

Research Paper

The impact of cannabis legalization in Uruguay on adolescent cannabis use

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ABSTRACT

Background: In 2013, Uruguay became the first country in the world to legalize recreational cannabis, instituting a non-commercial state regulatory model of production and supply. This study provides the first empirical evidence on its impacts on adolescent use of cannabis and related risks.

Methods: We use a generalization of the synthetic control method (SCM) to estimate the impact of legalization in Uruguay on adolescent past year and month cannabis use, perceived availability of cannabis and perceived risk of cannabis use. We compare biennial high school student self-reported survey data from Montevideo and regions in the interior of Uruguay post-legalization (2014–2018) and post initial implementation (2015–2018) to a synthetic counterfactual constructed using a weighted combination of 15 control regions in Chile.

Results: We find no evidence of an impact on cannabis use or the perceived risk of use. We find an increase in student perception of cannabis availability (58% observed vs. 51% synthetic control) following legalization.

Conclusion: Our findings provide some support for the thesis that Uruguay's state regulatory approach to cannabis supply may minimize the impact of legalization on adolescent cannabis use. At the same time, our study period represents a period of transition: pharmacy access, by far the most popular means of access, was not available until the summer of 2017. Additional study will be important to assess the longer-term impacts of the fully implemented legalization regime on substance use outcomes.

Introduction

In December 2013, Uruguay became the first country in the world to legalize the sale, cultivation, and distribution of recreational cannabis, putting it at the forefront of a growing list of nations and states in the U.S. that have liberalized their cannabis laws in recent years. Unlike the for-profit commercial models that have been adopted in a number of U.S. states such as Colorado, Washington, and California, Uruguay's approach to legalization is a non-commercial regulatory one. In Uruguay, the government controls all large-scale production, requires registration and limits the weekly quantities that a user may purchase, and prohibits advertising in all its forms (Cerdá & Kilmer, 2017). Given the unprecedented changes in cannabis policy that are taking place across the globe, and the growing number of jurisdictions considering some form of legalization, it is critical that we understand the impacts of different legalization models on drug use and related health and social outcomes.

The present study provides the first empirical evidence on the impact of legalization in Uruguay, examining adolescent cannabis use. The effect of cannabis legalization on adolescent use is of particular importance given evidence that heavy and chronic cannabis use in adolescents is associated with an elevated risk of developing cannabis use disorder (Stinson, Ruan, Pickering & Grant, 2006), cognitive impairment, and neurodevelopmental complications (Batalla et al., 2013; Meruelo, Castro, Cota & Tapert, 2017). Although those under the age of 18 are not legally permitted to purchase or consume cannabis in Uruguay, nor, for that matter, in any other jurisdiction that has legalized, there are a number of mechanisms by which legalization may nonetheless impact adolescent cannabis use. Legalization may affect perceptions of the risk of use (Joffe & Yancy, 2004; Khatapoush & Hallfors, 2004) and the social stigma associated with use (Cruz, Queirolo & Boidi, 2016), increase youth access via third-party purchases (Cerdá et al., 2017), alter illicit market availability (MacCoun, 2011), and/or impact market price (Hall & Weier, 2015).

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Further, legalization may have an even broader effect on adolescent substance use if it impacts cannabis use and cannabis serves as a substitute or complement to alcohol and other illicit drugs (Cameron & Williams, 2001; Hopfer, 2014; Subbaraman, 2016; Williams, Liccardo Pacula, Chaloupka & Wechsler, 2004).

Legalization in Uruguay

Unlike cannabis reform legislation in the U.S., which has largely been passed by popular referendum, legalization in Uruguay was enacted by a top-town effort from the president and his ruling party (Walsh & Ramsey, 2015). In fact, at the time of enactment, legalization was opposed by more than 60% of Uruguayans (Cerdá & Kilmer, 2017). By contrast, recent Pew polling data suggests that more than 60% of Americans support legalizing recreational use (Geiger, 2018). The expressed motivation of the legalization of recreational cannabis in Uruguay was to eliminate the illicit drug trade and its associated violence and public health related harms (Cruz et al., 2016; Hudak, Ramsey & Walsh, 2018). Drug possession for personal use had been decriminalized in Uruguay since 1974 (Walsh & Ramsey, 2015).

