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RESEARCH ARTICLE

# Effects of Cannabis Legalization on Adolescent Cannabis Use Across 3 Studies

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**Introduction:** Canada, Uruguay, and 18 states in the U.S. have legalized the use of nonmedical (recreational) cannabis for adults, yet the impact of legalization on adolescent cannabis use remains unclear. This study examined whether cannabis legalization for adults predicted changes in the probability of cannabis use among adolescents aged 13−18 years.

**Methods:** Data were drawn from 3 longitudinal studies of youth (spanning 1999−2020) centered in 3 U.S. states: Oregon, New York, and Washington. During this time, Oregon (2015) and Washington (2012) passed cannabis legalization; New York did not. In each study, youth average age was 15 years (total N=940; 49%−56% female, 11%−81% Black/African American and/or Latinx). Multilevel modeling (in 2021) of repeated measures tested whether legalization predicted within- or between-person change in past-year cannabis use or use frequency over time.

**Results:** Change in legalization status across adolescence was not significantly related to within-person change in the probability or frequency of self-reported past-year cannabis use. At the between-person level, youth who spent more of their adolescence under legalization were no more or less likely to have used cannabis at age 15 years than adolescents who spent little or no time under legalization.

**Conclusions:** This study addresses several limitations of repeated cross-sectional studies of the impact of cannabis legalization on adolescent cannabis use. Findings are not consistent with changes in the prevalence or frequency of adolescent cannabis use after legalization. Ongoing surveillance and analyses of subpopulations are recommended.

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## INTRODUCTION

Despite its importance as a policy shift and widespread adoption by states, research on the impact of nonmedical cannabis legalization for adults (legalization for brevity) is in its early stages. Early onset, frequent, heavy, or prolonged cannabis use during adolescence is associated with difficulties with academic performance and attainment, social relationships, depression, suicidal thoughts and behaviors, substance use disorder, and poorer adult functioning.[1−4] Thus, possible increases in adolescent cannabis use after legalization of adult cannabis use are of concern for public health. To date, little is known about changes in adolescent cannabis use associated with legalization.[5,6] A clear understanding of whether adolescent cannabis use may increase after legalization is critical to inform policy and prevention.

Although the use of nonmedical cannabis remains illegal for individuals aged <21 years in all states, legalization of adult use may lead to higher rates of, more frequent, or heavier cannabis use among adolescents

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through increased availability, removal of legal penalties, increasing potency, decreased perceptions of harm, and increased perceptions of acceptability.[7−10] Factors such as removal of penalties and increasing acceptability may result, respectively, in immediate or delayed changes in use—or both. Early evidence suggests that adolescent cannabis use is largely unchanged after legalization. In the U.S., Youth Risk Behavior Surveillance System data from 1999 to 2017 showed no change in the likelihood of cannabis use among youth aged 14−18 years (Grades 9−12) and decreases in cannabis use frequency among users after legalization.[11] Data from the National Survey on Drug Use and Health showed no significant change from 2008 to 2016 in past-month cannabis use or heavy use among youth. Early data from Canada also suggest that youth cannabis use is largely holding steady after nationwide legalization in 2018.[12,13]

Other studies used repeated cross-sectional data from large, state-specific data sets to test for post-legalization changes in cannabis use. For example, statewide data from the California Healthy Kids Survey spanning 2010−2018 showed increases in both past-month and lifetime cannabis use among 7th-, 9th-, and 11th-grade students.[14] Conversely, a study using 2010−2016 data from the Washington Healthy Youth Survey found no change in the prevalence of past-month cannabis use among 12th graders after legalization and significant decreases among 8th and 10th graders.[15]

Large, repeated cross-sectional studies afford strong tests of population-level associations but preclude parsing of within- versus between-person change and tests of whether population-level changes are being driven by individuals whose cannabis use actually changed.[16,17] Repeated cross-sectional data may confound changes in use attributable to legalization with nationwide trends in cannabis use. Conversely, longitudinal studies address all of these limitations. Longitudinal studies including multiple birth cohorts are particularly well suited to parse the influences of age and legalization on cannabis use because they enable the separation of change because of individual development (age) from change because of history (birth cohort and legalization). Longitudinal data sets allowing examination of both within- and between-person effects of legalization are especially rare.[6]

