

Supplementary Online Content

Wen H, Hockenberry JM. Association of medical and adult-use marijuana laws with opioid prescribing for Medicaid enrollees. *JAMA Intern Med*. Published online April 2, 2018. doi:10.1001/jamainternmed.2018.1007

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This supplementary material has been provided by the authors to give readers additional information about their work.

eTable 1. Descriptive Statistics of Study Variables Weighted by State Population

State-Population Weighted Statistics	Mean 2011-2016 (S.D.)
# All Opioid Prescriptions (per quarter per 1,000 enrollees)	162.04 (59.98)
# Schedule II Opioid Prescriptions (per quarter per 1,000 enrollees)	122.32 (51.03)
# Schedule III-V Opioid Prescriptions (per quarter per 1,000 enrollees)	39.72 (12.98)
# Non-Opioid Pain Prescriptions (per quarter per 1,000 enrollees)	304.68 (93.23)
\$ All Opioid Spending (per quarter per 1,000 enrollees)	4599.33 (344.92)
\$ Schedule II Opioid Spending (per quarter per 1,000 enrollees)	4224.68 (3298.15)
\$ Schedule III-V Opioid Spending (per quarter per 1,000 enrollees)	374.65 (230.06)
\$ Non-Opioid Pain Spending (per quarter per 1,000 enrollees)	14688.54 (6420.30)
Marijuana Dispensary 0/1	0.06 (0.22)
PDMP Establishment 0/1	0.20 (0.40)
PDMP Mandate 0/1	0.32 (0.46)
Pain Clinic Law 0/1	0.25 (0.43)
Medicaid Expansion 0/1	0.35 (0.47)
# DATA-Waived Physicians (per quarter per 1,000 residents)	6.97 (4.08)
# Office-Based Psychiatrists (per quarter per 1,000 residents)	8.17 (3.34)
# Primary Care Physicians (per quarter per 1,000 residents)	71.94 (11.46)
% Unemployment Rate	6.98 (1.93)
% Poverty Rate	15.61 (2.60)
\$ Median Household Income (\$1K)	52.89 (7.92)

Source: Authors' analysis of the CMS State Drug Utilization Data 2011-2016.

eTable 2. Effective Dates & Dispensary Status of Medical Marijuana Laws & Adult-Use Marijuana Laws between 2011 and 2016

STATES	EFFECTIVE DATES	DISPENSARY STATUS
<u>Medical Marijuana Law:</u>		
<i>Connecticut</i>	2012-05	law permitted: 2012-10; first legal operation: 2014-08
<i>Delaware</i>	2011-07	law permitted: 2011-07; first legal operation: 2015-06
<i>Illinois</i>	2014-01	law permitted: 2014-01; first legal operation: 2015-10
<i>Maryland</i>	2014-06	law permitted: 2015-09
<i>Massachusetts</i>	2013-01	law permitted: 2013-05; first legal operation: 2015-06
<i>Minnesota</i>	2014-05	law permitted: 2014-05; first legal operation: 2015-10
<i>New Hampshire</i>	2013-07	law permitted: 2013-07; first legal operation: 2016-05
<i>New York</i>	2014-07	law permitted: 2014-07; first legal operation: 2016-01
<u>Adult-Use Marijuana Law:</u>		
<i>Alaska</i>	2015-02	<u>adult-use:</u> law permitted: 2015-02; first legal operation: 2016-01
<i>Colorado</i>	2012-12	<u>adult-use:</u> law permitted: 2013-09; first legal operation: 2014-01 <u>medical:</u>
<i>Oregon</i>	2015-07	law permitted: 2013-08; first legal operation: 2014-03 <u>adult-use:</u> law permitted: 2015-10; first legal operation: 2016-10
<i>Washington</i>	2012-12	<u>medical & adult-use:</u> law permitted: 2012-12; first legal operation: 2014-07

Source/Notes: National Conference of State Legislation (NCSL). NCSL Marijuana Deep Dive:

<http://www.ncsl.org/bookstore/state-legislatures-magazine/marijuana-deep-dive.aspx>;

Bradford AC, Bradford WD. Medical marijuana laws may be associated with a decline in the number of prescriptions for Medicaid enrollees. *Health Affairs (Millwood)*. 2017 May 1;36(5):945-51;

Powell D, Pacula RL, Jacobson M. Do medical marijuana laws reduce addictions and deaths related to pain killers?. *National Bureau of Economic Research Working Paper Series*. No. w21345. 2015 Jul 10.

eMethods. Variable Measurement & Model Specifications

Main Analysis:

$$\ln(\# \text{Opioid}_{s,t}) = \beta_0 + \beta_1 \text{MedMrj}_{s,t} \times \text{MedMrj}_t + \beta_2 \text{RecMrj}_{s,t} \times \text{RecMrj}_t + \beta_3 \text{MrjDisp}_s \times \text{MrjDisp}_t + \beta_4 \text{PDMPEst}_s \times \text{PDMPEst}_t + \beta_5 \text{PDMPMdt}_s \times \text{PDMPMdt}_t + \beta_6 \text{PainLaw}_s \times \text{PainLaw}_t + \beta_7 \text{MDCDExp}_s \times \text{MDCDExp}_t + \beta_8 \text{DATADoc}_{s,t} + \beta_9 \text{Psych}_{s,t} + \beta_{10} \text{PCDoc}_{s,t} + \beta_{11} \text{Unemp}_{s,t} + \beta_{12} \text{Pov}_{s,t} + \beta_{13} \text{HHInc}_{s,t} + \rho_s + \tau_t + \varepsilon_{s,t}$$

