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Publication Date

2022-11-01

DOI

10.1016/j.ypmed.2022.107297

Peer reviewed

HHS Public Access

Author manuscript

Prev Med. Author manuscript; available in PMC 2023 November 01.

Published in final edited form as:

Prev Med. 2022 November ; 164: 107297. doi:10.1016/j.ypmed.2022.107297.

Relationship between mandatory warning signs for cannabis use during pregnancy policies and birth outcomes in the Western United States

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Abstract

As U.S. states legalize recreational cannabis, some enact policies requiring Mandatory Warning Signs for cannabis during pregnancy (MWS-cannabis). While previous research has found MWS for alcohol during pregnancy (MWS-alcohol) associated with increases in adverse birth outcomes, research has not examined effects of MWS-cannabis. This study uses Vital Statistics birth certificate data from June 2015 – June 2017 in seven western states and policy data from NIAAA's Alcohol Policy Information System and takes advantage of the quasi-experiment created by Washington State's enactment of MWS-cannabis in June 2016, while nearby states did not. Outcomes are birthweight, low birthweight, gestation, and preterm birth. Analyses use a Difference-in-Difference approach and compare changes in outcomes in Washington to nearby states in the process of legalizing recreational cannabis (Alaska, California, Nevada) and, as a secondary analysis, nearby states continuing to criminalize recreational cannabis (Idaho, Montana, Wyoming). Birthweight was −7.03 grams lower (95% CI −10.06, −4.00) and low birthweight 0.3% higher (95% CI 0.0, 0.6) when pregnant people were exposed to MWS-cannabis than when pregnant people were not exposed to MWS-cannabis, both statistically significant (p=0.005 and p=0.041). Patterns for gestation, −0.014 weeks earlier (95% CI −0.038, 0.010) and preterm birth 0.2% higher (95% CI −0.2, 0.7), were similar, although not statistically significant (p=0.168 and 0.202). The direction of findings was similar in secondary analyses, although statistical significance varied. Similar to MWS-alcohol, enacting MWS-cannabis is associated with an increase in adverse birth outcomes. The idea that MWS-cannabis provide a public health benefit is not evidence-based.

Keywords

policy; cannabis; pregnancy

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Introduction

In 2012, Colorado and Washington State became the first states to legalize cannabis for recreational use in the United States.[1] Currently, 15 states have legalized cannabis for recreational use.[1] Importantly, legalizing cannabis has contributed to reductions in arrests and incarceration, particularly among adults.[2] While there were early hopes that legalizing cannabis would result in reductions in other substance use, these benefits have not been substantiated.[3,4] Research, instead, has identified potential health risks associated with cannabis legalization.[5,6] Thus, more attention is now being paid to health-related regulations,[7] such as regulations used for tobacco and alcohol-- taxation, potency of products, stringency of retail sales licensing, and lower-risk use guidelines--[1,8] as strategies to reduce health harms related to cannabis use.

Possible adverse health effects of pregnant people's cannabis use is one area public health authorities are concerned about in the context of legalization.[9,10] Evidence indicates there are some adverse health effects associated with cannabis use during pregnancy, including increased risks of low birthweight and adverse childhood psychological outcomes.[11–13] These effects have been documented particularly among people who continue to use cannabis after discovering pregnancy and people who use both cannabis and tobacco during pregnancy.[11,13] Research suggests pregnant people's cannabis use is increasing, although research is mixed as to whether this increase is due to legalization.[10,14–18]