To the authors' knowledge, there are 3 published longitudinal studies of adolescent cannabis use including assessments before and after legalization. Short-term longitudinal data from Oregon eighth and ninth graders showed that adolescents who were already using cannabis used more frequently after legalization, but legalization did not predict increased prevalence of use.[18] Canadian data from the longitudinal arm of the COMPASS project showed a steeper rise in cannabis use from ages 16 to 17 years among males after than before legalization,[12] but overall trends in cannabis use over time did not differ after legalization. Findings from the Seattle Social Development Project—The Intergenerational Project suggest that the probability of any past-year cannabis use among youth aged 10−20 years in Washington State was higher after legalization.[19]

The Three Generation Research Consortium study brings together 3 prospective, intergenerational studies: the Three Generation Study (3GS) (2005−2020), the Rochester Intergenerational Study (RIGS) (1999−2019), and the Seattle Social Development Project—The Intergenerational Project (2002−2018) (referred to as TIP for brevity in the remaining part of this paper). These studies are all broadly focused on understanding the intergenerational transmission of substance use and risk behavior. The 3GS (Oregon) and TIP (Washington) are centered in 2 of the earliest states to legalize nonmedical cannabis use and included assessments of youth from multiple birth cohorts both before and after cannabis legalization. RIGS data were collected well before New York State legalized cannabis in 2021 and provide nonlegal comparison data.

This study aimed to extend the earlier TIP study[19] by integrating data from 3 longitudinal data sets to test whether legalization predicted changes in past-year cannabis use or use frequency among youth at both the within- and between-person levels. The analytic approach involved a comparison of cannabis use among (1) adolescents in Oregon and Washington surveyed both before and after legalization (within-person effects) and (2) individuals of the same ages who had versus had not lived in areas or at times where/when recreational marijuana use was legal for adults (between-person effects). The New York sample comprised most of this latter group, but some 3GS and TIP participants aged through adolescence before legalization or left Oregon and Washington.

# METHODS

## Study Sample

Participants in 3GS were the children of men in the longitudinal Oregon Youth Study (OYS). Participants' fathers were originally recruited to OYS as boys in 1983−1985 from fourth-grade classes of schools in neighborhoods of a midsized Oregon City with higher than city-average rates of juvenile arrests. Beginning in 2005, OYS men who became fathers were invited to participate in 3GS with their first 2 biological children by each mother (i.e., a participant with 2 children each with 2 women might have 4 children in the study); 93% of eligible families were recruited. The 3GS is ongoing. This analysis included observations from 2005 to 2020 from 186 3GS participants (44.4% male, 10.6% Black/African American and/or Latinx) assessed at least once from ages 13 to

18 years. They were born on average in 1998 (range: 1990−2005). On average, 3GS youth were aged 15.3 years, and 31.1% of assessments occurred in a time and place when legalization was in effect. Retention from wave to wave has averaged 82%.

Participants in RIGS were children of youth recruited to the longitudinal Rochester Youth Development Study, a sample representative of seventh/eighth graders in Rochester, New York, public schools in 1988, with oversampling of boys and children residing in areas of the city with a high resident arrest rate. Beginning in 1999, firstborn children of Rochester Youth Development Study participants were recruited into RIGS. In subsequent years, any new firstborns were recruited once they reached age 2 years. Children were assessed annually to the age of 18 years (in 2019). This analyses included 471 RIGS children (49.4% male, 80.6% Black/African American and/or Latinx) assessed at least once from 1999 to 2019 at ages 13−18 years (mean birth year=1995 [range: 1986−2005]). On average, RIGS youth were aged 15.4 years, and 0.2% of observations occurred when and where legalization was in effect. Retention through the end of the study was 86%.

