romano-Wolf p-values correcting for multiple hypothesis testing are in curly brackets.

Table 2: Marginal Effects of Recreational Marijuana Legalization in Oregon on High School Chronic Absenteeism, Dropout Rates, and 11th-Grade Math and ELA Test Scores

	Chronic Absenteeism	Dropout Rate		Not Proficient in Math		Not Proficient in ELA	
	All	Female	Male	Female	Male	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Legal x Post	0.0292	0.0097	0.0069	0.0152	-0.0027	0.0322	-0.0136
	(0.0134)	(0.0044)	(0.0035)	(0.0151)	(0.0260)	(0.0160)	(0.0296)
	[0.018]	[0.018]	[0.028]	[0.161]	[0.459]	[0.026]	[0.324]
	{0.030}	{0.030}	{0.030}	{0.243}	{0.431}	{0.050}	{0.391}
Dependent Mean	0.24	0.03	0.04	0.71	0.70	0.28	0.38
Observations	1,550	1,553	1,553	766	777	777	814

Notes: This table reports marginal effects from the estimation of equation (3). Chronic absenteeism is not available by gender. There are fewer observations in columns (4)-(7) because proficiency rates are only available between 2014-15 and 2017-18. All specifications control for the proportions of students who are Asian, Hispanic, Black, disabled, and receive free-or-reduced-price lunch, and include school and year fixed effects. Standard errors clustered by county are in parentheses. One-tailed p-values are shown in square brackets and Romano-Wolf p-values correcting for multiple hypothesis testing are in curly brackets.

Table 3: Placebo Test with Random Assignment of Vote-Share Across Counties

	Marijuana Access	Marijuana Use (Extensive)	Marijuana Use (Intensive)	Chronic Absenteeism	Dropout Rate	Not Proficient in Math	Not Proficient in ELA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Placebo Treatment x Post	0.0007	-0.0027	-0.0448	0.0168	0.0009	0.0104	0.0089
	(0.0093)	(0.0074)	(0.0589)	(0.0149)	(0.0024)	(0.0139)	(0.0123)
	[0.468]	[0.357]	[0.224]	[0.133]	[0.356]	[0.229]	[0.236]
Observations	105,476	120,135	119,090	1,550	1,553	1,004	1,035

Notes: This table reports marginal effects from the estimation of equations (2) and (3) where *Legal* is replaced with a binary variable *Placebo Treatment* that equals 1 if the randomly assigned vote-share against legalization is less than 55% and 0 if it is greater than or equal to 55%. Columns (1)-(3) control for student gender and ethnicity and include county and year fixed effects. Columns (4)-(7) control for the proportions of students who are Asian, Hispanic, Black, disabled, and receive free-or-reduced-price lunch, and include school and year fixed effects. Standard errors clustered by county are in parentheses and one-tailed p-values are shown in square brackets.

Table 4: Short- and Medium-Run Effects of Recreational Marijuana Legalization in Oregon on 11th-Grade Marijuana Access and Use by Student Gender

	Marijuana Access		Marijuana Use (Extensive)		Marijuana Use (Intensive)	
	Female	Male	Female	Male	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)
Legal x (2016 or 2017)	-0.0156	-0.0409	0.0109	-0.0242	0.2377	-0.0795
	(0.0272)	(0.0274)	(0.0226)	(0.0229)	(0.1545)	(0.1640)
	[0.284]	[0.068]	[0.316]	[0.146]	[0.062]	[0.314]
Legal x (2018 or 2019)	0.062	-0.0011	0.0727	0.0319	0.3102	0.1384
	(0.0269)	(0.0265)	(0.0221)	(0.0205)	(0.1493)	(0.1320)
	[0.011]	[0.484]	[0.001]	[0.061]	[0.019]	[0.147]
Dependent Mean	0.63	0.67	0.19	0.22	1.04	1.59
Observations	53,277	52,199	60,541	59,594	60,140	58,950

Notes: This table reports marginal effects from the estimation of equation (2) with interactions of *Legal* and dummy variables for different post-legalization years. Probit models are used in columns (1)-(4), while interval regression models are used in columns (5) and (6). There are fewer observations in columns (1) and (2) because data on marijuana access is not available in 2013. All specifications control for student ethnicity and include county and year fixed effects. County-level school enrollment weights are applied in each model. Standard errors clustered by county are in parentheses and one-tailed p-values are shown in square brackets.