Uruguay's law provides for citizens and permanent residents over the age of 18 to legally acquire cannabis by one of three means: (1) home cultivation, (2) cannabis social clubs, or (3) pharmacies. In an effort to discourage problematic use, individuals are only allowed to access one of these three supply mechanisms, and there are limits as to the amounts that may be grown (six plants) or purchased (no more than 10 g per week) (Cerdá & Kilmer, 2017). Uruguay's law was rolled out in phases, and, importantly for the present study, access through pharmacies only became available in July of 2017. The registry for home-growers began in August of 2014, and cannabis club registration began in October of 2014 (Walsh & Ramsey, 2015). As of November 2018, of an estimated population of 3.5 million people, 31,565 people had registered to purchase in pharmacies (18,110 in Montevideo, the capital city of Uruguay, and 13,455 individuals in the Interior, the other urban regions in the country); 6,980 individuals had registered as home growers (2,101 in Montevideo and 4,879 in the Interior); and 2,831 were members of cannabis clubs (1,326 in Montevideo and 1,505 in the Interior) (Mercado regulado de cannabis Informe V., 2018).

Legalization & adolescent cannabis use

Most of the research on the relationship between cannabis legalization and adolescent cannabis use has focused on the impact of medical marijuana laws (MML) in the United States. Studies have shown that while adolescent use tends to be higher in states that allow medical marijuana (Wall et al., 2011), it does not appear to increase after the passage of MMLs (Choo et al., 2014; Hasin et al., 2015).

More recently, studies have begun to report on the effects of the legalization of recreational cannabis in U.S. states, with mixed findings that offer some indication of increased use among adolescents in some contexts. Using a difference-in-difference approach that compared past 30-day cannabis use among students in Washington and Colorado to students in non-legalizing states before (2010–2012) and after (2013–2015) the passage of the laws, Cerdá et al. (2017) find an increase in past-month cannabis use among 8th and 10th graders following legalization in Washington State, but find no significant impact among 12th graders, and no effect among adolescents of any age in Colorado. A study of legalization in Oregon compared pre and post legalization cohorts of youth and found that there was no effect on the initiation of use, but there was evidence of increased use among youth who were already using cannabis at the time of legalization (Rusby et al., 2018). A more recent study, using household data from all US states (Cerdá et al., 2020), shows no increase in adolescent frequent use, past month or past year cannabis use after the passage of recreational cannabis legalization, although it finds some indication of small increases in cannabis use disorders among adolescent cannabis users.

Methods

We compare observed post-intervention cannabis use outcomes in Uruguay to those predicted in the absence of legalization using a generalization of the synthetic control method (SCM) (Abadie & Gardeazabal, 2003; Abadie, Diamond & Hainmueller, 2010; Doudchenko & Imbens, 2016). SCM, rather than using a single control unit or the simple average of control units to estimate a counterfactual time trend for the treated unit in the absence of the treatment, creates a weighted average of a set of controls. Weights are generated from pre-intervention data on each outcome of interest such that the weighted combination of control units mirrors the intervention unit as closely as possible during the pre-intervention period (Imbens, 2017). In so doing, the synthetic control aims to provide a good approximation of how the outcome(s) of interest of the treated unit would have developed if no treatment had taken place. The treatment effect is estimated as the difference between the actual outcome(s) for the treated unit post-intervention and the counterfactual outcome(s) from the synthetic control.

We compare biennial national high school student self-reported survey data in Montevideo and regions in the interior of Uruguay post-legalization to a synthetic control counterfactual group constructed from a weighted combination of 15 regions in Chile. Chile is similar epidemiologically, socially, economically and culturally to Uruguay. Further, Chile resembles the regulatory status of Uruguay pre-legalization – both countries had decriminalized, but not legalized, cannabis. Our primary analysis considers the post-legalization period from 2014 to 2018. We also conduct secondary analyses in which we treat 2014 as a pre-intervention year and 2015 as the first year post intervention. Though the symbolic import of legalization may have had an impact on adolescent use and related risks immediately following legalization, the first substantive means of legal (adult) access – cannabis clubs and home registration – were not available until several months after the student survey was conducted in 2014.

Sample

Our data on adolescent substance use and perceptions of risk and availability are drawn from school-based repeated cross-sectional surveys of students enrolled in 8th, 10th and 12th grade in urban regions in Uruguay (10,000+ inhabitants) and Chile (30,000+ inhabitants). Student age in these grades typically ranges from 13 to 17. We exclude improbable ages, restricting the study population to students between the ages of 12 and 21 (97.7% of respondents). The National Drug Observatories in each country use a common sampling scheme and instrument, modeled after the Monitoring the Future Surveys in the U.S. (Miech et al., 2018), allowing for inter-country comparisons. Surveys are carried out approximately every two years and samples are selected via a clustered, multistage stratified design. Survey data collection takes place in school classrooms under strictly confidential procedures. Prior to survey administration, students are informed that the survey is anonymous and voluntary and that the data are handled under strict confidentiality protocols in accordance with each country's legislation. Surveys are self-administered, and take approximately 50 minutes. Surveys include built-in logic and consistency checks. School cooperation rates in recent surveys have ranged from 76% to 86%. We did not find any substantive changes in rates of school response or student reporting following legalization. Further methodological details of the survey, the questionnaires and main results can be found on the web page of the Uruguayan National Drug Observatory (<https://goo.gl/qTxmMC>) and the Chilean Drug Observatory (<http://goo.gl/JJ2MX4>).