Participants in TIP were children of participants in the longitudinal Seattle Social Development Project who were recruited in 1985 (during a period of busing to reduce racial segregation) at age 10 years from public elementary schools that served but were not necessarily located in higher-crime neighborhoods in Seattle, Washington. Starting in 2002, Seattle Social Development Project participants who had become parents were recruited (family rate of 82%) to TIP along with the oldest biological child with whom they had regular contact. The children were assessed in 10 subsequent waves, the latest in 2018. This analysis included 283 youth (51.4% male, 32.4% Black/African American and/or Latinx) assessed at least once from 2002 to 2018 across ages 13–18 years (mean birth year=1997 [range: 1989−2004]). On average, TIP youth were aged 15.5 years, and 35.4% of the assessments occurred in a state and at a time when legalization was in effect. Retention from wave to wave averaged 92%.

Procedures and measures for the 3 studies were approved by IRBs at the Oregon Social Learning Center (3GS), the State University of New York at Albany (RIGS), and the University of Washington (TIP). Table 1 shows the numbers of observations from each study that were available at each adolescent age. Adolescents were assessed annually from ages 13 to 18 in RIGS and TIP and biannually in 3GS at ages 13−14, 15−16, and 17−18 years. Age at each assessment was rounded down to the nearest year for analysis. Samples sizes are lower at ages 17 and 18 years because some offspring had not yet reached those ages.

### Measures

Adolescents self-reported their frequency of cannabis use in the last year at each biannual assessment for 3GS and each annual assessment for TIP or since their last (annual) interview for RIGS. Thus, this outcome was easily harmonized across studies. Cannabis use before age 13 years was too rare to model accurately and was excluded. Two outcome measures were created: any past-year use (1 for *yes*, 0 for *no*) and frequency of use (0 for *no use*, 1 for *1−20 occasions*, 2 for *21+ occasions*). Frequency of use was split at 20 vs 21+ occasions because reports of using >20 times per year were rare in these community samples of adolescents.

Most participants affected by legalization were in Washington State or Oregon, where the policy went into effect in December 2012 and July 2015, respectively; for the small numbers of assessments occurring in other legalized states (e.g., California), the enactment dates in those locations were used. At Level 1, legalization was treated as time varying and coded as (1) in effect or (0) not in effect at the time and place of each adolescent assessment on the basis of the dates when possession and use by adults became legal. The Level-1 legalization variable was person-mean centered to denote within-person effects of legalization on cannabis use across adolescence. RIGS observations did not contribute to the time-variant or within-person legalization effect because recreational cannabis use was illegal for all but 1 participant (at 3 assessments).

At Level 2, a time-invariant or between-person legalization predictor was coded as the number of assessments occurring at a time and place with legalization and then grand-mean centered. Thus, the Level-2 legalization effect denotes the extent to which youth were more likely to use cannabis if they were exposed to legalization across more versus fewer years (including none at all).

Race/ethnicity (Black/African American and/or Latinx=1 or not=0), sex (male=1 or female=0), birth cohort year (grand-mean centered at 1996), and average age (grand-mean centered at age 15 years) were included in all models. All models also controlled for study membership using 2 dummy variables (ref: TIP).

### Statistical Analysis

Data were pooled across studies (N=940 adolescents; 3,650 personan-time assessments) and arrayed by age. Multilevel modeling (in 2021) was used to test the impacts of legalization on the likelihood and frequency of cannabis use at the within- (Level-1, age) and between- (Level-2, adolescents) subjects levels across ages 13−18 years. Models were estimated using Robust Maximum Likelihood estimation with a logit link in Mplus (Version 8.4), with cannabis use and use frequency designated as categorical outcomes and modeling linear and quadratic changes in cannabis use across adolescence. Accounting for overall age trends and cohort effects was important because later-born offspring may have been at lower contextual risk for cannabis use[20] but were exposed to legalization across more of their development. The *TYPE=COMPLEX* option was used to account for family clustering in the 3GS sample. Missing data were handled using Full Information Maximum Likelihood estimation. A grand-mean-only model was estimated first to obtain an estimate of the intraclass correlation and test for significant linear and quadratic changes in the probability of cannabis use over time. Next, the Level-2 control variables were included. Finally, legalization was included as both a Level-1 and Level-2 predictor of adolescent cannabis use. Significance tests were 2 sided. The final model equations were as follows:

