Legalization of Recreational Marijuana and Community Sales Policy in Oregon: Impact on Adolescent Willingness and Intent to Use, Parent Use, and Adolescent Use

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Abstract

Studies investigating the impact of medical marijuana legalization have found no significant changes in adolescent use. In one of the few studies focused on recreational marijuana, we investigated how recreational marijuana legalization and community sales policy influenced factors that likely impact youth use (youth willingness and intent to use, parent use), as well as youth use. Legalization of recreational marijuana in Oregon coincided with our study on adolescent substance use. Cohort 1 transitioned from 8th to 9th grade prior to legalization and Cohort 2 made this transition during legalization ($N = 444$; 53% female). Communities were allowed to opt out of sales. Multivariate linear regression models estimated the impact of legalization and community sales policy on changes in attitudes and parent use (two time points one year apart). Zero-inflated Poisson growth curve models estimated the effects on initial levels and rate of change from 8th through 9th grade (four time points). In communities opting out of sales, the prior-to-legalization cohort were less likely to increase their willingness and intent to use marijuana and the legalization cohort were more likely to increase intent to use. For youth who used marijuana, legalization was associated with increased use, and those in communities opting out of sales had greater growth in marijuana use. Community policy appears to impact youth attitudes towards, and use of, marijuana. Results suggest that legalization of recreational marijuana did not increase marijuana use for youth who did not use marijuana, but did increase use in youth who were already using.

Keywords

legalization of recreational marijuana; adolescence; marijuana use; attitudes toward marijuana; community policy

Although marijuana use among youth has declined from a peak in the mid-1990s, national trends suggest that marijuana use has been on the rise since 2008 across 8th through 12th

grades (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2014). This has been attributed to changing adolescent attitudes and beliefs about marijuana, specifically, that it is not believed to be as harmful as it has been portrayed (Johnston et al., 2014). Adolescents whose parents perceive little risk to marijuana use tend to have similar attitudes (Kandel, Griesler, Lee, Davies, & Shaffsan, 2001). Recent legalization of recreational marijuana for adults in several states may contribute to these changing beliefs among parents and the larger community. A study with annual surveys from 2004–2013 showed that adolescents reported a decreased perception of risk for marijuana use along with increased legalization of medical marijuana, and these results were nationwide, not just in states where legalization had occurred (Schmidt, Jacobs, & Spetz, 2016). Research on changing attitudes about marijuana and youth marijuana use, given the legalization of adult recreational marijuana use, is needed.

Regardless of decreased perceptions of risk, research consistently shows that marijuana use during adolescence has harmful consequences into adulthood. A critical period of brain development and reorganization occurs during puberty and adolescence, leaving adolescents who use marijuana vulnerable to lasting consequences on cognition, memory, and problem solving (Crane, Schuster, Fusar-Poli, & Gonzalez, 2013; National Institute on Drug Abuse, 2010; Schneider, 2008). Chronic marijuana use that begins during adolescence has been associated with anxiety symptoms and with lower educational and economical attainment in adulthood (Epstein et al., 2015). Furthermore, marijuana use in early adolescence was also associated with subsequent illegal drug use and dependence in later adolescence, emerging adulthood, and adulthood (Meier et al., 2012; Toumbourou et al., 2007; Tucker, de la Hayem, Kennedy, Green, & Polard, 2014). Given these consequences, it is critical to understand how legalization of adult recreational marijuana may affect exposure to marijuana, and onset and acceleration of marijuana use during adolescence.

Studies investigating the impact of medical marijuana legalization on youth found little to no immediate changes in adolescent use (Choo et al., 2014; Lynne-Landsman, Livingston, & Wagenaar, 2013). Although Wall et al. (2011) found higher prevalence in youth marijuana use and lower perceptions of risk in states that passed legalization of medical marijuana, these rates were higher prior to legalization. Similarly, Hasin et al. (2015) found greater youth use of marijuana prior to and post legalization in states that legalized medical marijuana compared to those that had not, but no increase in youth use following legalization. Moreover, when controlling for factors related to adolescent substance use, there was no significant difference in youth marijuana use and perceived risk between youth residing in states with legalized medical marijuana compared to those without (Choo et al., 2014; Harper, Strumpf, & Kaufman, 2012). To date, then, there is little evidence to suggest that the legalization of medical marijuana has materially changed youth perceptions about marijuana or their marijuana use.

There are only a few studies investigating how legalization of recreational marijuana use may impact youth attitudes toward marijuana and marijuana use. To date, two studies investigating youth marijuana use have occurred in the state of Washington during the legalization of recreational marijuana. One study compared marijuana use in a cohort of students who transitioned from 8th grade to 9th grade prior to legalization to a cohort of

students who transitioned from 8th grade to 9th grade after legalization, and found no significant differences in youth marijuana use between the two cohorts (Mason, Hanson, Fleming, Ringle, & Haggerty, 2015). A second study also found no significant differences in youth marijuana use between youth who participated in a school intervention pertaining to the impact of substance use prior to legalization compared to those who participated in the intervention post legalization (Estoup, Moise-Campbell, Varman, & Stewart, 2016). The adolescents participating post marijuana legalization, however, reported experiencing more negative social and psychological consequences from marijuana use and had higher perceptions of risk.