Table 5: Short- and Medium-Run Effects of Recreational Marijuana Legalization in Oregon on High School Chronic Absenteeism, Dropout Rates, and 11th-Grade Math and ELA Test Scores

	Chronic Absenteeism	Dropout Rate		Not Proficient in Math		Not Proficient in ELA	
	All	Female	Male	Female	Male	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Legal x (2016 or 2017)	0.0274	0.0093	0.0081	0.0077	0.0082	0.0152	-0.0289
	(0.0133)	(0.0053)	(0.0037)	(0.0158)	(0.0246)	(0.0227)	(0.0353)
	[0.023]	[0.044]	[0.018]	[0.313]	[0.371]	[0.254]	[0.210]
Legal x (2018 or 2019)	0.0313	0.0100	0.0055				
	(0.0175)	(0.0072)	(0.0047)				
	[0.041]	[0.088]	[0.123]				
Legal x (2018)				0.0302	-0.0229	0.0671	0.0163
				(0.0252)	(0.0309)	(0.0254)	(0.0310)
				[0.120]	[0.232]	[0.006]	[0.301]
Dependent Mean	0.24	0.03	0.04	0.71	0.70	0.28	0.38
Observations	1,550	1,553	1,553	766	777	777	814

Notes: This table reports marginal effects from the estimation of equation (3) with interactions of *Legal* and dummy variables for different post-legalization years. Chronic absenteeism is not available by gender. There are fewer observations in columns (4)-(7) because proficiency rates are only available between 2014-15 and 2017-18. All specifications control for the proportions of students who are Asian, Hispanic, Black, disabled, and receive free-or-reduced-price lunch, and include school and year fixed effects. Standard errors clustered by county are in parentheses and one-tailed p-values are shown in square brackets.

Table 6: Two-Sample Instrumental Variable Estimates of the Effect of Marijuana Use on High School Chronic Absenteeism, Dropout Rates, and 11th-Grade Math and ELA Test Scores

	Chronic Absenteeism	Dropout Rate		Not Proficient in Math		Not Proficient in ELA	
	All	Female	Male	Female	Male	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A:							
Marijuana Use	0.8022	-0.0773	-0.1058	-0.3242	-0.5571	-0.4146	-0.2269
(Extensive)	(0.2387)	(0.0505)	(0.0772)	(0.2913)	(0.4172)	(0.3134)	(0.3751)
	[0.332, 1.273]	[-0.177, 0.022]	[-0.258, 0.046]	[-0.901, 0.253]	[-1.383, 0.269]	[-1.035, 0.206]	[-0.969, 0.515]
	{0.377, 1.643}	{-0.259, 0.049}	{-0.408, 0.087}	{-1.466, 0.518}	{-2.192, 0.517}	{-1.643, 0.367}	{-1.697, 1.036}
Panel B:							
Marijuana Use	0.1373	-0.0141	-0.0160	-0.0371	-0.0568	-0.0475	-0.0232
(Intensive)	(0.0486)	(0.0095)	(0.0122)	(0.0307)	(0.0410)	(0.0318)	(0.0380)
	[0.042, 0.233]	[-0.033, 0.005]	[-0.040, 0.008]	[-0.098, 0.024]	[-0.138, 0.024]	[-0.110, 0.015]	[-0.098, 0.052]
	{0.062, 0.328}	{-0.051, 0.009}	{-0.064, 0.014}	{-0.150, 0.047]	{-0.218, 0.049}	{-0.167, 0.034}	{-0.169, 0.096}
Observations	230	230	230	125	127	124	127

Notes: This table reports two-sample instrumental variables estimates of the effects of marijuana use on educational outcomes. Marginal effects of marijuana use on the extensive margin for each educational outcome are in *Panel A*, while effects of marijuana use on the intensive margin for each outcome are presented in *Panel B*. Columns (1)-(3) include the years 2012-13 through 2018-19, while columns (4)-(7) include 2014-15 through 2017-18. Standard errors clustered by county are in parentheses. Standard 95% confidence intervals are in square brackets, while 95% confidence intervals assuming that *Legal x Post* is a weak IV are in curly brackets.