Level 1: $Outcome_{ij} = \beta_{0j} + \beta_{1j}\,(Age_{ij}) + \beta_{2j}\,(Age2_{ij}) + \beta_{3j}\,(Legalization - time\ varying_{ij})$

Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}(Mean\ age_j) + \gamma_{02}(Birth\ year_j) + \gamma_{03}(Black/Latinx_j) + \gamma_{04}(Male_j) + \gamma_{05}(In\ 3GS_j) + \gamma_{06}(In\ RIGS_j) + \gamma_{07}(Legalization - mean_j) + u_{0j}$, where $\beta_{1j}=\gamma_{10}$, $\beta_{2j}=\gamma_{20}$, and $\beta_{3j}=\gamma_{30}$

## RESULTS

Table 1 shows the sample sizes and prevalence/frequency of cannabis use, legalization, and years lived in a legal state by age and study. Cannabis use prevalences

**Table 1.** Sample Size, Number of Observations, and Prevalence of Cannabis Use and Legalization by Study

| Study | Age (years) 13 | 14 | 15 | 16 | 17 | 18 | Total |
|---|---|---|---|---|---|---|---|
| Observations (*k*) | | | | | | | |
| TIP (*n*=283) | 124 | 105 | 114 | 101 | 107 | 89 | 640 |
| RIGS (*n*=471) | 427 | 442 | 441 | 427 | 407 | 392 | 2,536 |
| 3GS (*n*=186) | 81 | 97 | 67 | 102 | 36 | 91 | 474 |
| Total (N=940) | 632 | 644 | 622 | 630 | 550 | 572 | 3,650 |
| Prevalence of past-year cannabis use, % | | | | | | | |
| TIP | 0 | 7 | 10 | 16 | 27 | 38 | 15 |
| RIGS | 3 | 5 | 8 | 15 | 20 | 29 | 13 |
| 3GS | 10 | 8 | 34 | 31 | 33 | 40 | 25 |
| Total | 3 | 6 | 11 | 17 | 22 | 32 | 15 |
| Frequency of past-year cannabis use, % | | | | | | | |
| TIP | | | | | | | |
| No use | 100 | 93 | 90 | 84 | 73 | 62 | 85 |
| 1−20 times | 0 | 7 | 8 | 13 | 18 | 56 | 11 |
| ≥21 times | 0 | 0 | 2 | 3 | 9 | 12 | 4 |
| RIGS | | | | | | | |
| No use | 97 | 95 | 92 | 85 | 80 | 71 | 87 |
| 1−20 times | 2 | 4 | 7 | 11 | 14 | 20 | 10 |
| ≥21 times | <1 | 1 | 2 | 4 | 6 | 9 | 3 |
| 3GS | | | | | | | |
| No use | 90 | 92 | 66 | 69 | 67 | 60 | 75 |
| 1−20 times | 6 | 6 | 24 | 23 | 25 | 20 | 16 |
| ≥21 times | 4 | 2 | 10 | 9 | 8 | 20 | 9 |
| Mean years in legal state (range 0−3) | | | | | | | |
| TIP | 0.80 | 0.91 | 0.97 | 1.06 | 0.95 | 0.88 | 0.93 |
| RIGS | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 |
| 3GS | 0.81 | 0.54 | 0.76 | 0.64 | 0.44 | 0.63 | 0.65 |
| Total | 0.25 | 0.23 | 0.26 | 0.28 | 0.22 | 0.24 | 0.26 |

*Note:* Percentages may sum to >100 owing to rounding.
3GS, Three Generation Study; RIGS, Rochester Intergenerational Study; TIP, Seattle Social Development Project − The Intergenerational Project.

across ages are comparable with state-specific data from the 2018−2019 National Survey on Drug Use and Health.[21]