The legalization of recreational marijuana may affect parents' attitudes and own use, which may subsequently influence their adolescent's tendency to start using marijuana and their frequency of use. One recent study found that adolescent onset of marijuana is associated with their parent's use (Miller, Siegel, Hohman, & Crano, 2013), and this association was mediated by parent attitudes toward marijuana. In a different study, the association between parent marijuana use and adolescent use was mediated by less parental monitoring and more exposure to marijuana (Kerr, Tiberio, & Capaldi, 2015). These studies addressed only the association between parent and adolescent marijuana use; however, to date there is insufficient evidence that the legalization of recreational marijuana does or does not lead to an increase in marijuana use by parents of adolescents.

Little longitudinal research has addressed gender differences in marijuana use and the pathways to marijuana use in adolescents. Historically, boys have used marijuana at higher rates than girls, but that gap has narrowed and in some cases, particularly in earlier grades, girls are outpacing boys (Buu et al., 2014; Chen & Jacobson, 2012). Girls also appear to transition to regular marijuana use after initiation faster than boys (Schepis et al., 2011). Boys, on the other hand, tended to accelerate their marijuana use during middle adolescence at higher rates than girls (Chen & Jacobson, 2012). One study found that girls who initiate marijuana use at early ages are more vulnerable to subsequent poor outcomes than early initiating boys, including early alcohol use disorders (e.g., Buu et al., 2014). Much more research is needed to understand differential pathways for and outcomes of adolescent marijuana use by gender, and relevant to the present study, the potential for differential impact of marijuana legalization on adolescent girls' and boys' marijuana use.

Recent Marijuana Legislation

It is important to put this quasi-experimental study into the context of recent initiatives and legislation in Oregon or nearby states that may impact youth and parent attitudes and use. First, many states have legalized medical marijuana, including California in 1996 (Proposition 215), Washington in 1998 (Initiative 692), and Colorado (Amendment 20). In 1998 Oregon voters approved medical marijuana use (Measure 67), yet voters rejected retail sales of medical marijuana in 2004 (Measure 33) and 2010 (Measure 74). In 2013, House Bill 3460 approved a medical marijuana dispensary system overseen by the Oregon Health Authority. Second, recreational marijuana became legalized in nearby states, Washington and Colorado, in 2012. There was about a two-year gap between legalization and the implementation of recreational marijuana sales; sales in Colorado began in January of 2014

and sales in Washington began in July of 2014. In the fall of 2014, Oregon voters passed Measure 91 to legalize recreational marijuana for persons 21 years or older. This legalization went into effect in July, 2015 (House Bill 3400), and in October, 2015, sales of recreational marijuana began through medical marijuana dispensaries. The present study focused on the enactment of legalization of recreational marijuana and the implementation of sales.

The Present Study

In the state of Oregon, the legalization of recreational marijuana use for adults (ages 21 and over) was enacted in July of 2015, and sales began in October of 2015. Oregon allowed local communities (counties and cities) to opt out of marijuana sales. Cities and counties could elect to implement local sales bans if 55% or more of the voters in their jurisdiction had voted against Measure 91, and had until July 2015 to request to opt out of sales. With our study investigating adolescent substance use already underway, we were uniquely positioned to track how legalization of recreational marijuana and community policy regarding marijuana sales may affect adolescent attitudes and expectations regarding marijuana use, parent use, and adolescent recent use via a quasi-experimental longitudinal design. Studies investigating the impact of legalization of medical or recreational marijuana on youth have found little to no changes in adolescent use. We hypothesized that youth marijuana use would not change in the school year immediately following legalization enactment and implementation of sales, but other factors that likely impact youth use, such as attitudes about marijuana and use by parents, would change within the year. We also hypothesized that community marijuana sales policy would influence the effect of legalization on youth attitudes and use, with opting out of sales having a protective effect. Specifically, we expected that increases in youth willingness and intent to use marijuana would be lower for the legalization cohort in communities that opted out of sales. We also expected that youth marijuana use would be lower for the legalization cohort in communities that opted out of sales compared to communities that allowed sales.