We focus on municipalities in the largest metropolitan areas in Uruguay and Chile. This includes Montevideo, the capital of Uruguay (50 schools and 2,647 students in the last year of survey data), and urban areas in the rest of the country (50 schools and 2,581 students); and fifteen regions in Chile that serve as our control units: Arica and

Parinacota, Tarapacá, Antofagasta, Atacama, Coquimbo, Valparaíso, Región Metropolitana, Libertador Bernardo O'Higgins, Maule, Biobío, Araucanía, Los Ríos, Los Lagos, Aysén, and Magallanes in Chile (1,604 schools and 30,626 students).

The Uruguayan Observatory on Drugs reviews each student survey questionnaire prior to data entry and drops observations for students with highly inconsistent or inaccurate survey responses. For example, students who respond “yes” to lifetime use of Relevon, a fictional drug, or answered “yes” to past month use of *every* illicit substance, are dropped from the aggregated results. For comparability purposes, we implemented the same set of rules for dropping observations from Chile's survey data, resulting in the deletion of 2.6% of observations for Chile.

Outcome measures

Our primary outcome variables are past year and past month cannabis use, frequent cannabis use (defined as use 10 days or more in the past month), the prevalence of students reporting there is “great risk” or “moderate risk” (versus “no risk”, “low risk”) associated with frequent cannabis use, and the prevalence of students reporting cannabis “would be easy or very easy to obtain” (versus “difficult” or “very difficult” to obtain). The first year of data collection and availability varies by outcome. Student survey response data on past year and past month cannabis use are available from 2001 to 2018. The survey question regarding perceived risk of frequent use was first asked in 2003 and the question regarding perceived availability was first asked in 2005, so our analyses for these outcomes begin in 2003 and 2005, respectively. Survey data collection on the number of days of cannabis use in the past month, which we use to define “frequent use,” was not asked in Uruguay until 2007, so our analyses for frequent use begins in 2007. For those years where there was no overlap of data collection between Uruguay and Chile, we interpolated the data using linear interpolation. A table showing data availability and missingness is shown in Table 1 in the Supplementary Materials.

Our primary analysis treats 2014 as the first post-intervention year. This was the first year following the passage of the law that legalized the sale, cultivation, and distribution of recreational cannabis for Uruguayan citizens and permanent residents over the age of 18. However, cannabis clubs and home grower registration, the first means by which legal access to cannabis was available, were not in place until August and October of 2014, and the student survey was conducted in the spring of that year. We therefore conduct a set of additional analyses in which we treat 2015 as the first post-intervention year.

Statistical analysis

We use a generalization of SCM proposed by Doudchenko & Imbens (2016) to create a weighted combination of control units (urban regions in Chile) for each of the outcomes of interest such that the weighted combination most closely fits Uruguay's trends prior to legalization. This generalized approach relaxes the restrictions of the standard SCM that the intercept be zero and the weights be non-negative and sum to one. Instead, the approach uses cross-validated Elastic Net regularization to calculate the optimal weight values on the control units so as to minimize the distance between the outcomes for the treated and the control units in the pre-intervention period. This more flexible approach may offer advantages in settings where the standard SCM produces poor pretreatment model fit (Li, 2017), as was the case with our data.

Elastic Net is a regularized linear regression method that combines L1 (LASSO) (Tibshirani, 1996) and L2 (Ridge) regularization (Hoerl & Kennard, 1970): L1 regularization adds a penalty equal to the sum of the absolute value of the coefficients, effectively shrinking some parameters to zero; L2 regularization adds a penalty equal to the sum of the squared values of the coefficients, forcing the parameters to be

relatively small. The Elastic Net tuning parameter λ determines the ratio of L1 and L2 penalty. The second Elastic Net tuning parameter, α , determines the degree of regularization (Zou & Hastie, 2005).