In response to the concern about possible adverse health effects of pregnant people's cannabis use, five states have enacted policies requiring posting point-of-sale Mandatory Warning Signs related to cannabis use during pregnancy (MWS-cannabis) in places where cannabis is sold.[19] MWS-cannabis policies provide pregnancy-specific warnings about cannabis use to increase pregnant people's awareness about the risks of use and thus lead them to stop using during pregnancy. However, the idea that MWS reduce substance use is not well-supported by existing evidence. Specifically, despite point-of-sale Mandatory Warning Signs for alcohol use during pregnancy (MWS-alcohol) going into effect in more than 15 states by the mid-1990s and currently in effect in 25 states, alcohol use during pregnancy has remained roughly steady since the mid-1990s.[20–25] One national study found that MWS-alcohol was associated with lower self-reported alcohol consumption.[26] A study about pregnancy-specific alcohol warning messages on bottle labels found that these labels were associated with small decreases in alcohol consumption during pregnancy among lower risk, but not higher risk, drinkers.[27,28] Research on effects of state-level pregnancy-specific substance use policies in general indicates that such policies typically do not achieve intended purposes of reducing substance use during pregnancy; instead, many appear to increase adverse health outcomes and reduce prenatal care and substance use disorder treatment utilization.[29–33] Research on MWS-alcohol is consistent with this larger literature; the research finds that enacting MWS-alcohol is associated with increases in low birthweight and preterm births, as well as decreases in prenatal care use.[31,32] These findings suggest that MWS policies, like other pregnancy-specific substance use policies, may increase pregnant people's fears of judgment and punishment and thus lead them to avoid prenatal care.[34,35] An important and policy-relevant research question is whether the

findings related to MWS-alcohol apply to MWS-cannabis, a question this study seeks to answer.

Methods

Overarching study design

This study used individual-level birth data from 2015-2017 Natality Birth Data (Vital Statistics) and state-level policy data from the Alcohol Policy Information System (APIS), original legal research, and other secondary sources. The University of California, San Francisco, Institutional Review Board, considered this research exempt. It sought to examine the relationship between enacting MWS-cannabis and adverse birth outcomes. To do so, we took advantage of a quasi-experiment where Washington State enacted MWS-cannabis and nearby states did not. We used a Difference-in-Differences framework to compare changes in birth outcomes in Washington State to changes in birth outcomes in comparison states before and after Washington State enacted MWS-cannabis in June 2016. This study is one component of a larger project to understand the relationship between MWS-cannabis and a range of outcomes, including birth outcomes and beliefs about and attitudes towards pregnant people's cannabis use. The larger project has a community advisory board comprised of people with relevant lived experience and who have provided insight into interpreting the findings in this manuscript.

Data source(s)

We relied on these data sources:

1. Vital statistics birth certificate data to measure birth outcomes (birthweight, low birthweight, gestation, and preterm birth) and individual-level control variables. We relied on restricted use individual-level Vital Statistics data for U.S. births of people who were estimated to have become pregnant between June 2015 and June 2017 (one year before and after MWS-cannabis was enacted in Washington State) from the United States National Center for Health Statistics. Consistent with other assessments of trends in adverse birth outcomes over time,[36] we restricted analyses to singleton births (97% of births) because multiple births have different birthweight and gestation curves as well as higher likelihood of adverse birth outcomes.[37,38]

2. NIAAA's APIS and original legal research for MWS-cannabis (our primary exposure variable) and for recreational cannabis policy. State-level MWS-cannabis data and recreational cannabis legalization data were obtained from APIS[1,19] as well as original legal research conducted by APIS policy coders using Westlaw and HeinOnline, online legal databases. The legal research process has been described previously.[39]

3. U.S. Bureau of Labor Statistics to obtain state-level unemployment data, to serve as a state-level control variable.

We merged policy data with individual-level vital statistics data based on the month/year the person became pregnant.

State selection

As an intervention state, we sought to identify a state that had enacted MWS-cannabis long enough ago that outcome data would be available and long enough after legalizing recreational cannabis for the effects of those policies to be distinguishable. We identified five states with MWS-cannabis. We chose Washington State as the intervention state because it legalized recreational cannabis in 2012 and enacted MWS-cannabis in June 2016.[1,19] The other four states (Arizona, Colorado, Illinois, Oregon) that had enacted MWS-cannabis (as of January 1, 2021)[19] were not suitable for inclusion for several reasons: Colorado and Illinois enacted MWS-cannabis in 2020 or 2021, too recent for Vital Statistics birth certificate data to be available and their outcomes may be confounded by the COVID-19 pandemic; Arizona enacted MWS-cannabis in 2017, but did not legalize recreational cannabis until 2020;[1,19] and Oregon enacted MWS-cannabis less than three months after legalizing recreational cannabis in 2015,[1,19] which meant it would not be possible to distinguish effects of MWS-cannabis from effects of legalizing recreational cannabis.