There was a high degree of within-person dependence in past-year cannabis use across observations (intraclass correlation=0.532 in the grand-mean-only model). Tables 2 and 3 show the results for the dichotomous past-year cannabis use and cannabis-use frequency outcomes, respectively. The quadratic model fit best for both outcomes, given significant nonlinear trends. Identifying as Black/African American and/or Latinx and/or participating in TIP versus in 3GS predicted both a lower probability and frequency of past-year cannabis use; being born in more recent years predicted a lower probability but not frequency of use. There was no effect of sex or the average age of participation on the probability or frequency of cannabis use. The Level-1 (within-person) effect of change in legalization status across adolescence was not significantly related to within-person change in the probability or frequency of cannabis use. At Level 2, youth who spent more years under legalization were no more or less likely to have used cannabis and did not use either more or less frequently at age 15 years than adolescents who spent little or no time under legalization. Sensitivity analyses (1) using cannabis-use frequency (0−21+) as a count variable in a Poisson regression model, (2) using ever lived under legalization (yes/no) at Level 2, (3) using the proportion of available waves lived under legalization at Level 2, (4) using legalization at Level 1 only, and (5) with and without group- and grand-mean centering of legalization variables yielded the same null finding.

## DISCUSSION

This study integrated longitudinal data from 3 studies of youth centered in 3 states—2 that adopted cannabis legalization early on and 1 that did not—to examine

**Table 2.** Between- and Within-Person Impacts of Legalization on Past-Year Cannabis Use (Yes/No) Across Ages 13−18 Years

| Parameters | Unstandardized estimate (SE) | Standardized estimate $b_{StdY}$ (SE) | *p*-value |
|---|---|---|---|
| Within-person effect | | | |
| Age | 0.953 (0.099) | 0.403 (0.028) | **<0.001** |
| Age[2] | −0.075 (0.035) | −0.032 (0.014) | **0.024** |
| Legalization (time varying) | 0.358 (0.493) | 0.151 (0.210) | 0.470 |
| Between-person effect | | | |
| Mean age | 0.099 (0.185) | 0.037 (0.070) | 0.593 |
| Birth year | −0.101 (0.044) | −0.038 (0.016) | **0.019** |
| Black/Afr. Am./Latinx | −0.676 (0.322) | −0.255 (0.118) | **0.031** |
| Male | 0.078 (0.243) | 0.030 (0.092) | 0.748 |
| Study: 3GS versus TIP | 1.229 (0.376) | 0.464 (0.138) | **0.001** |
| Study: RIGS versus TIP | −0.197 (0.360) | −0.074 (0.137) | 0.586 |
| Legalization (years exposed) | 0.150 (0.191) | 0.057 (0.072) | 0.430 |

*Notes:* Boldface indicates statistical significance ($p<0.05$).
*p*-Values presented are for standardized estimates. $b_{StdY} = b/SD(Y)$, and $b_{StdY}$ estimates denote the change in the predicted log odds in standardized units for a 1-unit change in the predictor. $Age^2$ denotes age squared.
3GS, Three Generation Study; Afr. Am., African American; RIGS, Rochester Intergenerational Study; TIP, Seattle Social Development Project − The Intergenerational Project.

whether legalization predicted changes in the probability or frequency of past-year cannabis use among adolescents. A novel contribution of this study was the attempt to disentangle within-person versus between-person changes in cannabis use after legalization. Thus, it was assessed whether legalization coincided with a higher or lower likelihood or frequency of past-year cannabis use within the same adolescents across time and between-person differences in the probability and frequency of cannabis use for youth who spent more years in states with legalization. Results did not support an association between legalization and either within- or between-person change in cannabis use from ages 13 to 18 years.

Taken together with previous studies, these findings add weight to the conclusion that adolescent cannabis use is holding steady in the wake of legalization, at least in the years relatively proximate to the policy change. This analyses expand on previous findings by specifically parsing variance in adolescent cannabis use owing to age, sex, birth cohort (i.e., population-level trends in use), and legalization.