Additional Analysis:

$$\ln(\$ \text{Opioid}_{s,t}) = \beta_0 + \beta_1 \text{MedMrj}_{s,t} \times \text{MedMrj}_t + \beta_2 \text{RecMrj}_{s,t} \times \text{RecMrj}_t + \beta_3 \text{MrjDisp}_s \times \text{MrjDisp}_t + \beta_4 \text{PDMPEst}_s \times \text{PDMPEst}_t + \beta_5 \text{PDMPMdt}_s \times \text{PDMPMdt}_t + \beta_6 \text{PainLaw}_s \times \text{PainLaw}_t + \beta_7 \text{MDCDExp}_s \times \text{MDCDExp}_t + \beta_8 \text{DATADoc}_{s,t} + \beta_9 \text{Psych}_{s,t} + \beta_{10} \text{PCDoc}_{s,t} + \beta_{11} \text{Unemp}_{s,t} + \beta_{12} \text{Pov}_{s,t} + \beta_{13} \text{HHInc}_{s,t} + \rho_s + \tau_t + \varepsilon_{s,t}$$

$$\ln(\# \text{Non-Opioid}_{s,t}) = \beta_0 + \beta_1 \text{MedMrj}_{s,t} \times \text{MedMrj}_t + \beta_2 \text{RecMrj}_{s,t} \times \text{RecMrj}_t + \beta_3 \text{MrjDisp}_s \times \text{MrjDisp}_t + \beta_4 \text{PDMPEst}_s \times \text{PDMPEst}_t + \beta_5 \text{PDMPMdt}_s \times \text{PDMPMdt}_t + \beta_6 \text{PainLaw}_s \times \text{PainLaw}_t + \beta_7 \text{MDCDExp}_s \times \text{MDCDExp}_t + \beta_8 \text{DATADoc}_{s,t} + \beta_9 \text{Psych}_{s,t} + \beta_{10} \text{PCDoc}_{s,t} + \beta_{11} \text{Unemp}_{s,t} + \beta_{12} \text{Pov}_{s,t} + \beta_{13} \text{HHInc}_{s,t} + \rho_s + \tau_t + \varepsilon_{s,t}$$

$$\ln(\$ \text{Non-Opioid}_{s,t}) = \beta_0 + \beta_1 \text{MedMrj}_{s,t} \times \text{MedMrj}_t + \beta_2 \text{RecMrj}_{s,t} \times \text{RecMrj}_t + \beta_3 \text{MrjDisp}_s \times \text{MrjDisp}_t + \beta_4 \text{PDMPEst}_s \times \text{PDMPEst}_t + \beta_5 \text{PDMPMdt}_s \times \text{PDMPMdt}_t + \beta_6 \text{PainLaw}_s \times \text{PainLaw}_t + \beta_7 \text{MDCDExp}_s \times \text{MDCDExp}_t + \beta_8 \text{DATADoc}_{s,t} + \beta_9 \text{Psych}_{s,t} + \beta_{10} \text{PCDoc}_{s,t} + \beta_{11} \text{Unemp}_{s,t} + \beta_{12} \text{Pov}_{s,t} + \beta_{13} \text{HHInc}_{s,t} + \rho_s + \tau_t + \varepsilon_{s,t}$$

Sensitivity Analysis I:

$$\ln(\# \text{Opioid}_{s,t}) = \beta_0 + \beta_1 \text{MedMrj}_{s,t} \times \text{MedMrj}_t + \beta_2 \text{RecMrj}_{s,t} \times \text{RecMrj}_t + \beta_3 \text{MrjDisp}_s \times \text{MrjDisp}_t + \beta_4 \text{PDMPEst}_s \times \text{PDMPEst}_t + \beta_5 \text{PDMPMdt}_s \times \text{PDMPMdt}_t + \beta_6 \text{PainLaw}_s \times \text{PainLaw}_t + \beta_7 \text{MDCDExp}_s \times \text{MDCDExp}_t + \beta_8 \text{DATADoc}_{s,t} + \beta_9 \text{Psych}_{s,t} + \beta_{10} \text{PCDoc}_{s,t} + \beta_{11} \text{Unemp}_{s,t} + \beta_{12} \text{Pov}_{s,t} + \beta_{13} \text{HHInc}_{s,t} + \rho_s + \tau_t + \rho_c \times t + \varepsilon_{s,t}$$

Sensitivity Analysis II:

$$\ln(\# \text{Opioid}_{s',t}) = \beta_0 + \beta_1 \text{MedMrj}_{s',t} \times \text{MedMrj}_t + \beta_2 \text{RecMrj}_{s',t} \times \text{RecMrj}_t + \beta_3 \text{MrjDisp}_{s'} \times \text{MrjDisp}_t + \beta_4 \text{PDMPEst}_{s'} \times \text{PDMPEst}_t + \beta_5 \text{PDMPMdt}_{s'} \times \text{PDMPMdt}_t + \beta_6 \text{PainLaw}_{s'} \times \text{PainLaw}_t + \beta_7 \text{MDCDExp}_{s'} \times \text{MDCDExp}_t + \beta_8 \text{DATADoc}_{s',t} + \beta_9 \text{Psych}_{s',t} + \beta_{10} \text{PCDoc}_{s',t} + \beta_{11} \text{Unemp}_{s,t} + \beta_{12} \text{Pov}_{s,t} + \beta_{13} \text{HHInc}_{s,t} + \rho_{s'} + \tau_t + \varepsilon_{s',t}$$

(s' includes states that started to implement medical/adult-use marijuana laws during the study period and those with medical/adult-use marijuana laws in place before 2011 as comparison states)

Source/Notes:

s: state, t: year-quarter;

$\ln(\# \text{Opioid}_{s,t})$: logarithmic-transformed number of Medicaid prescriptions for all opioid pain medications, Schedule II opioids, and Schedule III-V opioids, on a quarterly, per 1,000 Medicaid enrollees basis. We only included the buprenorphine formulations that are approved for, and generally prescribed for, pain management (e.g., Buprenex® injectable, Butrans® transdermal patch, Belbuca® buccal film), but excluded those for medication-assisted treatment of opioid addiction (e.g., Suboxone® sublingual tablet and film, Subutex® sublingual tablet, Zubsolv® sublingual tablet, Bunavail® buccal film). Methadone is a full opioid agonist that can also be used in medication-assisted treatment. However, the methadone prescriptions reflected in the study data are largely for pain management. Those for medication-assisted treatment are exclusively provided in opioid treatment programs funded directly by state and local substance abuse treatment agencies, which are not captured by the data. Therefore we included methadone in measurement of opioid pain medications;