Method

This study made use of a naturally occurring longitudinal quasi-experimental design that compared two cohorts of youth. The first cohort transitioned from 8th grade (middle school) to 9th grade (the first year of high school) and completed 9th grade prior to the legalization of recreational marijuana in Oregon, whereas the second cohort transitioned from 8th grade to 9th grade during the time legalization of recreational marijuana was enacted. Recreational marijuana legalization was not enacted while these students were in 8th grade, but was enacted prior to the beginning of their 9th grade. Sales of recreational marijuana begin during the fall of the second cohort's 9th grade year. Figure 1 shows a timeline for this study design, including when four time points of data collection occurred. The fall assessment for the second cohort began in October following the implementation of marijuana sales. During each time point, students completed questionnaires about their own marijuana use in the past 30 days and on characteristics of their social network (NetQ). A longer student questionnaire (FullQ) that included attitudes about marijuana was administered during the first (T1) and fourth (T4) time points (during the spring of their 8th and 9th grade school years). Parent questionnaires (PQs) regarding their own marijuana use were also collected during T1 and

T4. The Committee for the Protection of Human Subjects Institutional Review Board of Oregon Research Institute has reviewed and approved this research.

Participants

Participants were drawn from 11 rural and suburban middle schools from seven school districts in Oregon when they were in the 8th grade. Two cohorts of 8th grade students from different communities were recruited for study participation; Cohort 1 was recruited from six schools in three school districts in spring 2014 and Cohort 2 was recruited from five schools in four school districts in spring 2015. Students who were participating in the grade-wide social network assessments (NetQs) were invited to also participate in the study with multimethod assessments, including a longer annual questionnaire (FullQ) and parent questionnaire (PQ). Eligibility criterion was the capability to read in English or Spanish. Parent consent and youth assent were obtained for youth participation in this part of the study, and 444 students actively participated (average age at T1 was 14.4). The primary parents of participating youth (the parent who spends the most time with the adolescent) were invited to participate in the PQ, and 343 parents consented and participated in the PQ. Of participating youth, 47% were male, 39% were Latino/Hispanic (the 61% of non-Hispanics were predominantly Caucasian), 54% were in Cohort 2 (the legalization cohort), and 55% lived in a community that opted out of marijuana sales. Of participating parents reporting their gender, 85% were female; 27% were Latino/Hispanic.

Data Collection Procedures

Youth online questionnaires were completed on computers at school. A research assistant was present during the surveys to remind students that the surveys were voluntary and confidential, to monitor, and to answer any questions. Students did not receive compensation for completing the surveys. Questions on student marijuana use were asked three times during the school year (fall, winter, and spring), and questions about attitudes toward marijuana were asked once a year (during the spring assessment). Participating parents were surveyed once a year (also in the spring). The parent survey was an internet survey sent to the parent via e-mail, or if they preferred, paper surveys were mailed to them. Parents were offered minimal compensation for their participation.

Measures

Two data time points, one year apart, were collected on youth attitudes regarding marijuana use and on parent marijuana use. Four data time points within one year were collected on youth marijuana use.

Attitudes about marijuana—Youth were asked how willing they would be to try marijuana if they were with a group of friends and there was some marijuana there that they could have if they wanted. Willingness was coded to 0 for *not willing at all* to 1 for *a little willing* to *very willing*. Two questions asked youth about their intentions to use marijuana in the future: in the next few years, and when they are "grown up". Intentions were coded 0 if they responded *no* to both items and 1 if they responded *maybe* or *yes* to either item. Measures of willingness and intentions to use various tobacco products have been validated

and were associated with subsequent use (Andrews & Peterson, 2006; Gibbons, Gerrard, Blanton, & Russell, 1998).

Youth marijuana use—Youth were asked how many days they used marijuana in the last 30 days (item from the Oregon Healthy Teens Survey; Boles, Biglan, & Smolkowski, 2006). Youth marijuana use was associated with other youth behaviors as expected, such as use of other substances and antisocial behavior (Boles et al., 2006). On the internet survey, students were provided a drop-down menu to select the number of days, from 0 to 30.

Parent marijuana use—Measures of parent substance use were slightly modified from those used in the National Household Survey (Office of Applied Studies, 2002). This measure shows high stability, with coefficients ranging from .76 to .90 (Tildesley & Andrews, 2008). The primary parent was asked whether he or she currently used marijuana, and if so, how often. Answers were provided on a scale from 0 to 5, from *currently not using* to *some each day*. Given the low use reported by parents (7% reported use at T1), parent use was dichotomized with 0 reflecting *no use in the past year* and 1 reflecting *some use in the past year*.

Analytic Method

Descriptive statistics were run for each variable at each data time point to examine any cohort differences in the variables at baseline. Cohort 2 had a higher proportion of students who identify as Latino/Hispanic (56%) compared to Cohort 1 (18%). The ethnic breakdown of participants was representational of the communities from which the sample was drawn. Cohort differences in gender, willingness and intention to use, parent use, and current marijuana use were not detected. We also compared differences in T1 variables for youth whose parents participated in the study to those whose parents did not participate, and differences in youth attitudes and marijuana use were not detected.

A set of multivariate linear regression models estimated the impact of legalization, community sales policy, and the interaction of legalization and sales policy on changes in attitudes about marijuana and parent marijuana use (Model 2 includes the interaction effect). Gender, ethnicity (Hispanic versus non-Hispanic), and the baseline value (T1) of the outcome variable were included as covariates in the model. For cases with complete data (T1 and T4), models were estimated with odds ratios and 95% confidence intervals in IBM SPSS Statistics for Windows, Version 23.0.