**Table 3.** Between- and Within-Person Impacts of Legalization on Past-Year Cannabis Use Frequency Across Ages 13−18 Years

| **Parameters** | Unstandardized estimate (SE) | Standardized estimate $b_{StdY}$ (SE) | *p*-value |
|---|---|---|---|
| Within-person effect | | | |
| Age | 0.969 (0.100) | 0.406 (0.028) | **<0.001** |
| Age[2] | −0.065 (0.032) | −0.027 (0.013) | **0.036** |
| Legalization (time varying) | 0.306 (0.472) | 0.128 (0.199) | 0.519 |
| Between-person effect | | | |
| Mean age | 0.136 (0.193) | 0.048 (.068) | 0.478 |
| Birth year | −0.085 (0.045) | −0.030 (.016) | 0.059 |
| Black/Afr. Am./Latinx | −0.691 (0.344) | −0.245 (.120) | **0.040** |
| Male | 0.116 (0.254) | 0.041 (.091) | 0.650 |
| Study: 3GS versus TIP | 1.341 (0.387) | 0.476 (.133) | **<0.001** |
| Study: RIGS versus TIP | −0.104 (0.383) | −0.037 (0.136) | 0.786 |
| Legalization (years exposed) | 0.181 (0.203) | 0.064 (0.071) | 0.369 |

*Note:* Boldface indicates statistical significance ($p<0.05$).
*p*-Values presented are for standardized estimates. $b_{StdY} = b/SD(Y)$, and $b_{StdY}$ estimates denote the change in the predicted log odds in standardized units for a 1-unit change in the predictor.
$Age^2$ denotes age squared.
3GS, Three Generation Study; Afr. Am., African American; RIGS, Rochester InterGenerational Study; TIP, Seattle Social Development Project − The Intergenerational Project.

Despite this findings, continued monitoring of potential changes in adolescent cannabis use after legalization is warranted. Legalization may have different impacts in different states, depending on the specific policies in place or the levels of use and pro-use norms before the passage of legalization. Both Oregon and Washington had relatively high rates of adolescent cannabis use[22] and well-established medical cannabis markets before legalization. Legalization may have less of an impact (or no impact) in these states owing to existing high rates of use. Alternatively, differences in policy implementation, such as the location and number of outlets and allowance of home grows, may have differing implications for adolescent cannabis use.[23] In addition, the impacts of legalization on adolescent cannabis use may take more years to emerge or be detected[24] than were covered by this study. For example, Bae and Kerr[25] found both initial and compounding increases over time in the impacts of legalization on college students' cannabis use in early-, middle-, and later-adopting states. Notably, after the repeal of alcohol prohibition in the U.S. in 1933, population levels of drinking did not reach the preprohibition levels for 40 years.[24]

## LIMITATIONS

Several limitations should be considered when interpreting this findings. The included samples were not state representative; although the focal youth themselves lived in a broad range of neighborhood contexts, their parents were participants in studies that oversampled youth who lived in relatively higher-crime neighborhoods in their respective cities in the 1980s. Higher-crime and lower SES communities are important to study because they often experience disproportionate legal consequences from substance use and are under-resourced with regard to treatment. Youth in Oregon and Washington were pooled for testing the impacts of legalization, despite policy differences in these states. Findings may not generalize to either state or to other states that have or may yet legalize nonmedical cannabis use. Youth from New York State may not be representative of youth in nonlegal states, given New York's history of liberal cannabis policy and indeed recent legalization. For this study, RIGS was advantageous because it had many design features in common with the other samples. Other limitations include the smaller sample size in comparison with population-based cross-sectional studies and threats to internal validity inherent in pre−post designs. These limitations are balanced by important strengths, including the integration of data from 3 intensive studies; the use of longitudinal data with assessments both before and after legalization; and the separation of variance in cannabis use because of age, birth cohort, and legalization.

## CONCLUSIONS

The rates of adolescent cannabis use may be holding steady after nonmedical cannabis legalization for adults, but ongoing surveillance is recommended. Future studies should examine the potential differences in the impact of legalization across demographic groups. Given the impacts of legalization on increased cannabis use by parents,[8] future studies should consider whether children of parents who use cannabis are more susceptible to legalization impacts than children of parents who abstain.

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