The optimal values for the Elastic Net tuning parameters in our analyses were chosen via leave one out cross-validation. Specifically, each control unit is treated in turn as the pseudo-treated unit and for a given set of tuning parameters (α and λ), a set of weights are generated and used to predict the outcome for the pseudo-treated unit over the period of study. The performance of the model is then evaluated by computing the mean squared error averaged over all control units, and the values of the tuning parameters are chosen to minimize this cross-validated error.

After creating weights, we compare the post-legalization prevalence rates of Uruguay, which comprises a population weighted average of Montevideo and the Interior, to its synthetic control, a weighted combination of the 15 Chilean control units. The estimated effect is the difference in the prevalence between Uruguay's observed outcome values in the post period and the outcome values of its synthetic control. Given differences in population density, rurality, and means of cannabis access, we also estimate trends separately for Montevideo and the Interior, constructing synthetic controls for each. Complete results for these separate analyses are shown in the Supplementary Materials.

SCM, including this generalized approach, precludes the use of traditional asymptotical inference techniques. Instead, common practice is to use “randomization inference” or “placebo tests” to assess how unusual any estimated effects may be. Thus, for each outcome, we treat each of 15 Chilean regions in the control donor pool as the “treated” unit, and construct a synthetic control for each region using the remaining controls. We then calculate the proportion of control regions with an estimated effect as extreme or more extreme than the difference estimated for Uruguay and its synthetic control. If the post-treatment difference between the actual treated unit and its synthetic control is larger than the difference for most of the placebo units, this provides evidence that the treatment had an effect.

Sensitivity analyses

Our primary analysis constructs the SCMs using the pre-intervention outcome data for regions in Uruguay and Chile. We conduct sensitivity analyses that incorporate covariates into the construction of the SCMs (Results shown in the Supplementary Materials). These covariates include the percent of the population under the age of 25, the percent male, unemployment rate, and the percentage with a high school level education or higher. We obtained covariate data for each of the regions in Chile from the National Socioeconomic Characterization Survey (CASEN), and from the Continuous Household Survey from the National Institute of Statistics (INE) for the regions in Uruguay.

Per Doudchenko & Imbens (2016), we adjust for covariates in our models by fitting the Elastic Net SCM model on the residuals of a linear mixed effects (LME) model. This approach is similar to Xu's (2017) Generalized Synthetic control Method, which uses an interactive fixed effects model to construct the counterfactual trends. Here, the LME model is first fit on the data with a random intercept for region and fixed effects for all other covariates. The Elastic Net SCM is then fit on the residuals of the LME model. The synthetic control outcomes are constructed as the sum of these two parts: a weighted average of the best linear unbiased predictions (BLUP) for the prevalence rates in Montevideo and the Interior from the LME model, and a weighted average of the residuals from the LME with the weights determined by the Elastic Net SCM.

Results

Table 1 shows the weights applied to each Chilean donor region to form the synthetic controls using the pre-legalization data (2001 – 2013, 2003– 2013, 2005 – 2013, 2007–2013). The resulting Mean

Table 1
Weighted regions for synthetic Uruguay.

Chilean Regions	Past Year Use	Past Month Use	Frequent Use (10 + days/month) Among Users	Perceived Availability	Perceived Risk
Tarapaca	−0.012	0.020	0.005	−0.025	0.003
Antofagasta	0.044	0.022	−0.001	0.175	0.016
Atacama	0.039	0.021	0.000	0.055	0.010
Coquimbo	−0.030	−0.011	−0.001	−0.020	0.011
Valparaíso	0.021	0.019	−0.001	0.053	0.018
Bernardo O'higgins	0.002	0.013	−0.002	−0.062	0.019
Maulé	0.004	0.010	−0.002	−0.113	0.011
Bío Bío	0.016	0.003	−0.001	0.101	0.031
Araucania	0.007	−0.001	0.000	0.161	0.029
Los Lagos	0.081	0.043	0.000	0.086	0.022
Aysén	0.027	0.017	−0.002	0.131	0.035
Magallanes	0.028	0.036	−0.002	−0.147	0.042
R. Metropolitana	0.013	0.014	0.001	0.030	0.019
Los Ríos	0.039	−0.002	−0.001	0.067	−0.029
Arica y Parinacota	0.066	0.045	0.004	0.225	0.058
MSPE (Percentile)	6e-04 (6.7%)	3e-04 (6.7%)	6e-04 (93.3%)	3e-04 (13.3%)	3e-04 (26.7%)

* Weights are from the models build using pre-intervention biennial survey data (through 2013).

