USING SURVEY DATA TO UNDERSTAND THE IMPACT OF MEDICAL MARIJUANA LAWS

Christine Mauro, PhD

Columbia University, Department of Biostatistics

CPDD

June 12, 2018

Disclosures

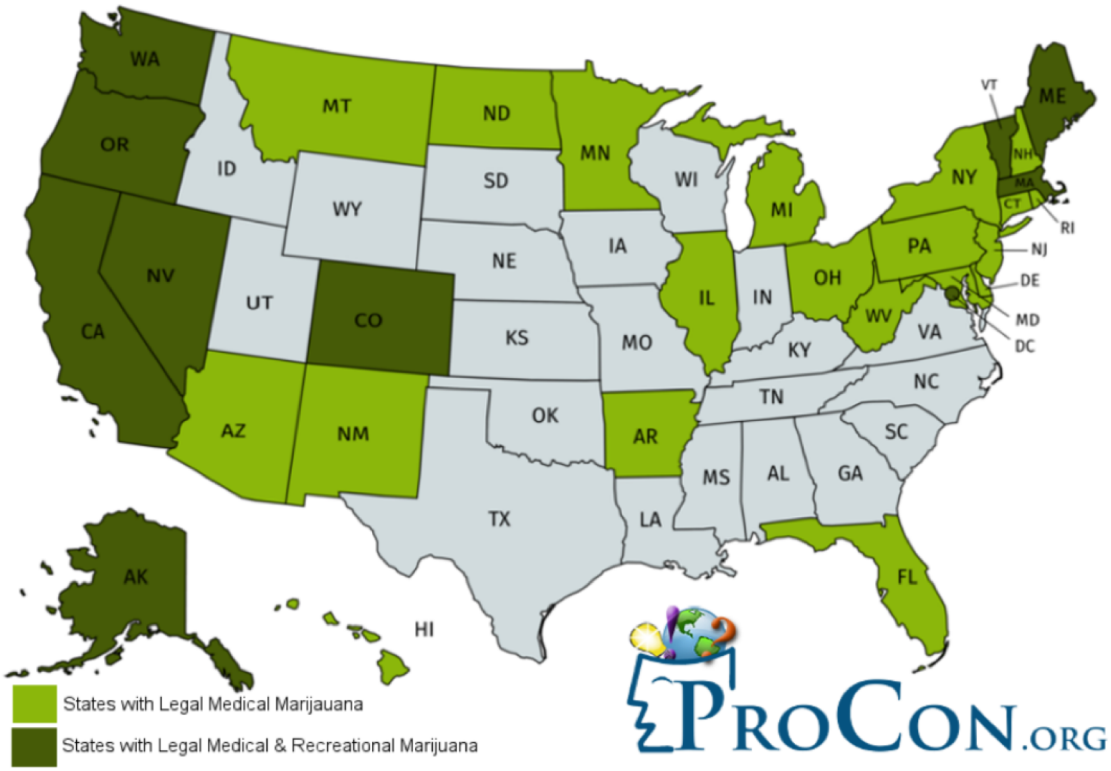
- No conflicts of interest.

- This work was supported by a grant from the National Institute on Drug Abuse (R01DA037866-Martins).

Outline

- Overview
- Difference-in-Difference (DID) Analyses
- Stolzenberg et al. 2015
- Modeling Medical Marijuana Laws (MMLs)
- Conclusions and Future Work

29 Legal Medical Marijuana States & DC
9 Legal Recreational Marijuana States & DC



Nov. 5, 1996 - California Becomes First State to Legalize Medical Marijuana

"Voters in California [pass] a state medical marijuana initiative in 1996. Known as Proposition 215 (45 KB), it permits patients and their primary caregivers, with a physician' s recommendation, to possess and cultivate marijuana for the treatment of AIDS, cancer, muscular spasticity, migraines, and several other disorders; it also protects them from punishment if they recommend marijuana to their patients."

Marijuana Use in Adolescents

- Adolescent marijuana use is associated with adverse later effects
- Identification of factors influencing adolescent use is of substantial public health importance.
- It is of *particular* interest to examine whether state laws permitting the use of marijuana for medical purposes may influence adolescent marijuana use.
  - Aside: we have also examined the impact on other age groups.

What is the Causal Question?

- A causal question compares a factual event to a **counterfactual event**.
- Causal contrast of interest for understanding the impact of MML policy
  - Past month marijuana use in a specific state in a specific year in the **presence** of an MML.

  VS.

  - Past month marijuana use in the SAME state in the SAME year in the **absence** of an MML.
- The problem: Only one of these is ever observed!

Causal Questions

- What **substitute** can we use for the unobserved counterfactual? **We need a valid control group!**
  - Past month marijuana use in a specific state in a specific year in the presence of an MML.