Data Source: Centers for Medicare and Medicaid Services (CMS). State Drug Utilization Data:

<https://www.medicaid.gov/medicaid/prescription-drugs/state-drug-utilization-data/index.html>;

References:

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National Alliance of Advocates for Buprenorphine Treatment (NAABT). Are there other uses for Buprenorphine? [Internet]. Farmington, CT: NAABT. https://www.naabt.org/faq_answers.cfm?ID=10

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National Alliance of Advocates for Buprenorphine Treatment (NAABT). Education section FAQ: are there other uses for buprenorphine? [Internet]. Farmington, CT: NAABT; 2015. http://www.naabt.org/faq_answers.cfm?ID=10

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$\ln(\$ Opioid_{s,t})$: logarithmic-transformed amount of Medicaid spending on all opioid pain medications, Schedule II opioids, and Schedule III-V opioids, on a quarterly, per 1,000 Medicaid enrollees basis. The spending data in the CMS State Drug Utilization Data represent pre-rebate amounts reimbursed by Medicaid only, which is a mandatory component of state reporting and consistently reported since the beginning of the Medicaid Drug Rebate Program in 1991. The nominal spending values between 2011 and 2016 were converted to real values based on national monthly Consumer Price Index (CPI);

Data Source: Centers for Medicare and Medicaid Services (CMS). State Drug Utilization Data: <https://www.medicaid.gov/medicaid/prescription-drugs/state-drug-utilization-data/index.html>;

$\#Non-Opioid_{s,t}$, $\$ Non-Opioid_{s,t}$: Medicaid prescriptions for, and spending on, non-opioid pain medications on a quarterly, per 1,000 Medicaid enrollees basis;

Data Source: Centers for Medicare and Medicaid Services (CMS). State Drug Utilization Data: <https://www.medicaid.gov/medicaid/prescription-drugs/state-drug-utilization-data/index.html>;

$MedMrj_{s} \times MedMrj_{t}$: difference-in-differences indicator for state implementation of medical marijuana laws that permit marijuana use for medical use;

Data Source: National Conference of State Legislation (NCSL). Marijuana Deep Dive: <http://www.ncsl.org/bookstore/state-legislatures-magazine/marijuana-deep-dive.aspx>;

Bradford AC, Bradford WD. Medical marijuana laws may be associated with a decline in the number of prescriptions for Medicaid enrollees. *Health Affairs (Millwood)*. 2017 May 1;36(5):945-51;

Powell D, Pacula RL, Jacobson M. Do medical marijuana laws reduce addictions and deaths related to pain killers?. *National Bureau of Economic Research Working Paper Series*. No. w21345. 2015 Jul 10;

RecMrj_s × RecMrj_t: difference-in-differences indicator for state implementation of adult-use marijuana laws that permit marijuana use for adult use;

Data Source: National Conference of State Legislation (NCSL). Marijuana Deep Dive:
<http://www.ncsl.org/bookstore/state-legislatures-magazine/marijuana-deep-dive.aspx>;

MrjDisp_s × MrjDisp_t: concurrent policy indicator for state opening of the first licensed marijuana dispensaries or existing dispensaries first legally operating; which opened up legal channels for people to access marijuana. Massachusetts was the only state during our study period that allowed home cultivation before the allowance and operation of dispensaries. So we created an additional indicator just to capture this in Massachusetts (one quarter lagged after the home cultivation allowance effective date since it usually takes 2-6 months to grow marijuana). No effect were found, and no influence on the estimated effects of other policy indicators. Therefore, we did not included this additional Massachusetts home-cultivation indicator in the analyses.

Data Source: National Conference of State Legislation (NCSL). Marijuana Deep Dive:
<http://www.ncsl.org/bookstore/state-legislatures-magazine/marijuana-deep-dive.aspx>;

Bradford AC, Bradford WD. Medical marijuana laws may be associated with a decline in the number of prescriptions for Medicaid enrollees. *Health Affairs (Millwood)*. 2017 May 1;36(5):945-51;

Powell D, Pacula RL, Jacobson M. Do medical marijuana laws reduce addictions and deaths related to pain killers?. *National Bureau of Economic Research Working Paper Series*. No. w21345. 2015 Jul 10;

PDMPEst_s × PDMPEst_t: concurrent policy indicator for state establishment of Prescription Drug Monitoring Programs;

Data Source: National Alliance for Model State Drug Laws (NAMSDL). Prescription drug monitoring programs: <http://www.namsdl.org/prescription-monitoring-programs.cfm>;

PDMPMdt_s × PDMPMdt_t: concurrent policy indicator for state implementation of mandatory registration and/or mandatory use of the existing PDMPs;

Data Source: National Alliance for Model State Drug Laws (NAMSDL). Prescription drug monitoring programs: <http://www.namsdl.org/prescription-monitoring-programs.cfm>;

PainLaw_s × PainLaw_t: concurrent policy indicator for state regulations on pain management clinics,

Data Source: Centers for Disease Control and Prevention (CDC) Public Health Law Program. State laws on prescription drug misuse and abuse: <https://www.cdc.gov/phlp/publications/topic/prescription.html>;

MDCDExp_s × MDCDExp_t: concurrent policy indicator for state implementation of Medicaid expansions in compliance with the Medicaid State Plan Amendment (SPA) provision of the ACA or through the Section §1115 waiver, or partial implementation of Medicaid expansions under the “early adoption” provision of the ACA;

Data Source: Kaiser Family Foundation (KFF). Status of state action on the Medicaid expansion decision:
<http://www.kff.org/health-reform/state-indicator/state-activity-around-expanding-medicaid-under-the-affordable-care-act/>;