Because most of the adolescents in our sample did not report any marijuana use, a Zero-inflated Poisson (ZIP) growth mixture modeling (GMM) approach provided the most appropriate modeling framework for estimating effects of legalization and sales policy on youth marijuana use from 8th grade to 9th grade (four time points). ZIP GMMs are able to estimate within-individual trajectories, appropriately weighting the zero observations for the odds that they represent—unobserved use vs. complete abstinence (Atkins, Baldwin, Zheng, Gallop, & Neighbors, 2013; Gupta, Szczesniak, & Macaluso, 2015; Liu, 2007; Zhu, Luo, & DeSantis, 2015). The ZIP models tested the odds of youth marijuana abstinence in the past month during 8th grade and changes in abstinence through 9th grade, as well as youth use in

8th grade and change in use through 9th grade for youth who reported use in the past month. Youth gender and ethnicity were included as covariates in the models.

Comparisons of nested models with and without random effects were performed to determine the random effects to be included in the final models. The resulting model specification included fixed effects for the logistic (odds) growth parameters (intercept and slope for the zero-inflated group) and random effects for the Poisson (count) growth parameters. After specifying the unconditional model, two conditional models evaluated the effects of legalization and community policy (Model 1) and the interaction of legalization by community policy (Model 2) on the odds of marijuana abstinence and number of days of marijuana use in the 8th grade (intercept parameters) and changes in the odds of abstinence and number of days used from 8th through 9th grade (across four time points, slope parameters). All models were estimated in MPLUS, version 7.3 (Muthén & Muthén, 1998–2012), with a maximum likelihood estimator with robust standard errors (MLR), to accommodate violations of model assumptions including multivariate normality and independence of observations, and to accommodate missing values. Given the computational burden imposed by the number of observations and several dimensions of integration (number of latent variables, random slopes, and latent variable interactions), the ZIP models were run using five integration points to reduce the computational complexity, allowing models with potentially small random effects to converge. This strategy afforded the opportunity to evaluate the presence and size of random effects, even when random effects approached zero, and aided the model selection process.

Results

The means, standard deviations, and the minimum and maximum scores of variables for each of the two cohorts at each data collection time point are reported in Table 1. Over one fifth of 8th grade youth reported willingness to use and over one fourth reported intent to use marijuana in the future. On average, youth reported spending time with friends who used marijuana one time in the last month, ranging from *none* to *seven or more times*. Only 7% of parents reported using marijuana in the past year at both time points. There was high variance in frequency of youth marijuana use, ranging from *no use* to *daily use in the past 30 days*. The percent of youth reporting any marijuana use in the last 30 days was 12.7% at T1, 10.9% at T2, 10.4% at T3, and 13.9% at T4.

Effects of Recreational Marijuana Legalization and Sales Policy on Youth Attitudes and Parent Use

Results of the multivariate linear regression models are shown in Table 2. The interaction of legalization and community sales policy was associated with changes in youth attitudes about marijuana. Youth in the legalization cohort with sales opt-out were more likely to increase intent to use marijuana ($p = .02$, OR = 5.78 [95% CI 1.38, 24.30]). Youth in the prelegalization cohort with sales opt-out were significantly less likely to increase willingness to use ($p = .02$, OR = 0.27 [95% CI 0.09, 0.78]) and intent to use ($p = .02$, OR = 0.28 [95% CI 0.10, 0.84]) compared to those with marijuana sales. Youth in the legalization cohort with sales were less likely to increase intent to use marijuana ($p = .04$, OR = 0.41 [95% CI 0.17,

0.98]). Changes in youth willingness and intent to use marijuana did not significantly differ by gender or ethnicity. Significant influences of legalization or sales policy on changes in parent use was not detected.

Effects of Marijuana Legalization and Policy on Youth Marijuana Use

Results of the conditional ZIP growth curve models are presented in Table 3 (results of the unconditional model are included in the text). Table 3 parameters for the odds of abstinence are expressed as odds ratios (OR) and rates of use are expressed as rate ratios (RR). ORs and RRs close to 1 suggest no or little difference in risk or rates of use, while values greater than 1 suggest an increase in risk or rates of use, and values less than 1 suggest a decrease in risk or rates of use. The odds of marijuana abstinence (the zero group) did not change from the spring of 8th grade to the spring of 9th grade (unconditional model, slope: $p = .832$, OR = 0.99, 95% CI = 0.91, 1.07). The conditional models did not detect an association between the probability of being in the zero group or changes in probability by gender, ethnicity, or marijuana legalization or sales policy.