Squared Prediction Error (MSPE) is shown for each of the outcomes of interest, along with the percentile of the MSPE in the distribution of MSPEs of all the placebo experiments. The weights for the synthetic Uruguay based on pre-intervention (through 2014) trends are shown in the Supplementary Materials.

Fig. 1 shows prevalences for Uruguay and its synthetic control for each of our outcomes, with 2014 as the first year post-treatment. Table 2 presents the average reported prevalence post-legalization (2014–2018) in Uruguay, for the synthetic control, and the difference between the two. The results of the placebo tests are shown in parentheses. Fig. 2 shows the trends in Uruguay and the synthetic control, treating 2015 as the first post-intervention year, and Table 3 presents the difference in outcomes for these models.

We found no meaningful difference in reported cannabis use (past year or past month) among adolescents in schools in Uruguay as compared to cannabis use predicted in the absence of legalization by the synthetic control. We estimated a 3% difference in past year cannabis use, a 2% difference in past month use, and a −2% difference in the prevalence of frequent cannabis use (10+ days/month) among students who reported any cannabis use in the past month between Uruguay and the Synthetic 2014–2018 (Table 2). The placebo tests indicated that these small differences were not statistically meaningful: for reported past year use, 10 out of 15 placebo tests had a difference as large or larger than what we found between Uruguay and the Synthetic, 13 of 15 placebo tests showed a difference as larger or larger for past month cannabis use, and 13 of 15 placebo tests showed a difference as large or larger for frequent use. The estimates were substantively the same in the secondary model (2015–2018) (Table 3). Likewise, in the sensitivity analyses incorporating covariates, and in the models estimated for Montevideo and the Interior separately, we found no meaningful differences in cannabis use post 2013 or post 2014. The sole exception was some indication of a reduction in frequent cannabis use among students in the Interior in the post-implementation (2015–2018) period. As shown in Table 4, reported frequent use among students who reported any cannabis use in the past month was an estimated 7% lower in the Interior as compared to its synthetic control. The magnitude of the difference was as large or larger in 2 of the 15 placebo tests, offering some small indication that the reduction in the Interior may have been greater than we would expect by chance.

The analyses provide some evidence that legalization may have led to an increase in student perceptions of cannabis availability. We estimated the percent of students responding yes to the statement “cannabis would be easy or very easy to obtain” was 6% higher in Uruguay post-legalization (2014–2018) than the synthetic control (58% in

Uruguay versus 51% for the synthetic). The magnitude of the difference was as large or larger in 2 of the 15 placebo tests, offering some, albeit weak, indication that the increase seen in Uruguay might be larger than the change we would expect by chance. The models estimated for the Interior and Montevideo separately (2014–2018 results shown in the Supplementary Materials) suggest the change in student reports of ease of cannabis access may have been driven by students in the Interior: the estimated difference post-legalization (2014–2018) was 9% for the Interior (52% in the Interior versus 43% for the synthetic interior) with 2 placebo tests as large or larger; post-implementation (2015–2019) (Table 4), the estimated difference was 10% (53% in the Interior versus 42% for the synthetic) with 1 placebo test as large or larger.

Discussion

We found the passage and early implementation of recreational cannabis legalization in Uruguay was not associated with changes in the prevalence of adolescent cannabis use or self-reported frequency of use. We did find some indication of an increase in student reports of cannabis availability in the Interior of the country. Given that we did not see a rise in use, this increase, insofar as it is real, may simply represent student perceptions of the new state of affairs post legalization with the rise of availability for those over 18 years of age, rather than an actual change in how easy it is in fact to obtain cannabis. Alternatively, it could suggest a real change in cannabis availability for youth that has not yet had an impact on adolescent consumption, but merits continued surveillance. Indeed, the 2018 Uruguayan student substance use survey found that 6 out of 10 adolescent cannabis users reported consuming cannabis purchased as buds, which is the form of cannabis sold in the legal market (VII encuesta nacional sobre consumo de drogas en estudiantes de enseñanza media, 2016).