Sommers BD, Kenney GM, Epstein AM. New evidence on the Affordable Care Act: coverage impacts of early Medicaid expansions. *Health Affairs (Millwood)*. 2014 Jan 1;33(1):78-87;

DATADocs_t: total number of the 100-patient-waived physicians and 30-patient-waived physicians per 100,000 state residents;

Data Source: Drug Enforcement Agency (DEA). Controlled Substances Act (CSA) Registrants Database;

Psych_{s,t}: number of office-based psychiatrists (including addiction psychiatrists) per 100,000 state residents;

Data Source: Health Resources and Services Administration (HRSA). Area Health Resources Files (AHRF):
<https://datawarehouse.hrsa.gov/topics/ahrf.aspx>;

$PCDoc_{s,t}$: number of office-based primary care physicians per 100,000 state residents. Primary care specialties include general practice, general internal medicine, and family medicine, but exclude pediatrics;

Data Source: Health Resources and Services Administration (HRSA). Area Health Resources Files (AHRF): <https://datawarehouse.hrsa.gov/topics/ahrf.aspx>;

$Unemp_{s,t}$: state unemployment rate, calculated as the number of unemployed persons divided by the number of persons in the labor force (aged 16 and above). The numerator and denominator excluding the institutionalized persons or those without employment who are not seeking employment;

Data Source: Health Resources and Services Administration (HRSA). Area Health Resources Files (AHRF): <https://datawarehouse.hrsa.gov/topics/ahrf.aspx>;

$Pov_{s,t}$: state poverty rate, calculated for the civilian noninstitutionalized population based on household income, household size, and household composition, relative to a set of dollar value thresholds called the “federal poverty level (FPL)”;

Data Source: Health Resources and Services Administration (HRSA). Area Health Resources Files (AHRF): <https://datawarehouse.hrsa.gov/topics/ahrf.aspx>;

$HHInc_{s,t}$: state median household income, calculated for the civilian noninstitutionalized population based on household. A household consists of all people who occupy a housing unit regardless of relationship. A household may consist of a person living alone or multiple unrelated individuals or families living together. Institutionalized persons, those in military group quarters, and those living in college dormitories, and unrelated children under the age of 15 excluded from the numerator and denominator when calculating the household income;

Data Source: Health Resources and Services Administration (HRSA). Area Health Resources Files (AHRF): <https://datawarehouse.hrsa.gov/topics/ahrf.aspx>;

ρ_s : state fixed effects, τ_t : year-quarter fixed effects. The two-way fixed effects account for the time-invariant state heterogeneity and the national secular trend in opioid prescriptions and spending that may systematically be correlated with marijuana liberalization;

$\rho_{c \times t}$: group-specific linear trends at the Census Division level accounting for the unobserved Census Division-wide confounding factors that evolve over time at a constant rate such as public sentiment towards pain management and opioid addiction treatment;

All models were population-weighted and were state-clustered to correct for the within-state serial correlation in error terms.

We excluded D.C. and Rhode Island from the study data, as well as one or several quarters of observations in Arizona, Illinois, Kansas, Kentucky, Louisiana, Mississippi, New Jersey, New Mexico, and Oregon. Regarding the data quality, although the Medicaid SDUD is very timely and useful data, it is prone to unusual patterns in state reporting due to the close linkage to the Medicaid drug rebate program. It is not unusual for states to revise and resubmit data for this system, with retroactive changes sometimes occurring several years after the end of a quarter. Therefore, we have checked with the CMS staff who are responsible for maintenance of the files about the potential data quality concerns and plotted out the state trends in the fee-for-service (FFS) and managed care data separately to check for any unusual, suspicious patterns during the study period. We have also compared the total FFS drug spending against the amounts reported on Form CMS-64, prior to rebates, to see if the orders of magnitude are similar as another quality check. One potential concern, as the reviewer noted, is that prescription drugs paid through Medicaid managed care organizations (MCO) were excluded from the required quarterly data reporting/rebate collection until March 23, 2010, when the ACA expanded the reporting/collection requirement to all the Medicaid MCO carve-ins. By the end of 2011 2nd quarter, the majority of the 22 States using a carve-in approach had collected all the required data and performed data verification checks. A few states revised/resubmitted the complete data later. D.C. is the only state that may still have incompleteness in its first three quarters of 2011 data. Therefore, we also excluded D.C. and started our study period from 2011

onward. Another potential data quality issue concerns the new adult eligibility group under the ACA Medicaid expansion. At the beginning of 2014, CMS noticed some confusion and inconsistency in state reporting associated with the new adult eligibility group and the increased federal matching rates available to this group. CMS provided states with timely reviews, clarifying information, and technical assistance. The 2014 onward data should have acceptable quality for analysis;

Reference: Department of Health and Human Services, Office of Inspector General: States' collection of rebate for drug paid through Medicaid managed care organizations. Washington DC; Sep 2012. <https://oig.hhs.gov/oei/reports/oei-03-11-00480.pdf>

eTable 3.

Estimated Effect of Medical Marijuana Laws & Adult-Use Marijuana Laws on Medicaid-Covered Prescription Rate of & Spending on All Opioid Pain Medications