To identify comparison states, we considered states that were also in the Western U.S. and were in the process of legalizing recreational cannabis (but not at the same time as Washington enacted MWS-cannabis) or that continued to criminalize recreational cannabis throughout the study period. We selected comparison states that met the parallel trends assumption, a key assumption of Difference-in-Differences analysis. We first considered Colorado, as it legalized cannabis for recreational purposes around the same time as Washington (in 2012). However, the parallel trends assumption was violated for all outcomes considered. Aside from Colorado, three nearby states were in the process of legalizing recreational cannabis (Alaska, California, and Nevada) and three nearby states continued to criminalize recreational cannabis throughout the study period (Idaho, Montana, and Wyoming). For these states and Washington, we confirmed that no other major policy changes plausibly related to our outcomes of interest, i.e. tobacco taxes,[40] other pregnancy-specific alcohol/drug policies,[19] occurred at the same time as the MWS-cannabis policy change that is the prime exposure of interest. Table 1 lists the MWS-cannabis enactment date plus legalization of recreational cannabis date for each included state. We selected the group of states that met the parallel trends assumption for all outcomes (Alaska, California, Nevada, “primary comparison states”, See Table 3 and Figure 1) to serve as our primary comparison, and the group of states that met the parallel trends assumption for only some outcomes (Idaho, Montana, Wyoming, “secondary comparison states”, See Table 4) to serve as a secondary comparison.

Variables

The main *exposure* was MWS-cannabis, coded as 1 for all babies born in Washington to people who became pregnant between June 2016-June 2017 (when MWS-cannabis was in effect) and 0 for babies born in Washington to people who became pregnant between June 2015-May 2016 and all people who became pregnant between June 2015 – June 2017 in other states (when MWS-cannabis was not in effect). MWS-cannabis policies require that warning signs about possible harms from cannabis use during pregnancy be posted in settings such as licensed premises where cannabis is sold.[19] *Outcomes* included birthweight (continuous, in grams), low birthweight (dichotomous, born less versus at or more than 2500

grams),[41] gestation (continuous, weeks), and preterm birth (dichotomous, born before versus at or after 37 weeks gestation).[42] We excluded cases with implausible birthweight (<299 and >4456 grams)[43] and cases with implausible gestation (<21 and >45 weeks).

Individual-level controls included maternal: parity (categorical: nulliparous, 1 previous live birth, 2+ previous live births), age (categorical: <19; 20–29; 30–39; 40 or older), marital status (dichotomous); education (categorical: less than high school, high school equivalent, more than high school), race/ethnicity (categorical: white, non-Hispanic; Black, non-Hispanic; Hispanic of any race; Asian/Pacific Islander, non-Hispanic; other/missing, non-Hispanic), nativity (dichotomous, U.S. born, non-U.S. born), and tobacco (dichotomous, of use during pregnancy). One state, California, ceased collecting marital status in 2017. Methods for handling this missing covariate are described below. *State-level controls* included timing of cannabis legalization (dichotomous, 1 for months in which recreational cannabis was legal and 0 for months in which recreational cannabis was not legal) and unemployment (continuous). *State* was the pregnant person's state of residence at the time of birth and *month* was the estimated month and year the person became pregnant.

Data analysis

Our overall approach to data analysis was a Difference-in-Differences analysis. We compare differences in changes in birth outcomes from before to after enactment of MWS-cannabis in Washington State to our primary comparison states (Alaska, California, Nevada) and, as a secondary analysis, to our secondary comparison states (Idaho, Montana, Wyoming). We conducted a sensitivity analysis that used all six comparison states. We also conducted sensitivity analyses, using month of birth rather than estimated month people became pregnant.

Difference-in-Differences models included individual- and state-level controls, as well as fixed effects for month and state, and accounted for clustering of standard errors according to state of residence and month of conception. Individual-controls were selected based on conceptual importance and on examinations of compositional changes of the sample [See Supplement 1]. Analyses were conducted in Stata 17.0. We tested the parallel trends assumption using post-estimation commands and graphical visualization.