Our findings contrast with some studies in U.S. states that have found increases in cannabis use among adolescents following legalization (e.g., Cerdá et al., 2017; Rusby et al., 2018), but are similar to more recent findings from a U.S. study that used data from all states that legalized recreational cannabis use and found no impact on adolescent use (Cerdá et al., 2020). The lack of short-term impact on adolescent use that we found may thus generalize across contexts, be it Uruguay's highly regulated regime, or the for-profit commercial models that have been adopted in U.S. states. In all cases, legal access to recreational cannabis is restricted to adults, and therefore may have less direct impact on availability for adolescents and their corresponding use, at least in the short term. The U.S. study that found some increase in past-month cannabis use among students in Washington state following

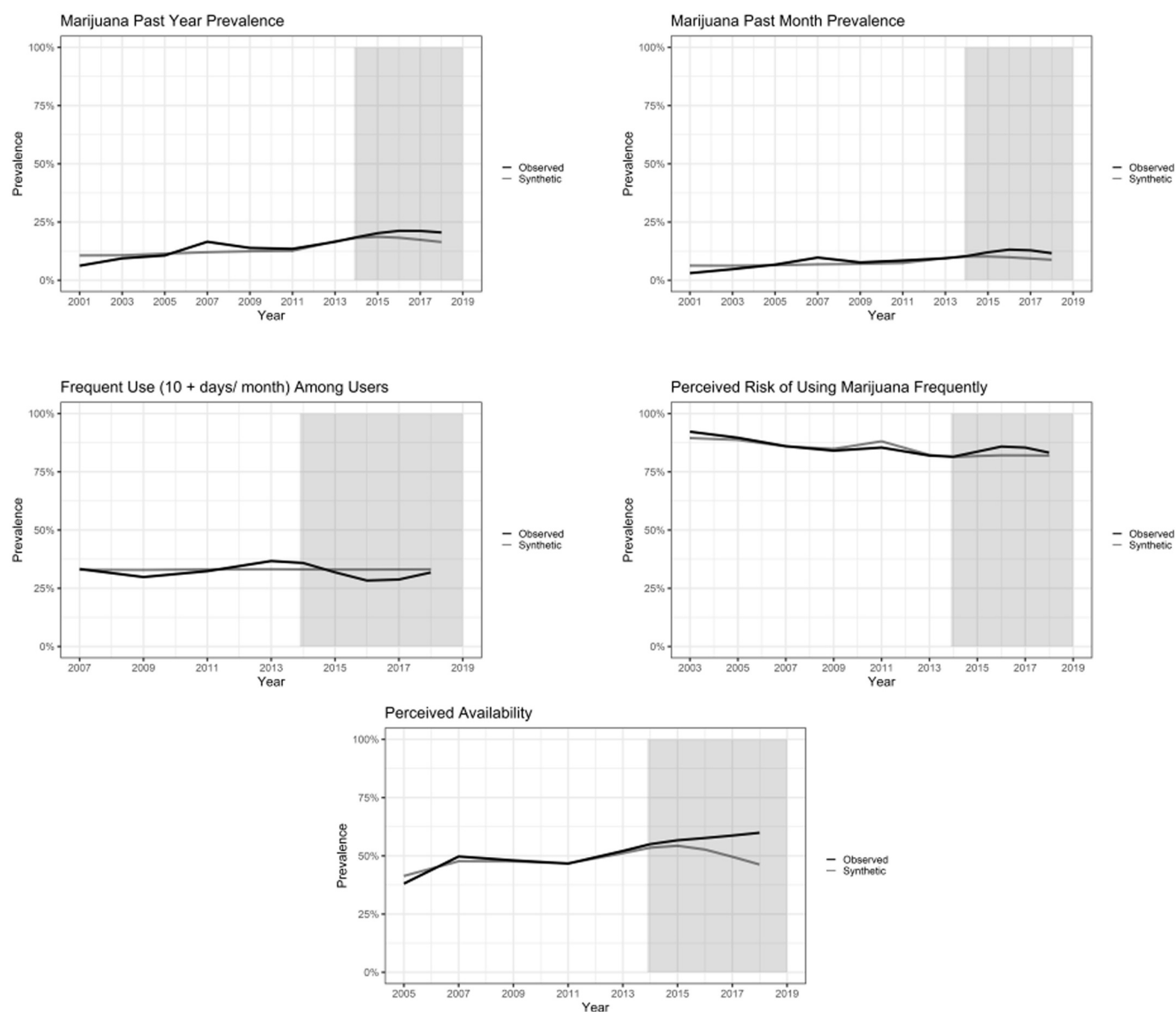


Fig. 1. Trends in student reported cannabis use and related risks in Uruguay and its synthetic control (2014–2018) Post-Legalization.

legalization (e.g., [Cerdá et al., 2017](#); [Rusby et al., 2018](#)) hypothesized that legalization may decrease stigma and perceptions of risk associated with cannabis use. We find no such shift among students in Uruguay. In fact, post-legalization, a larger share of students report there is “great risk” associated with frequent cannabis use (although this increase is not larger than what we would expect by chance.) The political campaign for legalization in Uruguay explicitly described the law as one aimed at promoting public health, and this orientation might minimize the extent to which legalization reduces perceptions of the risk or stigma associated with cannabis use.