PERCENTAGE CHANGE (%)	All Opioids Pain Medications	
	(1) PRESCRIPTIONS	(2) SPENDING
<i>Medical Marijuana Law</i>	-5.88* [-11.55,-0.21]	-2.87 [-8.16, 2.42]
<i>Adult-Use Marijuana Law</i>	-6.38* [-12.20,-0.56]	-9.78* [-18.29, -1.26]
<i>Marijuana Dispensary 0/1</i>	-0.36 [-8.99, 8.27]	-0.74 [-7.22, 5.74]
<i>PDMP Establishment 0/1</i>	-1.02 [-7.20, 5.15]	-1.42 [-5.53, 2.69]
<i>PDMP Mandate 0/1</i>	-5.77 [-17.05,5.51]	-7.76 [-17.33,1.81]
<i>Pain Clinic Law 0/1</i>	-0.94 [-10.21, 8.33]	0.10 [-10.33,10.53]
<i>Medicaid Expansion 0/1</i>	7.75 [-2.89, 18.40]	4.34 [-8.39,17.07]
<i># DATA-Waived Physicians (per 100,000 residents)</i>	-1.14* [-2.25, -0.03]	-2.68* [-5.07, -0.29]
<i># Office-Based Psychiatrists (per 100,000 residents)</i>	-0.96 [-2.92, 1.01]	-0.90 [-4.14, 2.34]
<i># Primary Care Physicians (per 100,000 residents)</i>	2.01[†] [-0.10, 4.11]	2.11 [-1.29, 5.51]
<i>% Unemployment Rate</i>	2.79 [-0.97, 6.55]	1.85 [-4.68, 8.38]
<i>% Poverty Rate</i>	8.08* [1.74, 14.42]	6.50 [-12.53,25.52]
<i>\$ Median Household Income (\$1K)</i>	-0.82 [-3.46, 1.82]	-0.95 [-5.88, 3.98]

Source: Authors' analysis of the CMS State Drug Utilization Data 2011-2016.

Notes: [†] $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; 95% confidence intervals in brackets clustered at the state level; presented in Figure 1 and Table 2.

eTable 4.

Estimated State-Specific Effects of Medical Marijuana Laws & Adult-Use Marijuana Laws on Medicaid-Covered Prescription Rate of & Spending on All Opioid Pain Medications

PERCENTAGE CHANGE (%)	All Opioids Pain Medications	
	(1) PRESCRIPTIONS	(2) SPENDING
<i>Medical Marijuana Law</i>	-5.88*	-2.87
	[-11.55,-0.21]	[-8.16, 2.42]
~ Connecticut	3.63	7.12
	[-6.29, 13.55]	[-3.07, 17.31]
~ Delaware	-12.12**	9.01
	[-20.02,-4.22]	[-5.90, 23.92]
~ Illinois	-4.29	-4.40
	[-13.89, 5.31]	[-23.94,15.15]
~ Maryland	2.83	8.90
	[-6.63, 12.30]	[-4.67, 22.48]
~ Massachusetts	-9.78*	-2.22
	[-18.60,-0.96]	[-10.78, 6.34]
~ Minnesota	-11.81**	-7.90*
	[-20.10,-3.52]	[-14.14,-1.67]
~ New Hampshire	-7.68	-9.18[†]
	[-23.04, 7.69]	[-19.49, 1.13]
~ New York	-8.03**	-10.02*
	[-13.68,-2.39]	[-18.01,-2.03]
<i>Adult-Use Marijuana Law</i>	-6.38*	-9.78*
	[-12.20,-0.56]	[-22.28,-2.72]
~ Alaska	-7.32*	-11.15**
	[-13.13,-1.51]	[-18.45,-3.85]
~ Colorado	-9.38*	-9.03**
	[-17.87,-0.89]	[-12.94,-5.12]
~ Oregon	-10.72**	-7.31[†]
	[-17.91,-3.53]	[-15.82, 1.20]
~ Washington	-4.73[†]	-7.70[†]
	[-10.51, 1.05]	[-12.95, 1.56]

Source: Authors' analysis of the CMS State Drug Utilization Data 2011-2016.

Notes: [†] $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; 95% confidence intervals in brackets clustered at the state level; presented in Figure 2.

eTable 5.

Estimated Effect of Medical Marijuana Laws & Adult-Use Marijuana Laws on Medicaid-Covered Prescription Rate of & Spending on Schedule II Opioid Pain Medications

PERCENTAGE CHANGE (%)	Schedule II Opioids	
	(1) PRESCRIPTIONS	(2) SPENDING
<i>Medical Marijuana Law</i>	-4.69[†] [-10.05,0.67]	-2.11 [-9.45, 5.12]
<i>Adult-Use Marijuana Law</i>	-7.79* [-14.73,-0.85]	-11.93* [-21,26,-2.60]
<i>Marijuana Dispensary 0/1</i>	-0.53 [-11.73,10.67]	-0.88 [-19.43,17.67]
<i>PDMP Establishment 0/1</i>	-3.14 [-12.27, 5.99]	-1.67 [-8.96, 5.62]
<i>PDMP Mandate 0/1</i>	-9.12* [-18.74,-0.50]	-8.12[†] [-16.47,0.24]
<i>Pain Clinic Law 0/1</i>	-0.14 [-7.76, 7.49]	0.24 [-8.96, 9.44]
<i>Medicaid Expansion 0/1</i>	9.54 [-2.19,21.27]	6.01 [-8.25,20.27]
<i># DATA-Waived Physicians (per 100,000 residents)</i>	-1.26[†] [-2.69, 0.17]	-2.41 [-3.95, -0.87]
<i># Office-Based Psychiatrists (per 100,000 residents)</i>	-1.04 [-4.55, 2.46]	-1.25 [-3.52, 1.02]
<i># Primary Care Physicians (per 100,000 residents)</i>	1.82 [-0.51, 4.14]	1.34 [-1.86, 4.54]
<i>% Unemployment Rate</i>	3.44[†] [-0.47, 7.25]	1.76 [-5.05, 8.57]
<i>% Poverty Rate</i>	11.33 [-2.80,25.46]	7.53 [-12.20,27,26]
<i>\$ Median Household Income (\$1K)</i>	-1.04 [-3.25, 1.17]	-0.80 [-4.17, 3.56]

Source: Authors' analysis of the CMS State Drug Utilization Data 2011-2016.

Notes: [†] $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; 95% confidence intervals in brackets clustered at the state level; presented in Figure 1 and Table 2.

eTable 6.