There was minimal missing data for individual-level controls, with most variables missing <1%; for these variables, we used casewise deletion. The only individual-level control variable missing more than 5% was marital status, which was missing for all of California beginning in 2017, when California stopped including those data in the Vital Statistics records. For models that included California, we first excluded marital status as a covariate and then used multiple imputation. Findings did not differ between analyses that excluded marital status as a covariate and the multiple imputation models that included marital status in direction or size of effect and did not differ in statistical significance for three of the four outcomes. We thus present simpler models that exclude marital status as a covariate.

Results

Sample description

Table 2 includes information about total births in Washington (MWS-cannabis state) as well as primary and secondary comparison states. In Washington from before to after MWS-cannabis, mean birthweight decreased (3,355 to 3,347 grams), the proportion of low birthweight and preterm births increased (5.1% to 5.3%; 8.0% to 8.2%, respectively), while gestation remained relatively flat. Birthweight also decreased in comparison states, while the percent low birthweight increased slightly in primary comparison states but not secondary comparison states, and the percent preterm births increased in all comparison states. Gestation remained flat in all comparison states.

Primary comparisons (Washington compared to Alaska, California, Nevada)

The change in birthweight from before to after Washington enacted MWS-cannabis was 7.03 grams less (95% CI −10.06, −4.00) and the change in low birthweight was 0.3% greater (95% CI 0.0, 0.6) among people exposed to MWS-cannabis than people not exposed to MWS-cannabis, both statistically significant (p=0.005 and p=0.041). This translates to 269 babies born low birthweight in Washington June 2016-June 2017 related to the MWS-cannabis policy. Patterns for gestation, −0.014 weeks earlier (95% CI −0.038, 0.010), and preterm birth, 0.2% greater (95% CI −0.2, 0.7), were similar, although not statistically significant (p=0.168 and 0.202) at a p<0.05 level [See Table 3 and Figure 1].

Secondary comparisons (Washington compared to Idaho, Montana, Wyoming)

The direction of findings was similar when comparing Washington to secondary comparison states, although statistical significance of findings varied, as did whether comparisons met the parallel trends assumptions [See Table 4].

Sensitivity analyses

In sensitivity analyses using birth month rather than estimated month people became pregnant, there was no substantive difference in findings, with the exceptions of the finding for low birthweight no longer being statistically significant in the primary comparisons and the finding for gestation no longer being statistically significant in the secondary comparisons.

Discussion

This study found that enacting MWS for cannabis use during pregnancy was associated with increased adverse birth outcomes, particularly lower birthweights and higher proportions of babies born low birthweight. While there was also a decrease in weeks gestation and an increase in the proportion of babies born preterm, these changes were not statistically significant at a p<0.05 level. These findings are similar to previous research about MWS for alcohol use during pregnancy.[31]

While, at face value, MWS for cannabis during pregnancy is assumed by policymakers to have public health value, our findings do not support this assumption. Extant literature