The absence of an effect of legalization on student cannabis use might also be explained by the post-legalization period that we studied, a period in which the legalization regime was not yet fully implemented for the vast majority of time. The registry for home-growers began in August 2014 and for cannabis clubs in October 2014; pharmacy sales did not begin until July of 2017. Given pharmacies are by far the most popular source of legal cannabis to registered adults, it will be important for future work to examine the impacts of the fully implemented legalization regime.

The post-legalization follow-up period also represents a statistical

Table 2

Average reported cannabis use and related risks in Uruguay and the synthetic control (2014–2018).

	Past Year Cannabis Use	Past Month Cannabis Use	Frequent Use Among Users (10 + days /month)	Perceived Risk of Frequent Use	Perceived Availability
Uruguay	20.32%	12.00%	31.32%	83.92%	57.58%
Synthetic Control	17.79%	9.69%	33.08%	81.84%	51.28%
Difference	2.53% (10/15)	2.31% (10/15)	1.76% (13/15)	2.08% (8/15)	6.31% (2/15)

*The numbers in the parentheses are the results of the placebo tests.

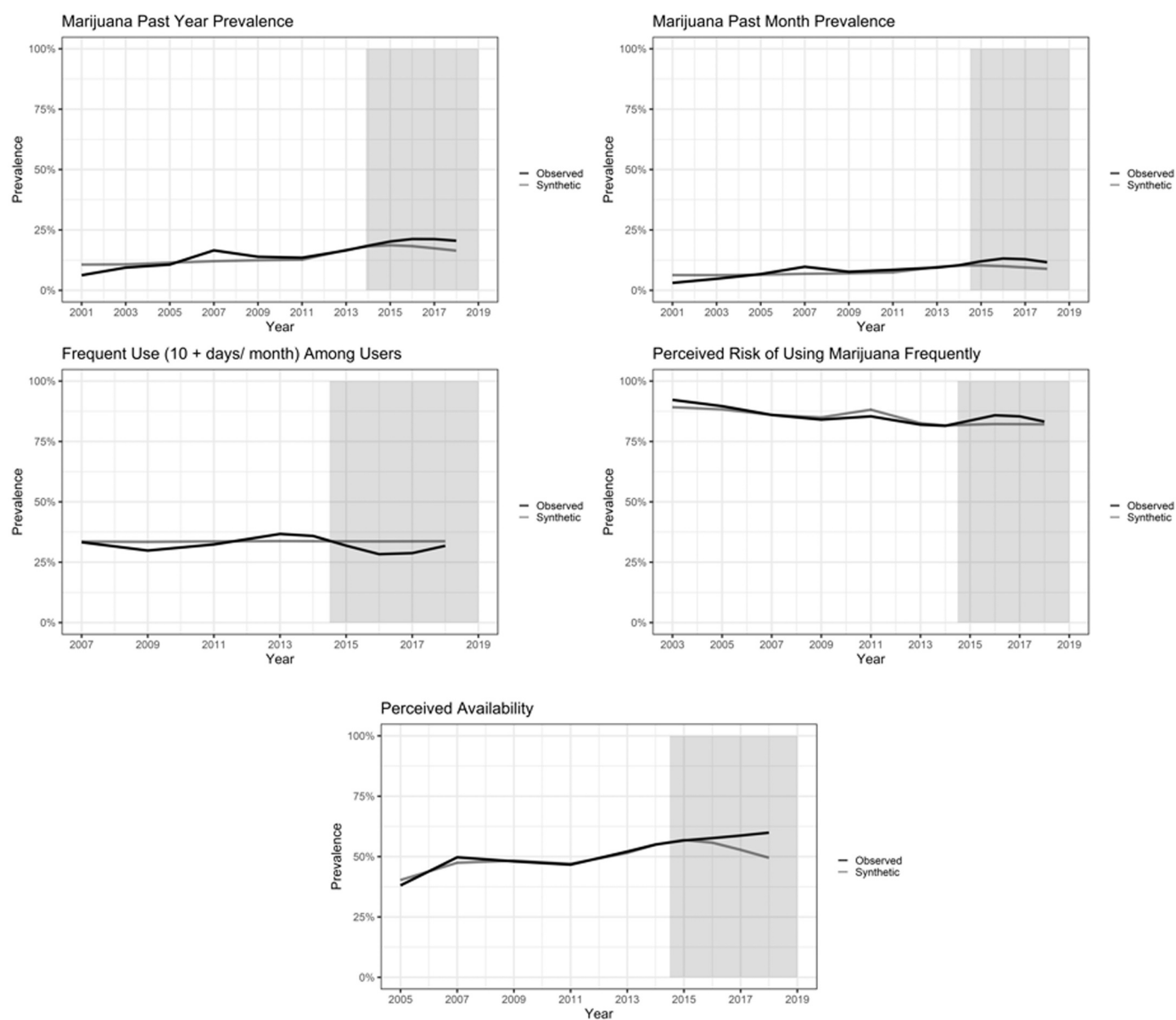


Fig. 2. Trends in student reported cannabis use and related risks in Uruguay and its synthetic control (2015–2018 Post-Legalization).

limitation of our study. With only two to three survey collection periods post legalization, our analyses are sensitive to year-to-year shifts in the data that may not reflect long-term trends. Additionally, the surveys are conducted biennially, which means we only have at most seven pre-legalization survey periods upon which to develop the synthetic control counterfactual, and for some outcomes, we have fewer. Finally, there are some years of non-overlapping surveys between Uruguay and Chile, requiring linear interpolation.

There are additional limitations inherent in the survey data that should be noted. While the substance use measures are drawn from

large and representative survey samples that are comparable across multiple years and countries, and we find no evidence of reporting biases related to legalization, the measures are self-reported and there is potential in survey data for response bias. Additionally, the surveys are designed to be representative of secondary school students enrolled in schools in the most populated areas in each country. We therefore cannot generalize our findings to all populations of adolescents in the country, and, importantly, those adolescents who are not in school may be at higher risk for problematic cannabis use.

A final consideration is that the SCM study design assumes that

Table 3

Average reported cannabis use and related risks in Uruguay and the synthetic control (2015–2018).

	Past Year Cannabis Use	Past Month Cannabis Use	Frequent Use Among Users (10 + days /month)	Perceived Risk of Frequent Use	Perceived Availability