Estimated Effect of Medical Marijuana Laws & Adult-Use Marijuana Laws on Medicaid-Covered Prescription for & Spending on Schedule III-V Opioid Pain Medications

PERCENTAGE CHANGE (%)	Schedule III-V Opioids	
	(1) PRESCRIPTIONS	(2) SPENDING
<i>Medical Marijuana Law</i>	-10.40* [-19.05,-1.74]	-14.27 [-32.20,3.75]
<i>Adult-Use Marijuana Law</i>	-1.36 [-12.93,10.21]	0.39 [-8.55, 9.33]
<i>Marijuana Dispensary 0/1</i>	0.02 [-9.24, 9.28]	0.59 [-7.74, 8.92]
<i>PDMP Establishment 0/1</i>	1.39 [-12.73,15.51]	2.01 [-15.42,19.44]
<i>PDMP Mandate 0/1</i>	1.83 [-5.32, 8.97]	2.88 [-9.49, 15.25]
<i>Pain Clinic Law 0/1</i>	-2.72 [-12.36,6.91]	-3.26 [-10.88,4.36]
<i>Medicaid Expansion 0/1</i>	3.83 [-6.88,14.53]	2.22 [-13.01,17.45]
<i># DATA-Waived Physicians (per 100,000 residents)</i>	-0.42[†] [-0.87, 0.03]	-0.77 [-1.70, 0.16]
<i># Office-Based Psychiatrists (per 100,000 residents)</i>	-0.82 [-2.32, 0.68]	0.35 [-4.76, 5.46]
<i># Primary Care Physicians (per 100,000 residents)</i>	2.66* [0.01, 5.32]	3.06 [-2.50, 8.61]
<i>% Unemployment Rate</i>	1.56 [-3.47, 6.60]	2.74 [-2.56, 8.03]
<i>% Poverty Rate</i>	-1.47 [-12.18,9.24]	-1.69 [-11.54,8.16]
<i>\$ Median Household Income (\$1K)</i>	-0.48 [-4.21, 3.25]	-1.46 [-4.84, 1.93]

Source: Authors' analysis of the CMS State Drug Utilization Data 2011-2016.

Notes: [†] $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; 95% confidence intervals in brackets clustered at the state level; presented in Figure 1 and Table 2.

eTable 7.

Estimated Effect of Medical Marijuana Laws & Adult-Use Marijuana Laws on Medicaid-Covered Prescription Rate of & Spending on Non-Opioid Pain Medications

PERCENTAGE CHANGE (%)	Non-Opioid Pain Medications	
	(1) PRESCRIPTIONS	(2) SPENDING
<i>Medical Marijuana Law</i>	-8.36* [-13.67,-3.05]	-3.92 [-9.28, 1.44]
<i>Adult-Use Marijuana Law</i>	-8.69* [-15.50,-1.89]	-9.85 [-21.85,2.15]
<i>Marijuana Dispensary 0/1</i>	0.28 [-8.57, 9.13]	1.44 [-3.07, 5.95]
<i>PDMP Establishment 0/1</i>	-1.27 [-11.57,9.03]	-1.07 [-11.24,9.10]
<i>PDMP Mandate 0/1</i>	4.68 [-1.04,10.40]	-2.46 [-8.60, 3.69]
<i>Pain Clinic Law 0/1</i>	5.27 [-4.61,15.15]	8.40 [-3.46,20.26]
<i>Medicaid Expansion 0/1</i>	8.51* [0.80, 16.22]	4.46 [-4.65,13.57]
<i># DATA-Waived Physicians (per 100,000 residents)</i>	-0.20 [-2.22, 1.82]	-0.14 [-1.83, 1.55]
<i># Office-Based Psychiatrists (per 100,000 residents)</i>	-1.16 [-3.20, 0.88]	-1.89 [-4.63, 0.85]
<i># Primary Care Physicians (per 100,000 residents)</i>	1.05 [-1.21, 3.31]	0.81 [-1.98, 3.61]
<i>% Unemployment Rate</i>	2.86 [-1.57, 7.28]	1.88 [-2.17, 5.92]
<i>% Poverty Rate</i>	5.27[†] [-0.43,10.97]	3.39 [-2.29, 9.08]
<i>\$ Median Household Income (\$1K)</i>	-1.49 [-4.06, 1.09]	-2.43 [-6.37, 1.52]

Source: Authors' analysis of the CMS State Drug Utilization Data 2011-2016.

Notes: [†] $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; 95% confidence intervals in brackets clustered at the state level; presented in Figure 1 and Table 2.