and feedback from this study's community advisory board provides explanations for the pathway through which MWS-cannabis could contribute to adverse birth outcomes. Research examining MWS-alcohol finds MWS-alcohol associated with decreased prenatal care use, suggesting that such warning signs may deter people from care, which might contribute to increased risk for adverse birth outcomes.[32] Qualitative research about barriers to prenatal care for pregnant people who use alcohol and/or drugs has found that fear of having already irreversibly harmed the baby and fear of being reported to Child Protective Services (CPS) related to substance use during pregnancy are reasons that pregnant people physically avoid and emotionally disengage from prenatal care.[34,35] While many people who use cannabis during pregnancy consider cannabis use during pregnancy to be safe,[44–46] it is possible that MWS-cannabis could increase some people's fears that they may have already irreversibly harmed their baby by using cannabis before they found out they were pregnant. This could make them believe that reducing or stopping later in pregnancy will not make a difference. It could also lead to people using either prescribed alternatives or other means of self-treatment that may increase risks of these outcomes. Relationships of MWS-cannabis to changes in cannabis use and other substances (including prescribed medications) should be explored in future research. Importantly though, similar to the legality of alcohol use, legalization of recreational cannabis has not removed requirements related to health care providers reporting birthing people who use cannabis to CPS; and pregnant people in states with legalized recreational cannabis report that this fear of health care providers reporting to CPS remains a barrier to prenatal care, even after legalization.[47,48] Pregnant and birthing people's drug use is considered reportable to CPS in Washington State.[49] Further, the Washington State Department of Health published guidelines in 2015 stating that all positive urine toxicology tests at the time of delivery should be reported to CPS;[50] they do not exclude cannabis from this guidance. Research conducted in Washington State found that health care providers had been commonly reporting cannabis use during pregnancy to CPS through 2013.[51] In the context of this threat of punishment, pregnant people may perceive a sign with a government warning on it as a threat of CPS involvement or punishment, something to be explored in future research.

These findings are also consistent with the broader literature on effects of pregnancy-specific alcohol and drug policies. While longstanding scholarly literature and advocacy efforts have separated out alcohol-focused from drug-focused pregnancy policies, a study published in 2018 found that, with the exception of MWS policies, most pregnancy-specific policies cover both.[52] Thus, with the exception of findings for MWS for alcohol policies, other findings from the literature about pregnancy-specific alcohol policies can generally be interpreted as applying to both alcohol and drugs and vice versa. This study suggests that the findings about the relationship between MWS-alcohol and birth outcomes[32] also appear to generalize to cannabis.

Policymakers and public health professionals concerned about increases in pregnant people's use of cannabis and possible health effects of an increase may wonder about the implications of these findings for policy and public health action. First, it is worth noting that substance (including cannabis) use during pregnancy is not typically new use in pregnancy, but rather use continued from before people became pregnant.[46,53] Work to understand people's reasons for continuing to use cannabis while they are pregnant and

developing resources and supports that are relevant for people's experiences may be more important for their health and the health of their pregnancy than MWS-cannabis. Second, recreational cannabis legalization does not remove the threat of punishment for pregnant people who use cannabis; as long as that threat is in place, it seems reasonable to assume that MWS for cannabis may have unintended consequences. Third, rather than looking to existing pregnancy-specific substance use policies for legal substances (such as alcohol and tobacco), it is important to remember that the origin of most pregnancy-specific alcohol and drug policies is in the War on Drugs and that the pregnancy-specific policies generally considered more supportive (e.g. priority treatment) appear to have emerged from advocacy responses to War on Drugs-inspired punitive policies.[54] Instead, policymakers and public health professionals should bring pregnant people who use cannabis in to the policymaking process to identify the information and supports relevant for their lives.

This study has some limitations. Specifically, we examined effects of a MWS-cannabis policy change in a single state. While internal validity of the study is high, given the study design, applying findings to other states should be done with attention to factors that may differ between Washington and other states of interest. That the finding was consistent with research about 40 years of MWS-alcohol in all U.S. states [32] suggest the findings may generalize, though. Should more states enact MWS-cannabis and these policy changes occur long enough before/after legalization and the first two years of the COVID-19 pandemic, additional research examining impacts of these policies would be warranted. Further, the outcome data were not collected for research purposes. While there are few measurement changes on the birth certificate during our two-year study period, a possibly relevant variable (marital status) was no longer included in the data beginning in 2017. However, we did not find differences across our two approaches to handling these missing data. The data also do not include relevant mediators, such as data on knowledge about cannabis use during pregnancy or data on cannabis use, which may be important to explore in future research.

Conclusions

Similar to findings for MWS for alcohol use during pregnancy, enacting MWS for cannabis use during pregnancy is associated with increases in adverse birth outcomes. The idea that MWS for cannabis use during pregnancy provide a public health benefit is not based in evidence.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

The authors thank Meenakshi Subbaraman, PhD; Nancy Berglas, DrPH; Sue Thomas, PhD; and Claudia Zaugg, MPH for support with database creation and our Community Advisory Board for input interpreting findings.