Uruguay	20.78%	12.41%	30.18%	84.53%	58.23%
Synthetic Control	17.18%	9.66%	33.63%	82.12%	53.75%
Difference	3.61% (9/15)	2.74% (7/15)	–3.45% (10/15)	2.14% (8/15)	4.48% (3/15)

*The numbers in the parentheses are the results of the placebo tests.

Table 4

Average reported cannabis use and related risks in the Interior and its synthetic control (2015–2018).

	Past Year Cannabis Use	Past Month Cannabis Use	Frequent Use Among Users (10 + days /month)	Perceived Risk of Frequent Use	Perceived Availability
Uruguay	17.31%	9.90%	29.85%	85.97%	52.71%
Synthetic Control	12.65%	7.08%	36.47%	83.89%	42.40%
Difference	4.66% (5/15)	2.82% (7/15)	− 6.61% (2/15)	2.08% (8/15)	10.31% (1/15)

[†]The numbers in the parentheses are the results of the placebo tests.

passage of legalization in Uruguay did not affect substance use outcomes in the Chilean control regions. Given Uruguay only permits cannabis purchase by its own citizens, this is likely a reasonable assumption. Nonetheless, legalization may affect perceptions and social norms towards cannabis in neighboring countries.

Conclusion

The present study provides the first effort to estimate the effect of the first non-commercial model of national cannabis legalization on cannabis use outcomes. As analysts have noted (See e.g., [Caulkins & Kilmer, 2016](#)), there is a wide range of potential policies towards cannabis and it should not be viewed as a binary choice between prohibition and for-profit commercial models. It is thus critical that we study and evaluate the different models of legalization and the associated social and health impacts. Uruguay offers one prominent example of cannabis legalization without commercialization. Our study provides preliminary evidence that this type of non-commercial model of national cannabis legalization may not lead to an increase in adolescent cannabis use in the short term. At the same time, our results are preliminary and an evaluation of the longer-term impacts of the fully implemented regime is still needed.

Author contributions

HL supervised the statistical analyses, interpreted the results, and drafted and revised the manuscript. ARA performed the primary statistical analyses, and reviewed and commented on manuscript drafts. AS performed additional statistical analyses and provided statistical consulting. KR provided additional statistical consulting and reviewed and commented on manuscript drafts. ACC, JR, SM reviewed manuscript drafts and provided feedback and comments. MC obtained project funding, guided study design, contributed to the interpretation of results, and provided comments and edits to the manuscript.

Conflict of Interest Statement

None.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.drugpo.2020.102748](https://doi.org/10.1016/j.drugpo.2020.102748).

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