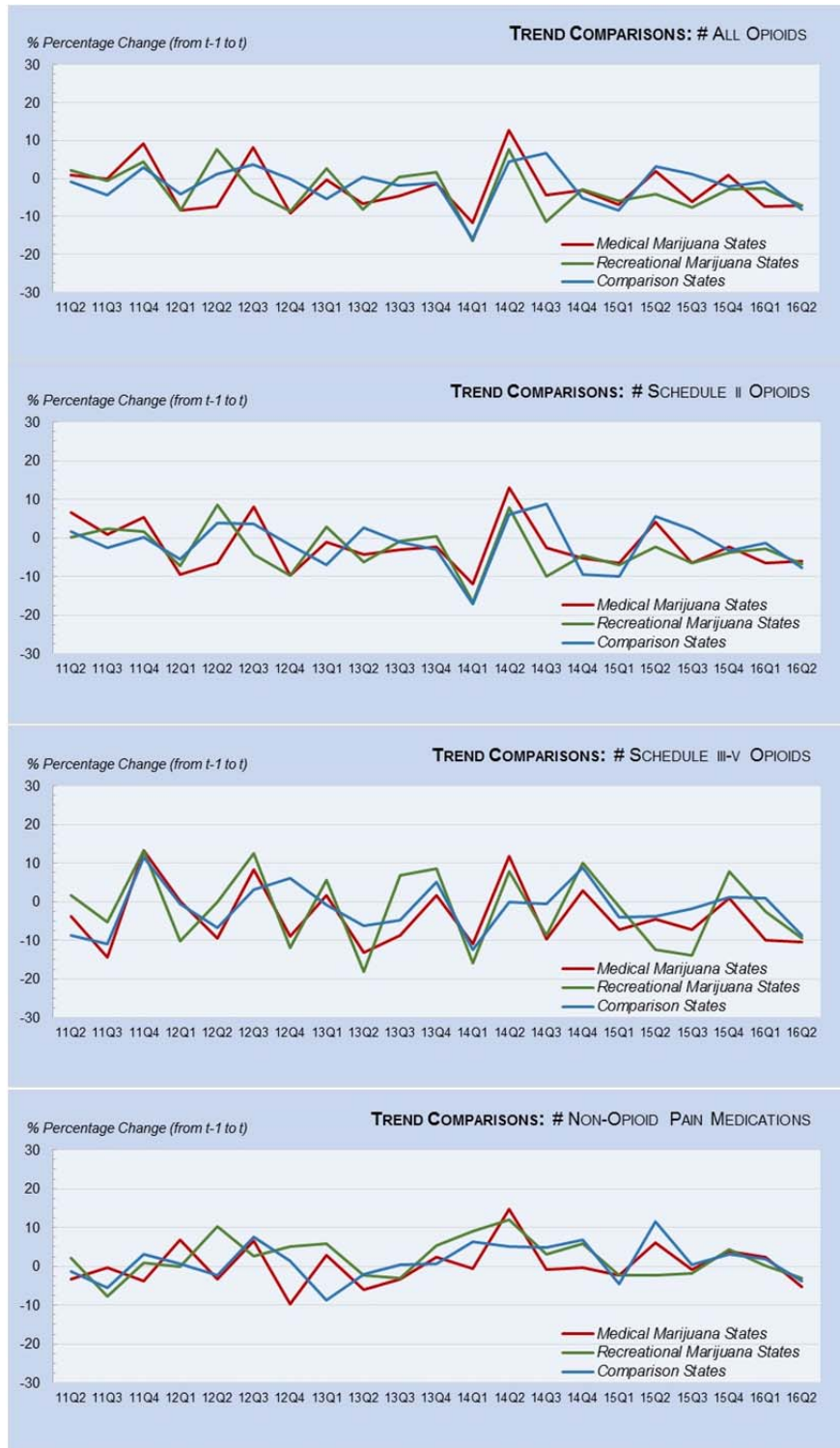
eTable 8. Tests for Pre-Policy Trend Differences of Medicaid-Covered Prescription for & Spending on Opioid and Non-Opioid Pain Medications between Medical Marijuana States & Comparison States, & between Adult-Use Marijuana States & Comparison States

Trend Differences in All Opioids Pain Medications	<i>F-Statistics</i>	
	# PRESCRIPTION	\$ SPENDING
<i>Pre-Medical Marijuana Law Difference</i>	1.47 (0.23)	1.10 (0.37)
<i>Pre-Adult-Use Marijuana Law Difference</i>	1.17 (0.34)	0.81 (0.53)
Trend Differences in Schedule II Opioids	# PRESCRIPTION	\$ SPENDING
<i>Pre-Medical Marijuana Law Difference</i>	1.49 (0.21)	1.24 (0.31)
<i>Pre-Adult-Use Marijuana Law Difference</i>	1.08 (0.38)	0.78 (0.55)
Trend Differences in Schedule III-V Opioids	# PRESCRIPTION	\$ SPENDING
<i>Pre-Medical Marijuana Law Difference</i>	0.89 (0.50)	1.28 (0.29)
<i>Pre-Adult-Use Marijuana Law Difference</i>	1.81 (0.14)	1.40 (0.24)
Trend Differences in Non-Opioid Pain Medications	# PRESCRIPTION	\$ SPENDING
<i>Pre-Medical Marijuana Law Difference</i>	0.76 (0.59)	1.86 (0.13)
<i>Pre-Adult-Use Marijuana Law Difference</i>	1.19 (0.33)	1.01 (0.42)

Source: Authors' analysis of the CMS State Drug Utilization Data 2011-2016.

Notes: *p*-values in parentheses corresponding to *F*-statistics of trend-difference tests.

eFigure. Trend Comparisons of Medicaid-Covered Prescription for & Spending on Opioid and Non-Opioid Pain Medications between Medical Marijuana States, Adult-Use Marijuana States & Comparison States



Source: Authors' analysis of the CMS State Drug Utilization Data 2011-2016.

eTable 9. Sensitivity Analyses of Effects of Medical Marijuana Laws & Adult-Use Marijuana Laws on Medicaid-Covered Opioid Pain Medication Prescribing Rate