Table 7: Effects of Recreational Marijuana Legalization in Oregon on Student Behavioral and Performance Outcomes for Schools with Different Levels of Student Disadvantage

Dependent Variable	Less Poor (1)	Poor (2)	More Poor (3)
Panel A:			
Chronic Absenteeism	0.0140	0.0115	0.0381
	(0.0236)	(0.0228)	(0.0239)
	[0.278]	[0.309]	[0.060]
Dropout Rate (Female)	-0.0029	-0.0017	0.0329
	(0.0045)	(0.0065)	(0.0115)
	[0.262]	[0.397]	[0.004]
Dropout Rate (Male)	-0.0046	0.0014	0.0234
	(0.0064)	(0.0052)	(0.0069)
	[0.239]	[0.397]	[0.001]
Panel B:			
Not Proficient in Math (Female)	0.0432	-0.0197	0.0216
	(0.0866)	(0.0470)	(0.0240)
	[0.311]	[0.339]	[0.188]
Not Proficient in Math (Male)	0.0416	-0.0072	0.0070
	(0.0608)	(0.0719)	(0.0334)
	[0.250]	[0.461]	[0.418]
Not Proficient in ELA (Female)	-0.0480	0.0182	0.0488
	(0.0391)	(0.0487)	(0.0278)
	[0.116]	[0.355]	[0.0457]
Not Proficient in ELA (Male)	0.0400	-0.0683	0.0071
	(0.1014)	(0.0675)	(0.0504)
	[0.348]	[0.159]	[0.444]

Notes: This table reports marginal effects from the estimation of equation (3) for three groups of schools: less poor, poor, and more poor. These groups are terciles of the proportion of students eligible for free-or-reduced-price lunch. *Panel A* shows results for student behavioral outcomes and includes the 2012-13 through 2018-19 school years, while *Panel B* shows results for student academic performance and includes the 2014-15 through 2017-18 school years. All specifications control for the proportions of students who are Asian, Hispanic, Black, disabled, and receive free-or-reduced-price lunch, and include school and year fixed effects. Standard errors clustered by county are in parentheses and one-tailed p-values are shown in square brackets.

Table 8: Effects of Recreational Marijuana Legalization in Oregon on Student Behavioral and Performance Outcomes for City, Suburban or Town, and Rural Schools

Dependent Variable	City (1)	Suburb or Town (2)	Rural (3)
Panel A:			
Chronic Absenteeism	0.0596	0.0371	0.0200
	(0.0207)	(0.0186)	(0.0133)
	[0.009]	[0.028]	[0.071]
Dropout Rate (Female)	-0.0020	0.0113	0.0059
	(0.0041)	(0.0068)	(0.0049)
	[0.320]	[0.053]	[0.117]
Dropout Rate (Male)	-0.0010	0.0084	0.0004
	(0.0042)	(0.0057)	(0.0052)
	[0.411]	[0.073]	[0.473]
Panel B:			
Not Proficient in Math (Female)	0.0399	0.0002	-0.0115
	(0.0539)	(0.0205)	(0.0273)
	[0.239]	[0.496]	[0.339]
Not Proficient in Math (Male)	-0.0121	-0.0154	-0.0191
	(0.0270)	(0.0337)	(0.0344)
	[0.332]	[0.326]	[0.292]
Not Proficient in ELA (Female)	-0.0066	0.0313	0.0158
	(0.0083)	(0.0327)	(0.0436)
	[0.221]	[0.173]	[0.360]
Not Proficient in ELA (Male)	-0.0524	-0.0062	-0.0252
	(0.0250)	(0.0483)	(0.0505)
	[0.033]	[0.450]	[0.310]
Number of Schools	48	123	84

Notes: This table reports marginal effects from the estimation of equation (3) for three groups of schools: city, suburban or town, and rural schools. *Panel A* shows results for student behavioral outcomes and includes the 2012-13 through 2018-19 school years, while *Panel B* shows results for student academic performance and includes the 2014-15 through 2017-18 school years. All specifications control for the proportions of students who are Asian, Hispanic, Black, disabled, and receive free-or-reduced-price lunch, and include school and year fixed effects. Standard errors clustered by county are in parentheses and one-tailed p-values are shown in square brackets.