Funding.

Research reported in this publication was supported by the California Department of Cannabis Control, Grant agreement 65328 and the National Institute On Alcohol Abuse And Alcoholism of the National Institutes of Health under Award Number R01AA023267. The content is solely the responsibility of the authors and does not

necessarily represent the official views of the National Institutes of Health. The funders had no role in study design; collection, analysis, and interpretation of data; writing of the manuscript; or the decision to submit the manuscript for publication. The authors have no conflicts of interest to disclose.

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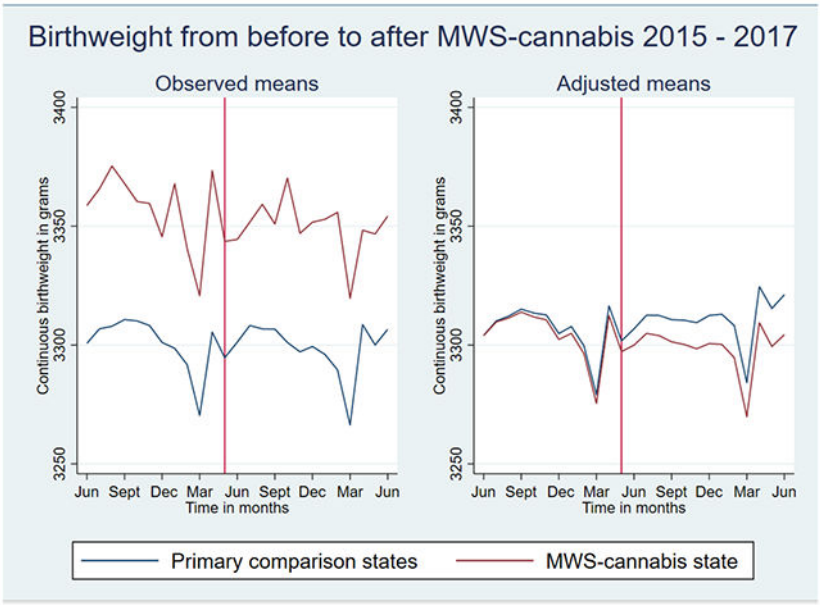