PERCENTAGE CHANGE (%)	All Opioid Pain Medication Prescribing Rate		Schedule II Opioid Prescribing Rate		Schedule III-V Opioid Prescribing Rate	
	(1)	(2)	(3)	(4)	(5)	(6)
	SENSITIVITY I	SENSITIVITY II	SENSITIVITY I	SENSITIVITY II	SENSITIVITY I	SENSITIVITY II
<i>Medical Marijuana Law</i>	-4.08[†] [-8.92, 0.76]	-6.20* [-12.22,-0.18]	-3.48 [-8.13, 1.17]	-4.29 [-10.90, 2.31]	-7.83* [-16.32, 0.66]	-12.50[†] [-26.30, 1.40]
<i>Adult-Use Marijuana Law</i>	-7.74* [-15.32,-0.16]	-7.78[†] [-16.28, 0.72]	-8.58* [-15.98,-1.17]	-8.62* [-16.29,-0.95]	-2.90 [-15.18, 9.38]	-3.79 [-19.39,11.81]
<i>Marijuana Dispensary 0/1</i>	0.87 [-7.65, 9.40]	-0.47 [-15.15, 14.21]	0.86 [-7.43, 9.15]	-0.57 [-14.26,13.12]	1.43 [-2.83, 5.69]	-1.14 [-19.33, 17.05]
<i>PDMP Establishment 0/1</i>	-1.50 [-7.48, 4.49]	-2.34 [-10.51, 5.83]	-1.84 [-10.60, 6.91]	-2.41 [-9.96, 5.14]	-1.69 [-7.67, 4.29]	-1.01 [-9.03, 7.02]
<i>PDMP Mandate 0/1</i>	-5.93 [-16.26, 4.40]	-4.34 [-13.67, 4.99]	-7.48[†] -15.57, 0.61	-4.69[†] [-9.93, 0.55]	3.18 [-8.22, 14.58]	0.37 [-7.13, 7.87]
<i>Pain Clinic Law 0/1</i>	-3.43 [-16.18, 9.32]	-0.67 [-8.73, 7.39]	-2.12 [-10.28, 6.04]	-0.75 [-7.74, 6.24]	-4.37 [-17.56, 8.82]	0.38 [-7.57, 8.33]
<i>Medicaid Expansion 0/1</i>	5.01 [-2.81, 12.82]	0.55 [-11.30, 10.20]	6.88 [-1.05, 14.81]	1.38 [-7.99,10.75]	3.02 [-7.97, 14.01]	-4.19 [-19.45,11.06]
<i># DATA-Waived Physicians (per 100,000 residents)</i>	-1.33* [-2.64, -0.02]	-1.21[†] [-2.53, 0.11]	-1.46* [-2.91, -0.01]	-1.42* [-2.63, -0.21]	-0.42[†] [-0.87, 0.03]	-0.98 [-4.90, 2.95]
<i># Office-Based Psychiatrists (per 100,000 residents)</i>	-1.05 [-6.03, 3.93]	-1.53 [-2.95, 1.16]	-1.17 [-4.72, 2.38]	-1.41 [-3.78, 0.96]	-0.80 [-4.24, 2.64]	-1.88 [-5.62, 1.85]
<i># Primary Care Physicians (per 100,000 residents)</i>	2.16 [-0.20, 4.52]	1.28 [-1.15, 3.70]	2.34[†] [-0.24, 4.91]	1.18 [-1.23, 3.59]	2.17 [-0.67, 5.01]	1.24 [2.04, 4.52]
<i>% Unemployment Rate</i>	2.16 [-1.55, 5.86]	1.48 [-3.04, 6.00]	2.02 [-1.64, 5.69]	1.28 [-3.11, 5.67]	1.57 [-3.76, 6.90]	2.29 [-3.20, 7.77]
<i>% Poverty Rate</i>	5.30[†] [-0.10, 10.70]	2.44 [-5.18, 10.05]	8.67* [0.39, 16.95]	3.19 [-6.23, 12.60]	2.01 [-5.48,9.49]	0.52 [-9.23, 10.27]
<i>\$ Median Household Income (\$1K)</i>	-0.89 [-4.28, 2.51]	-1.81 [-8.34, 4.72]	-0.97 [-4.20, 2.25]	-1.99 [-7.87, 3.88]	-0.46 [-5.47, 4.56]	-1.19 [-9.77, 7.38]

Notes: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; 95% confidence intervals in brackets clustered at the state level; sensitivity analysis I included in the covariates group-specific linear trends at the Census Division level; sensitivity analysis II limited comparison states to those with medical/adult-use marijuana laws in place before 2011.

eTable 10. Falsification Analyses of Effects of Medical Marijuana Laws & Adult-Use Marijuana Laws on Medicaid-Covered Prescribing Rates of Blood Thinning Agents, Influenza Antiviral Drugs, and Antibiotics

PERCENTAGE CHANGE (%)	Blood Thinning Agents	Influenza Antiviral Drugs	Antibiotics
	(1) PRESCRIPTIONS	(2) PRESCRIPTIONS	(3) PRESCRIPTIONS
<i>Medical Marijuana Law</i>	0.21 [-9.10,9.53]	4.12 [-4.01,12.25]	-2.51 [-9.05, 4.04]
<i>Adult-Use Marijuana Law</i>	-1.58 [-8.58,5.43]	-3.48 [-12.94,5.98]	-2.18 [-9.57, 5.21]
<i>Marijuana Dispensary 0/1</i>	-1.96 [-10.72,6.80]	1.39 [-5.43, 8.21]	-0.64 [-9.60, 8.31]
<i>PDMP Establishment 0/1</i>	5.16 [-5.61,15.93]	-1.34 [-11.70,9.02]	2.68 [-1.80, 7.16]
<i>PDMP Mandate 0/1</i>	-3.00 [-9.79, 3.80]	3.73 [-4.05,14.81]	2.18 [-5.21, 9.57]
<i>Pain Clinic Law 0/1</i>	1.11 [-1.44, 3.66]	-1.51 [-6.91, 3.88]	4.46 [-4.98,13.90]
<i>Medicaid Expansion 0/1</i>	3.26* [-0.50, 6.02]	5.43 [-7.38,18.24]	4.23 [-5.69, 14.15]
<i># DATA-Waived Physicians (per 100,000 residents)</i>	8.20 [-2.28,18.68]	-0.51† [-1.04, 0.02]	1.65 [-10.12,13.41]
<i># Office-Based Psychiatrists (per 100,000 residents)</i>	-0.26 [-2.95, 2.43]	-0.76 [-5.13, 3.61]	1.52 [-3.30, 6.34]
<i># Primary Care Physicians (per 100,000 residents)</i>	2.19 [-7.84, 3.56]	2.61 [-3.61, 8.82]	2.46† [-0.14, 5.07]
<i>% Unemployment Rate</i>	-3.27 [-14.07,7.53]	2.11 [-1.88, 6.11]	-1.80 [-6.24, 2.64]
<i>% Poverty Rate</i>	-3.93* [-7.55, -0.30]	3.18 [-2.76, 9.12]	-1.89 [-6.29, 2.51]
<i>\$ Median Household Income (\$1K)</i>	-0.47 [-5.41, 4.47]	0.57 [-2.32, 3.46]	-1.24 [-9.27, 6.78]

Notes: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; 95% confidence intervals in brackets clustered at the state level.