Table 9: Effects of the Minimum Drive-Time Between Public High Schools and Pre-Existing Medical Marijuana Dispensaries in Oregon on 11th-Grade Marijuana Access and Use by Student Gender

	Marijuana Access		Marijuana Use (Extensive)		Marijuana Use (Intensive)	
	Female	Male	Female	Male	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)
Minimum Drive-Time x Post	0.0246	0.0099	0.0155	0.0085	0.1441	0.1094
(Evaluated at 1.302 hours)	(0.0137)	(0.0137)	(0.0105)	(0.0104)	(0.0750)	(0.0803)
	[0.084]	[0.290]	[0.129]	[0.267]	[0.070]	[0.148]
	{0.317}	{0.381}	{0.347}	{0.381}	{0.307}	{0.347}
Dependent Mean	0.63	0.67	0.19	0.22	1.04	1.59
Observations	53,277	52,199	60,541	59,594	60,140	58,950

Notes: This table reports results from the estimation of equation (2) where *Legal* is replaced with weighted county averages of the minimum drive-time between public high schools and pre-existing medical marijuana dispensaries. These are not marginal effects, rather the marginal effects evaluated at the difference-in-means of the drive-time measure between counties that did and did not opt-out after legalization (1.302 hours, or 1 hour and 18 minutes). Probit models are used in columns (1)-(4), while interval regression models are used in columns (5) and (6). There are fewer observations in columns (1) and (2) because data on marijuana access is not available in 2013. All specifications control for student ethnicity and include county and year fixed effects. County-level school enrollment weights are applied in each model. Standard errors clustered by county are in parentheses. One-tailed p-values are shown in square brackets and Romano-Wolf p-values correcting for multiple hypothesis testing are in curly brackets.

Table 10: Effects of the Minimum Drive-Time Between Public High Schools and Pre-Existing Medical Marijuana Dispensaries in Oregon on High School Chronic Absenteeism, Dropout Rates, and 11th-Grade Math and ELA Test Scores

	Chronic Absenteeism	Dropout Rate		Not Proficient in Math		Not Proficient in ELA	
	All	Female	Male	Female	Male	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Minimum Drive-Time x Post	0.0190	0.0020	0.0021	0.0241	0.0204	0.0255	0.0030
	(0.0085)	(0.0019)	(0.0020)	(0.0099)	(0.0137)	(0.0084)	(0.0126)
(Evaluated at	[0.048]	[0.222]	[0.208]	[0.035]	[0.130]	[0.013]	[0.429]
1.302 hours)	{0.045}	{0.253}	{0.253}	{0.064}	{0.173}	{0.059}	{0.406}
Dependent Mean	0.24	0.03	0.04	0.71	0.70	0.28	0.38
Observations	1,550	1,553	1,553	766	777	777	814

Notes: This table reports results from the estimation of equation (3) where *Legal* is replaced with the minimum drive-time from a public high school to a pre-existing medical marijuana dispensary. These are not marginal effects, rather the marginal effects evaluated at the difference-in-means of the drive-time measure between counties that did and did not opt-out after legalization (1.302 hours, or 1 hour and 18 minutes). Chronic absenteeism is not available by gender. There are fewer observations in columns (4)-(7) because proficiency rates are only available between 2014-15 and 2017-18. All specifications control for the proportions of students who are Asian, Hispanic, Black, disabled, and receive free-or-reduced-price lunch, and include school and year fixed effects. Standard errors clustered by county are in parentheses. One-tailed p-values are shown in square brackets and Romano-Wolf p-values correcting for multiple hypothesis testing are in curly brackets.