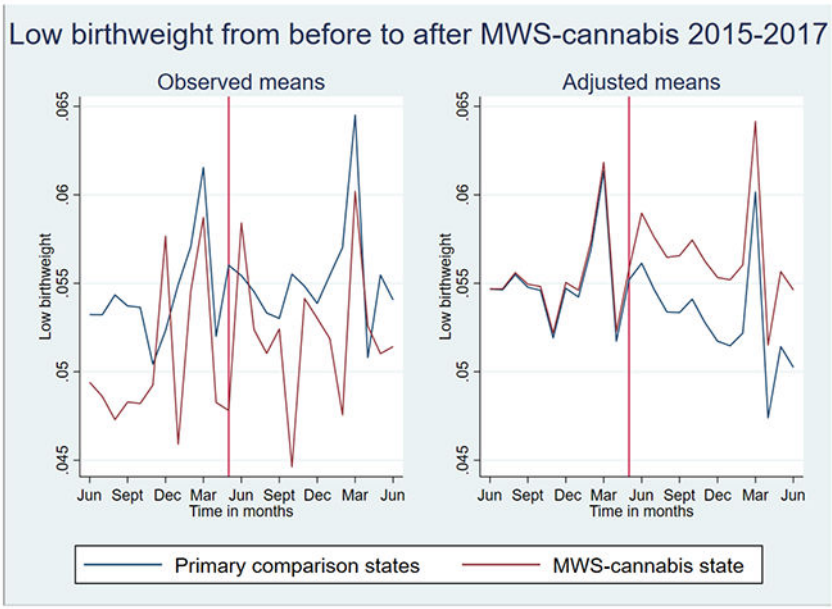

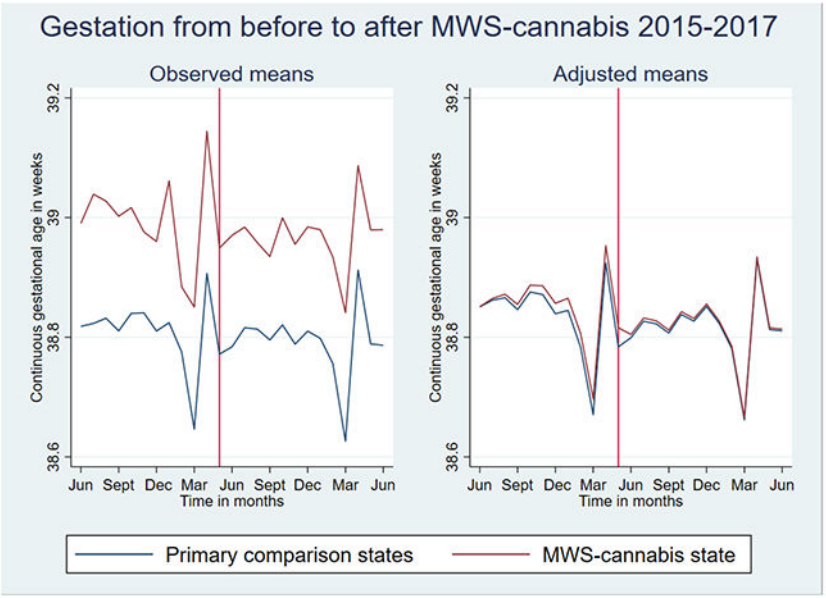

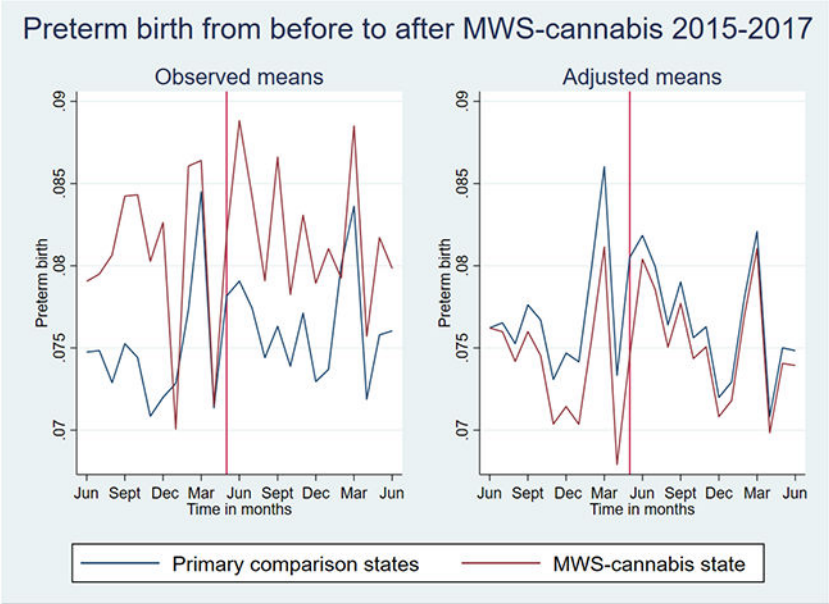

Figure 1.
Trends in birth outcomes in Washington (MWS-cannabis state) and primary comparison states (Alaska, California, Nevada)

Table 1.

Study states and MWS-cannabis and recreational cannabis legalization and enactment dates

	MWS-cannabis law and enactment date	Legalize recreational cannabis and date of legalization enactment
Washington	6/18/2016	Yes, 12/6/2012
Alaska	None	Yes, 2/24/2015
California	None	Yes, 11/9/2016
Nevada	None	Yes, 1/1/2017
Idaho	None	No
Montana	None	Yes, 1/1/2021
Wyoming	None	No
Data source: Alcohol Policy Information System: [1,19]		

Table 2.