For youth reporting marijuana use, the average number of days of use in the spring of 8th grade was significantly greater than zero (unconditional model, intercept: $p < .001$, RR = 6.74, 95% CI = 5.10, 8.91) with a rate of use ranging from 5.10 to 8.91 days for 95% of the sample and an average rate of use of 6.74 days. Significant increases in the rate of marijuana use occurred from spring of 8th grade to spring of 9th grade (unconditional model slope: $p < .001$, RR = 1.24, 95% CI = 1.16, 1.34) with an average rate increase of 24% every four months (interval of time points). Youth in the legalization cohort reported greater increases in marijuana use compared to those in the prelegalization cohort (Model 1, slope: $p < .006$; RR = 1.26, 95% CI = 1.10, 1.45) with an additional 26% rate increase over the prelegalization cohort. Gender, ethnicity, or sales policy differences on initial marijuana use or growth in marijuana use were not detected.

Additionally, the association of legalization with changes in youth marijuana use varied by sales policy. Youth in the prelegalization cohort with sales opt-out had higher rates of marijuana use in the spring of 8th grade (Model 2 intercept: $p = .007$, RR = 2.73, 95% CI = 1.48, 5.02) and increased marijuana use at a lower rate by the spring of 9th grade (Model 2 slope: $p < .001$, RR = 0.64, 95% CI = 0.52, 0.79) compared to youth in communities with sales. Youth in the legalization cohort with marijuana sales had lower rates of marijuana use during spring of 8th grade (Model 2 intercept: $p < .001$, RR = 0.16, 95% CI = 0.08, 0.36) and increased marijuana use almost twice as much by the spring of 9th grade (Model 2 slope: $p < .001$, RR = 2.08, 95% CI = 1.61, 2.68) compared to the other groups. Figure 2 shows the sample means of marijuana use for the four groups of youth (prelegalization with sales opt-out, prelegalization with sales, legalization with sales opt-out, legalization with sales) to illustrate the interaction effects.

Discussion

This quasi-experimental study addresses the associations of recreational marijuana legalization and community sales policy with youth attitudes, parent use, and youths' own use in the state of Oregon. Results are relevant to states which have already legalized

recreational marijuana use, for instance, to inform how sales and use are administered and regulated, as well as to states that might consider legalization in the future.

Legalization of recreational marijuana did not appear to affect initiation of marijuana use. However, youth in the legalization cohort who were already using marijuana at the time of legalization significantly increased their marijuana use compared to those in the prelegalization cohort. A similar study showing no significant changes on youth marijuana use after legalization of recreational marijuana in Washington state (Mason et al., 2015) did not distinguish abstinent from nonabstinent youth, in effect, assuming these two groups have the same risk factors. The ZIP models utilized in our study allow for this distinction, and indeed, our results imply different effects of legalization for youth depending on whether they had already initiated use or not. Therefore, in states that legalize recreational marijuana, current adolescent users of marijuana may represent a particularly high-risk population, requiring specially designed intervention efforts. When making policy decisions regarding marijuana, it is important to examine whether legalization impacts youth marijuana onset as well as frequency of use.

Youth in the prelegalization cohort with sales opt-out had the least amount of change in willingness and intent to use marijuana. It is likely that community norms, as suggested by the majority votes against legalization of recreational marijuana in communities with policy prohibiting sales, had an effect on youth attitudes. Similar community policies aimed at reducing the supply of tobacco and alcohol to limit youth access have shown immediate effects on youth use; however, there are challenges to sustaining these effects (Pentz, 2000). Specific to marijuana use, Wu, Swartz, Brady, and Hoyle (2015) found that youth who disapproved of marijuana use and believed that their peers did, too, were less likely to use marijuana.

We also found that youth in the legalization cohort with sales were less likely to increase intent to use marijuana, whereas those with sales opt-out were more likely to increase intent to use marijuana. One possible explanation for this finding may be that state-wide legalization had a "spillover" effect into communities that had formerly been isolated enough to have maintained a set of local norms regarding marijuana use. Furthermore, youth in the legalization cohort with sales opt-out had significantly lower use at baseline (spring of 8th grade), and a larger increase than youth in other groups. These youth may well have been more prone to a state-level spillover effect simply by having been relatively more negative about marijuana use prior to legalization then other similar-aged Oregon youth.

The direction of the interaction effect for changes in attitude matches the direction of changes in marijuana use in youth who were using marijuana. It appears that youth attitudes about marijuana coincided with increases in youth marijuana use for youth who already used. It will likely take longer than one year for changes in intention to use to impact youth who have not yet started using marijuana. Other research has shown that intentions are predictive of future use, but in longitudinal samples followed for more than one year (e.g., Andrews & Peterson, 2006).

We found no differences for legalization and community policy on parent report of their own use. Rates of parent use in the past year were quite low, even in the year following legalization. We found no evidence that many parents of youth use marijuana, even when it has been legalized. In Washington state, the largest increases in marijuana use since legalization have been in older adults, ages 50 to 64 (Stoner, 2016). As with changes in youth intention, significant changes in parent use of marijuana may take more than one year to appear. It is also feasible that parents underreported their own marijuana use, given the perceived stigma of use by parents of adolescents.