Table 11: Marginal Effects of Recreational Marijuana Legalization in Oregon on the Perceived Risk of Using Marijuana for 11th-Grade Students by Gender

	Perceived Risk of Marijuana Use	
	Female	Male
	(1)	(2)
Legal x Post	-0.0365	0.0037
	(0.0214)	(0.0214)
	[0.087]	[0.864]
Dependent Mean	0.56	0.46
Observations	58,423	56,932

Notes: This table reports marginal effects from the estimation of equation (2) where the dependent variable is a binary indicator for whether a student thinks using marijuana regularly is moderately or greatly risky. Probit models are used in both columns. Both specifications control for student ethnicity and include county and year fixed effects. County-level school enrollment weights are applied in each model. Standard errors clustered by county are in parentheses and two-tailed p-values are shown in square brackets.

Table 12: Marginal Effects of Recreational Marijuana Legalization in Oregon on the Place of Marijuana Acquisition for 11th-Grade Students by Gender

	Female		Male	
	Mean	Marginal Effect	Mean	Marginal Effect
Dependent Variable	(1)	(2)	(3)	(4)
Public Event	0.053	-0.0209	0.046	0.0404
		(0.0265)		(0.0242)
		[0.431]		[0.095]
Party	0.316	-0.0143	0.234	-0.0373
		(0.0658)		(0.0589)
		[0.828]		[0.526]
Friends 18 or Older	0.384	-0.0840	0.344	-0.1232
		(0.0653)		(0.0587)
		[0.198]		[0.036]
Friends Under 18	0.498	0.0540	0.481	-0.0054
		(0.0660)		(0.0576)
		[0.413]		[0.926]
Family Member	0.160	0.0241	0.204	0.0148
		(0.0551)		(0.0423)
		[0.662]		[0.726]
Medical Marijuana Cardholder or Grower	0.123	0.0391	0.102	-0.0172
		(0.0387)		(0.0365)
		[0.312]		[0.638]
Gave Someone Money to Buy It	0.174	0.0521	0.145	-0.0063
		(0.0380)		(0.0388)
		[0.171]		[0.871]
Grew It	0.025	0.0102	0.030	0.0172
		(0.0252)		(0.0299)
		[0.686]		[0.565]
Other Way	0.202	-0.0481	0.189	0.0059
		(0.0520)		(0.0497)
		[0.356]		[0.905]

Notes: This table reports marginal effects from the estimation of equation (2) where the dependent variables are dummies indicating where or how students acquired marijuana. The data come only from the OSWS and include the following years (spring semesters): 2012, 2014, 2016, and 2018. Pre-legalization averages of the dependent variables are in columns (1) and (3). Probit models are used in columns (2) and (4), and both columns control for student ethnicity and include county and year fixed effects. County-level school enrollment weights are applied in each model. Standard errors clustered by county are in parentheses and two-tailed p-values are shown in square brackets.

Table 13: Marginal Effects of Recreational Marijuana Legalization in Oregon on School District Expenditures from the General Fund

	Total General Fund Expenditures	Instruction	Support Services	Enterprise and Community Services	Facilities Acquisition and Construction	Other Uses
	(1)	(2)	(3)	(4)	(5)	(6)
Legal x Post	0.0559	0.0696	0.0381	0.0961	-0.0028	0.1736
	(0.0339)	(0.0543)	(0.0379)	(0.1543)	(0.1592)	(0.1968)
	[0.108]	[0.209]	[0.321]	[0.537]	[0.986]	[0.384]
Dependent Mean	$12,508	$6,698	$5,239	$27	$94	$451
Observations	1,358	1,358	1,358	1,358	1,358	1,358

Notes: This table reports marginal effects of legalization on the natural logarithm of per pupil school district expenditures from the general fund. Column (1) shows total general fund expenditures, and the remaining columns are categories of spending within the general fund. Standard errors clustered by county are in parentheses and two-tailed p-values are shown in square brackets.

Appendix

Survey Data

Oregon Healthy Teens Survey

The OHTS is a voluntary, anonymous survey administered to 8th and 11th grade students in the spring of odd-numbered years. The initial survey was done in 2001, and its final year was 2019. The survey was proctored by teachers within schools and was available in both English and Spanish. Students who chose not to participate in the survey or whose parents did not give them permission to participate were given another activity to do outside the classroom during survey completion.