Births and birth outcomes in Washington State and Comparison states

	Births N[a]		Birthweight mean (sd)		Low birthweight % (n)		Gestation mean (sd)		Preterm birth % (n)	
	Pre-	**Post-**	**Pre-**	**Post-**	**Pre-**	**Post-**	**Pre-**	**Post-**	**Pre-**	**Post-**
Washington	85,588	89,698	3,355 (523)	3,347 (527)	5.1 (4,351)	5.3 (4,760)	39.0 (2.1)	39.0 (2.2)	8.0 (7,017)	8.2 (7,503)
Alaska, California, and Nevada	510,714	530,538	3,299 (518)	3,297 (519)	5.5 (28,033)	5.6 (29,559)	38.8 (2.0)	38.8 (2.0)	7.6 (38,524)	7.7 (40,801)
Idaho, Montana, Wyoming	40,279	42,164	3,294 (520)	3,289 (520)	6.0 (2,409)	6.0 (2,544)	38.8 (2.2)	38.8 (2.2)	9.1 (3,654)	9.6 (4,017)

[a] these are the numbers of births included in birthweight models. Note that: 0.014% (17,699) of births were excluded from Washington, Alaska, California, and Nevada models due to having an implausible birthweight. An additional 0.002% (2,287) of births were excluded from Washington, Alaska, California, and Nevada models for gestation due to having an implausible gestation.

Table 3.

Relationship between enacting MWS-cannabis (in Washington State) and birth outcomes [a]

	Birthweight (grams)			**Low birthweight (<2500 grams)**			**Gestation (weeks)**			**Preterm birth (<37 weeks)**		
	N=1,154,161			**N=1,154,161**			**N=1,151,980**			**N=1,151,980**		
	Coef	**95% CI**	**p-value**	**Coef**	**95% CI**	**p-value**	**Coef**	**95% CI**	**p-value**	**Coef**	**95% CI**	**p-value**
MWS-cannabis	**−7.029**	**−10.055, −4.003**	**0.005**	**0.003**	**0.000, 0.006**	**0.041**	−0.014	−0.038, 0.010	0.168	0.002	−0.002, 0.007	0.202
Parallel trends test			0.402			0.863			0.306			0.197

[a] Washington, Alaska, California, Nevada

Bold indicates where finding is statistically significant and does not violate parallel trends assumption (p<0.05 indicates a violation of the parallel trends assumption)

Models control for individual-level: parity, age, education, race/ethnicity, nativity, and tobacco; state-level: recreational cannabis legalization and unemployment; included fixed effects for state and month and cluster standard errors by state and month

Table 4.

Relationship between enacting MWS-cannabis (in Washington State) and birth outcomes with alternative comparison states [b]

	Birthweight			Low birthweight			Gestation			Preterm birth		
	Coef	**95% CI**	**p-value**	**Coef**	**95% CI**	**p-value**	**Coef**	**95% CI**	**p-value**	**Coef**	**95% CI**	**p-value**
Washington compared to secondary comparison states [b]												
	N=249,741			**N=249,741**			**N=248,665**			**N=248,665**		
MWS	−3.469	−16.957, 10.019	0.473	0.003	−0.003, 0.008	0.218	−0.018	−0.037, −0.002	0.063	−0.001	−0.004, 0.001	0.122
Parallel trends test			0.567			0.035[d]			0.187			0.033[d]
Washington compared to primary and secondary comparison states [c]												
	N=1,235,386			**N=1,235,386**			**N=1,232,877**			**N=1,232,877**		
	−4.131	**−7.728, −0.534**	**0.031**	**0.002**	**0.000, 0.003**	**0.036**	−0.004	−0.018, 0.009	0.461	0.000	−0.003, 0.003	0.764
Parallel trends test			0.678			0.295			0.060			0.001[d]

[b] Washington, Idaho, Montana, Wyoming

[c] Washington, Alaska, California, Idaho, Montana, Nevada, Wyoming

[d] violates parallel trends assumption

Bold indicates where finding is statistically significant and does not violate parallel trends assumption ($p<0.05$ indicates a violation of the parallel trends assumption)

Models control for individual-level: parity, age, education, race/ethnicity, marital status (for comparison with secondary comparison states only), nativity, and tobacco; state-level: recreational cannabis legalization and unemployment; included fixed effects for state and month and cluster standard errors by state and month.