There were no gender differences for marijuana use or growth in use in this sample. A longer-term study may be needed to determine whether boys accelerated their marijuana use during high school more than girls, aligning with the work of Chen and Jacobson (2012), and whether the increased acceleration could be predicted by legalization.

We also did not detect ethnic differences for marijuana use or growth. Wu et al. (2015) found that for Hispanic youth aged 12–17 marijuana use was higher than for Caucasians. Following our study sample further into high school may provide more insight on ethnic differences in the growth of marijuana use across the high school years.

Limitations

This investigation involved a quasi-experimental design rather than a randomized experimental design, increasing threats to internal validity. Given the absence of randomization, we tested cohort differences at baseline to try to identify group differences and reduce this threat. Differences by cohort were detected for ethnicity; thus, ethnicity was included in models of direct and simple effects. No ethnic differences were found for study outcomes, minimizing concern regarding potential cohort–ethnicity confounds.

The differences we observed in attitudes and use patterns by legalization and sales policy suggest the possibility that the former *resulted from* the latter, but without random assignment to these conditions, causation cannot be inferred. Nevertheless, our study may be valuable in suggesting how recreational marijuana legalization may differentially affect different populations, as well as what might be done to minimize unwanted effects. Further confidence in the nature of these effects will benefit from replication in different geographic areas and with a longer postlegalization monitoring period. Optimally, states considering legalization in the future may also consider including such a study as part of the process.

All variables were youth-reported, with the exception of parent marijuana use, which was collected via parent report. Although we had fairly good rates of parent participation (77%), 23% of parents did not agree to participate in the study. Also, only 15% of participating parents were fathers; thus, the parent substance use data predominantly represents mothers' substance use. Since data were collected from the primary parent, defined as the parent who spent the most time with the participating adolescent, the data represents potential exposure from the parent with whom the adolescents more often spend time. Getting more precise measures on youth's exposure to marijuana (e.g., from other persons in the household such as a second parent or an older sibling), would provide a more accurate estimate regarding the association between legalization and increased youth exposure to marijuana, which would

likely increase their probability of onset. Moreover, multimethod measures from other reporters with potential influences, such as peer network assessments of marijuana-using peer affiliates, would improve the measurement of marijuana exposure.

This study is limited to a sample of youth in 8th grade through 9th grade. This is a critical age when youth are transitioning from middle school to high school, and are at risk for initiating marijuana use (Flory, Lynam, Milich, Leukefeld, & Clayton, 2004) as well as other substances (Boles et al., 2006). The longitudinal design with frequent assessments provided the opportunity to examine growth in use across a full year. Despite these strengths, results cannot be generalized beyond this period of transition from early- to midadolescence.

Given the timing of legalization, more long-term longitudinal analyses of differential effects with this sample is not possible. The strength of this study is that longitudinal data were collected before the Cohort 2 sample of youth were exposed to legalization and one year following legalization, allowing for the analysis of differential associations during this important time in adolescence, a time when experimentation with substances begins and accelerates (Biglan & Smolkowski, 2002), including marijuana (Johnston et al., 2014).

Implication for Policy and Youth Prevention

Legalization of recreational marijuana for adults may increase use by youth over time, as community attitudes shift, marijuana use becomes more normative, and exposure to marijuana increases. In the state of Oregon, advertising of marijuana products is already ubiquitous, and marijuana outlets are present in most communities that have not opted out of sales. Our findings indicate that there may be an immediate impact of legalization for youth who had already initiated marijuana use, as they increased their use after legalization. This was true even in communities that opted out of recreational sales, indicating that community-level opt-outs may not effectively reduce youth use. Prevention campaigns that educate youth of the risks of using marijuana while their brains are still developing, and building capacity and resources for parents to discuss marijuana with their adolescent children, may provide guidance as communities and states navigate the new landscape of legal recreational marijuana.

Acknowledgments

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Quasi-experimental Study Design								
Cohort 1	8th grade	9th grade						
	NQ,FQ,PQ	NQ	NQ	NQ,FQ,PQ				
Cohort 2				8th grade		9th grade		
				NQ,FQ,PQ		NQ	NQ	NQ,FQ,PQ
Marijuana Laws					1	2		
	Spring '14	Fall '14	Winter '15	Spring '15		Fall '15	Winter '16	Spring '16
NQ = Net Q, FQ = Full Q, PQ = Parent Q								
1: July 1, 2015 = Date legalization of recreational marijuana went into effect in Oregon								
2: October 2015 = Date of sales of marijuana began (through medical marijuana dispensaries)								