From 2013-2019, it was conducted by county in the following way. Eligible schools were stratified by county, randomly sampled, and their students were sampled in proportion to the number of same-grade students in the county. Schools that could not be associated with a single school district, virtual charter schools, and schools with less than ten 11th graders were not eligible to participate. County enrollment weights are provided for each grade. Roughly 15,000 8th graders and 13,000 11th graders are in the sample each year 2013-2019. Some counties did not participate in the 11th-grade survey: Wallowa (2013, 2015, 2017, 2019), Josephine (2015), Wheeler (2015), Crook (2017), Gilliam (2019). Additionally, Sherman, Gilliam, Wasco, Grant, Harney, and Lake counties had small sample sizes each year.

The following honesty checks were performed for internal validity. First, students reporting excessive use, early initiation, or discrepancies on questions about alcohol and marijuana use, smoking, sexual behavior, gambling, or fruit, vegetable, and beverage intake were removed. Second, students who surpassed a given threshold of exaggerated or conflicting responses were

removed. Third, if a student reported that they were dishonest on the survey then they were excluded.

Oregon Student Wellness Survey

The OSWS is a voluntary, anonymous survey administered to 6th, 8th, and 11th graders in the spring of even-numbered years. The first survey was conducted in 2010 and the final in 2018. It was open to all traditional public and charter schools and was administered by teachers within schools. Paper and pencil, as well as online, versions were available in both English and Spanish. Grade specific county enrollment weights are included in the data. Around 20,000 6th graders, 22,000 8th graders, and 16,000 11th graders are in the sample each year.

Observations were removed if the student's school or grade could not be identified, and the following honesty checks were performed for internal validity. First, students who reported that in the past 30 days they had used six or more of marijuana, cocaine, ecstasy, heroin, hallucinogens, methamphetamines, and steroids were marked as dishonest and removed. Second, students who responded that they had never used a substance when asked the age of first use but then responded that they had used the substance in the past 30 days were marked as dishonest and were removed. The substances checked were alcohol, cigarettes, other tobacco products, and marijuana. Third, students who reported excessively high amounts (averaging 10 or more times in the past 12 months) of physical fights, fighting at school, bullying, having been suspended and threatening with a weapon were marked as dishonest and removed. Finally, students whose reported age was more than two years less or more than two years more than would be expected for the reported grade level were marked as dishonest and removed. Additionally, students who reported that they were dishonest on the survey were excluded.

Item Non-Response

In the pooled dataset, 7% of the 11th-grade sample across all years are missing responses for the question on marijuana access; 4% are missing responses for the question on extensive margin marijuana use; and 5% are missing responses for the question on intensive margin marijuana use.

Table A1: Questions from the Oregon Student Wellness and Oregon Healthy Teens Surveys

	Oregon Student Wellness Survey		Oregon Healthy Teens Survey	
Outcome	Question	Years	Question	Years
Marijuana Access	If you wanted to get some, how easy would it be for you to marijuana? (0 – somewhat or very hard, 1 – sort of or very easy)	All	If you wanted to get some marijuana, how easy would it be for you to get some? (0 – sort of or very hard, 1 – sort of or very easy)	2015, 2017, 2019
Current Marijuana Use (Extensive Margin)	Which of the following illicit drugs did you use during the past 30 days? (Marijuana)	All	During the past 30 days, how many times did you use marijuana? (0 times)	All
Current Marijuana Use (Intensive Margin)	During the past 30 days, how many times did you use marijuana? (0, 1-2, 3-9, 10-19, 20-39, 40+ times)	All	During the past 30 days, how many times did you use marijuana? (0, 1-2, 3-9, 10-19, 20-39, 40+ times)	All
Source of Marijuana	During the past 30 days, from which of the following sources did you get marijuana? (I did not use marijuana, public event like a sporting event or concert, party, friends 18 or older, friends under 18, family member, medical marijuana cardholder or grower, I gave someone money to buy it for me, grew it, other way)	2012, 2014, 2016, 2018	-	-
Risk of Smoking/Using Marijuana	How much do you think people risk harming themselves (physically or in other ways) if they: Smoke marijuana regularly (at least once or twice a week)? (0 – no or slight risk, 1 – moderate or great risk)	All	How much do you think people risk harming themselves (physically or in other ways) if they: Use marijuana regularly (at least once or twice a week)? (0 – no or slight risk, 1 – moderate or great risk)	All