Figure 1.
Quasi-experimental study design: Marijuana legalization, sales, and survey timeline.
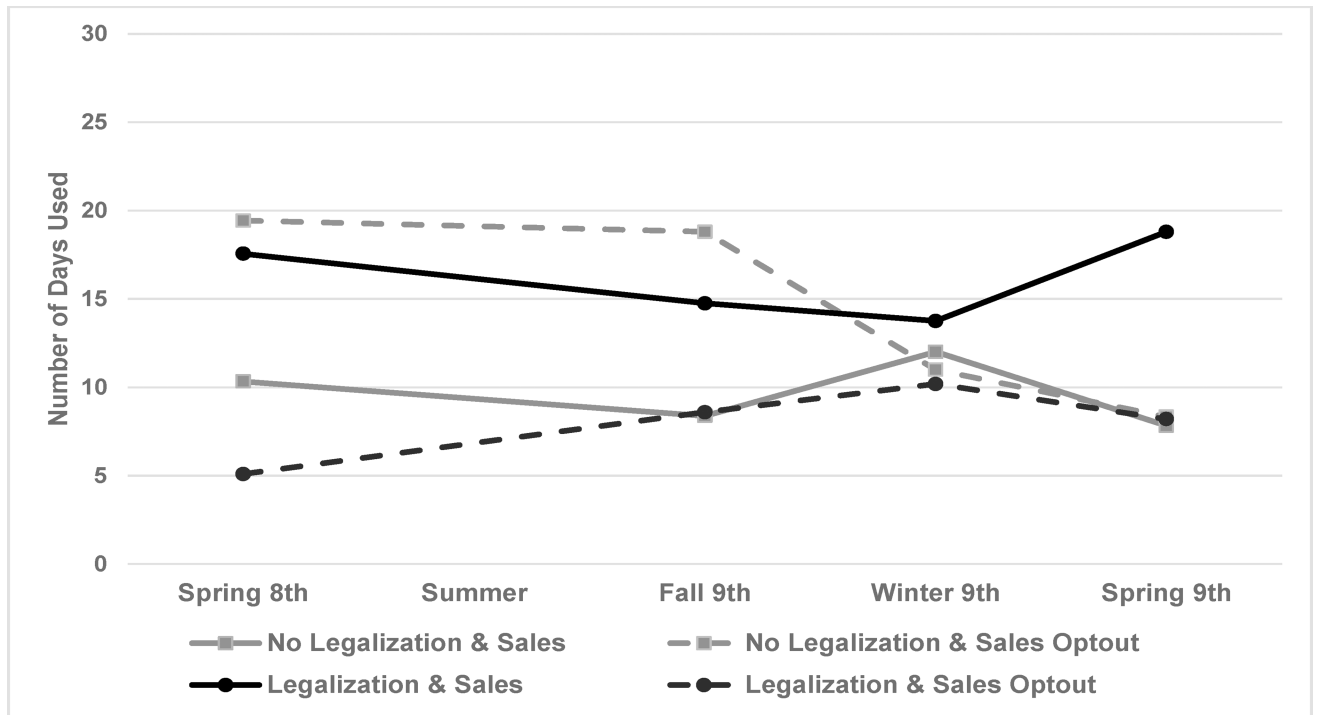
Figure 2.
Sample means of marijuana use by time for youth who reported current use illustrating the interaction effect for legalization and sales policy on youth marijuana use.

Table 1

Descriptive Statistics of Marijuana Variables for Each Cohort at Each Data Collection Time Point

Variable	T	Cohort 1				Cohort 2			
		M	*SD*	Min	Max	*M*	*SD*	Min	Max
Willingness to use	1	0.23	0.42	0	1	0.25	0.43	0	1
	4	0.30	0.46	0	1	0.26	0.44	0	1
Intentions to use	1	0.26	0.44	0	1	0.28	0.45	0	1
	4	0.33	0.47	0	1	0.29	0.46	0	1
Parent use	1	0.05	0.22	0	1	.09	0.29	0	1
	4	0.06	0.23	0	1	0.08	0.27	0	1
Youth use	1	1.44	5.55	0	30	1.25	4.63	0	30
	2	0.90	4.28	0	30	1.49	5.35	0	30
	3	1.30	4.84	0	30	1.15	4.38	0	30
	4	1.07	3.85	0	27	1.74	5.99	0	30

Note. T = assessment time point.

Table 2

Multivariate Linear Regression: Marijuana and Sales Policy on Youth Attitudes and Parent Use

Variable	Model 1			Model 2		
	b	SE	OR [95% CI]	b	SE	OR [95% CI]
Willingness (n = 301)						
Willingness (T1)	2.60 ***	0.34	13.45 [6.90, 26.21]	2.60 ***	0.34	13.51 [6.90, 26.44]
Male	−0.37	0.30	0.69 [0.38, 1.26]	−0.42	0.31	0.66 [0.36, 1.20]
Latino/Hispanic	0.39	0.34	1.48 [0.77, 2.86]	0.20	0.35	1.22 [0.61, 2.44]
Legalization	−0.22	0.34	0.80 [0.41, 1.56]	−0.74	0.46	0.48 [0.20, 1.17]
Sales Opt-Out	−0.62	0.33	0.54 [0.28, 1.04]	−1.31 *	0.54	0.27 [0.09, 0.78]
Legalization × Sales Opt-Out				1.28	0.73	3.59 [0.86, 15.07]
Intent (n = 282)						
Intent (T1)	2.35 ***	0.32	10.47 [5.55, 19.75]	2.37 ***	0.33	10.68 [5.60, 20.38]
Male	0.47	0.30	1.61 [0.89, 2.91]	0.40	0.31	1.50 [0.82, 2.74]
Latino/Hispanic	0.08	0.33	1.08 [0.57, 2.06]	−0.18	0.35	0.84 [0.43, 1.65]
Legalization	−0.22	0.33	0.81 [0.42, 1.54]	−0.88 *	0.44	0.41 [0.17, 0.98]
Sales Opt-Out	−0.27	0.32	0.76 [0.41, 1.44]	−1.26 *	0.55	0.28 [0.10, 0.84]
Legalization × Sales Opt-Out				1.75 *	0.73	5.78 [1.38, 24.03]
Parent Use (n = 282)						
Parent Use (T1)	5.74 ***	0.93	334.64 [54.5, 2054.1]	5.76 ***	0.94	317.62 [50.3, 2005]
Male	−0.59	0.76	0.58 [0.13, 2.55]	−0.60	0.76	0.55 [0.39, 2.45]
Latino/Hispanic	−0.40	0.88	0.66 [0.12, 3.72]	−0.28	0.92	0.75 [0.12, 4.63]
Legalization	0.69	0.80	2.05 [0.43, 9.81]	1.04	1.05	2.82 [0.36, 22.13]
Sales Opt-Out	0.17	0.80	1.14 [0.24, 5.47]	0.66	1.20	1.93 [0.18, 20.41]
Legalization × Sales Opt-Out				−0.82	1.57	0.44 [0.02, 9.55]

*
$p < .05$.

**
$p < .01$.

***
$p < .001$.

Table 3

Zero-Inflated Poisson Models of Legalization of Recreational Marijuana and Sales Policy on Growth in Youth Marijuana Use

	Model 1		Model 2	
	Intercept	**Slope**	**Intercept**	**Slope**
	OR [95%CI]	OR [95%CI]	OR [95%CI]	OR [95%CI]
Odds of Marijuana Abstinence (being in the zero group)				
Male	1.51 [0.89, 2.54]	0.98 [0.83, 1.16]	1.51 [0.89, 2.55]	1.00 [0.85, 1.17]
Latino/Hispanic	1.17 [0.66, 2.06]	0.86 [0.73, 1.02]	1.29 [0.70, 2.39]	0.87 [0.73, 1.04]
Legalization	0.58 [0.33, 1.02]	1.13 [0.95, 1.33]	0.76 [0.33, 1.72]	1.17 [0.92, 1.48]
Opted-Out	0.91 [0.52, 1.59]	1.11 [0.94, 1.31]	1.28 [0.53, 3.10]	1.21 [0.88, 1.65]
Legalization × Opted-Out	--	--	0.55 [0.16, 1.89]	0.87 [0.59, 1.28]
Means	1.00 [1.00, 1.00]	0.95 [0.80, 1.13]	1.00 [1.00, 1.00]	0.92 [0.77, 1.11]
Variances	--	--	--	--
Rates of Marijuana Use (number of days used in the past 30 days)				
	RR [95%CI]	RR [95%CI]	RR [95%CI]	RR [95%CI]
Male	1.02 [0.71, 1.47]	1.02 [0.91, 1.15]	1.02 [0.69, 1.49]	1.08 [0.96, 1.21]
Latino/Hispanic	1.09 [0.78, 1.52]	0.89 [0.79, 0.99]	1.53 [1.05, 2.22]	0.79[**] [0.70, 0.89]
Legalization	0.69 [0.45, 1.04]	1.26[**] [1.10, 1.45]	1.28 [0.79, 2.08]	0.87 [0.74, 1.03]
Opted-Out	0.74 [0.51, 1.08]	1.02 [0.90, 1.16]	2.73[**] [1.48, 5.02]	0.64[***] [0.52, 0.79]
Legalization × Opted-Out	--	--	0.16[***] [0.08, 0.36]	2.08[***] [1.61, 2.68]
Means	13.12 [9.65, 17.83]	1.18 [1.07, 1.29]	7.27[***] [5.10, 10.37]	1.34[***] [1.19, 1.49]
Variances	14.54 [7.19, 29.43]	1.24 [1.20, 1.28]	8.35[***] [4.03, 17.29]	1.32[***] [1.28, 1.37]
AIC	2347.81		2320.73	
BIC	2442.01		2431.32	
Log-likelihood	−1150.90		−1133.37	

Note. N = 444. -- indicates that parameter was set to zero or not included in model.

ZIP = zero-inflated Poisson; OR = Odds Ratio; RR = Rate Ratio; 95% CI = 95% confidence interval; AIC = Akaile's Information Criterion; BIC = Bayesian Information Criterion.

[*]
p < .05.

[**]
p < .01.

[***]
p < .001.