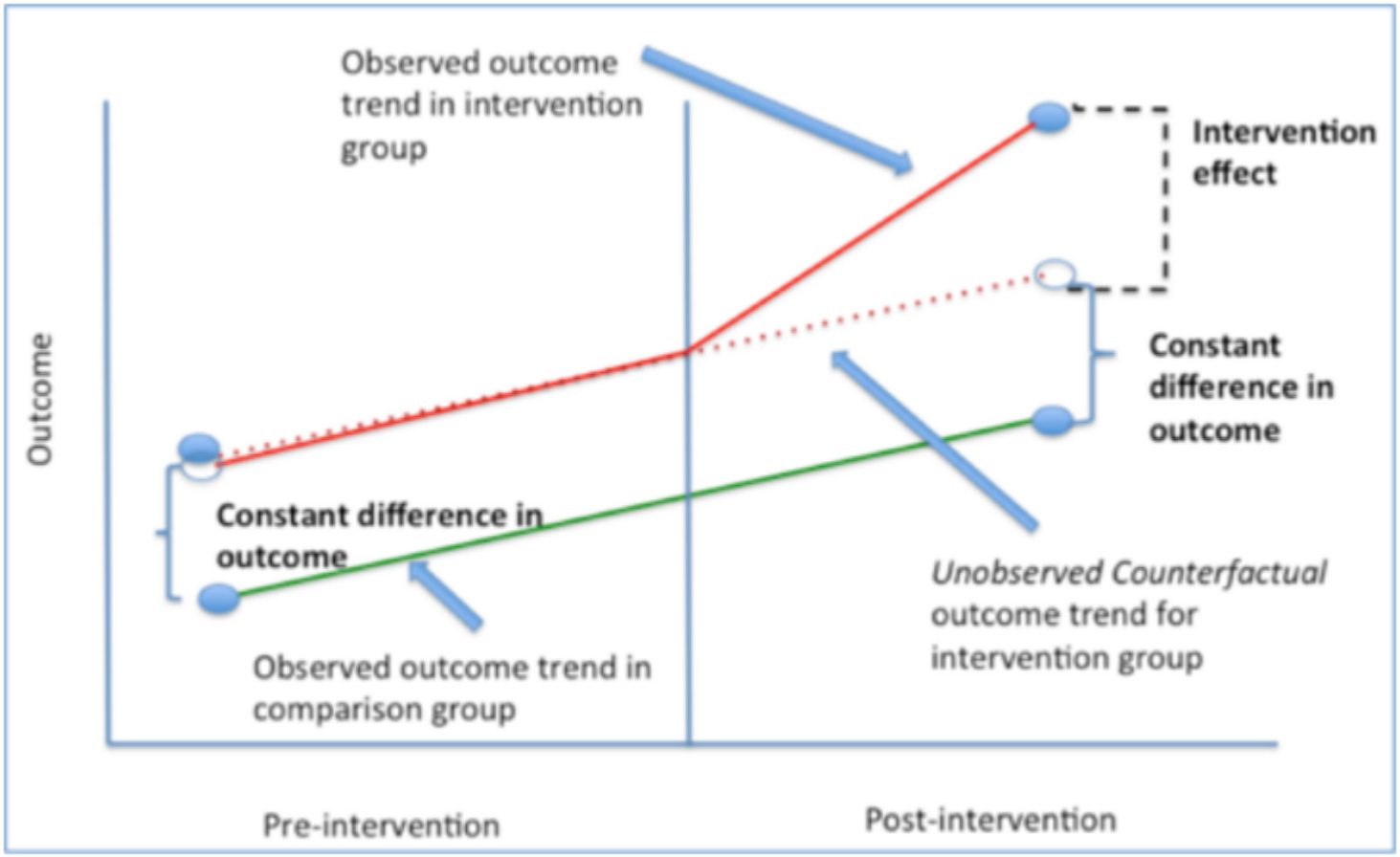
  VS.

  - Past month marijuana use in a ANOTHER(?) state in the SAME year in the **absence** of an MML.
- Can we just compare a state with an MML to a state without?
  - Or what about comparing all states with MMLs to all states without?

Difference-in-Difference (DID)

- Quasi-experimental design, makes use of longitudinal data from treatment and control groups **to obtain an appropriate counterfactual** to estimate a causal effect.
- Typically used to estimate the effect of a specific intervention or treatment by comparing the changes in outcomes over time between a population that is enrolled in a program (the intervention group) and a population that is not (the control group).

DID Visual



- https://www.mailman.columbia.edu/research/population-health-methods/difference-difference-estimation

DID Assumption

- Removes biases in post-intervention period comparisons between the treatment and control group that could be the result from permanent differences between those groups
- Key Assumption: Parallel Trend Assumption
  - In the absence of treatment, the difference between the 'treatment' and 'control' group is constant over time
  - No statistical test for this assumption, just visual inspection
- This approach assumes that there is a clear "pre" and "post" period for all units!!

Ideal Data

- Sample of individuals from some population repeatedly taken over time (pre and post passage)
  - Repeated Cross Sectional Data
  - Not necessarily the same individuals, but the same overall population or same set of entities (e.g. states, countries, companies)
- Very useful
  - To examine secular trends
  - To examine effect of interventions at the population level (e.g. new state laws)

Our Data

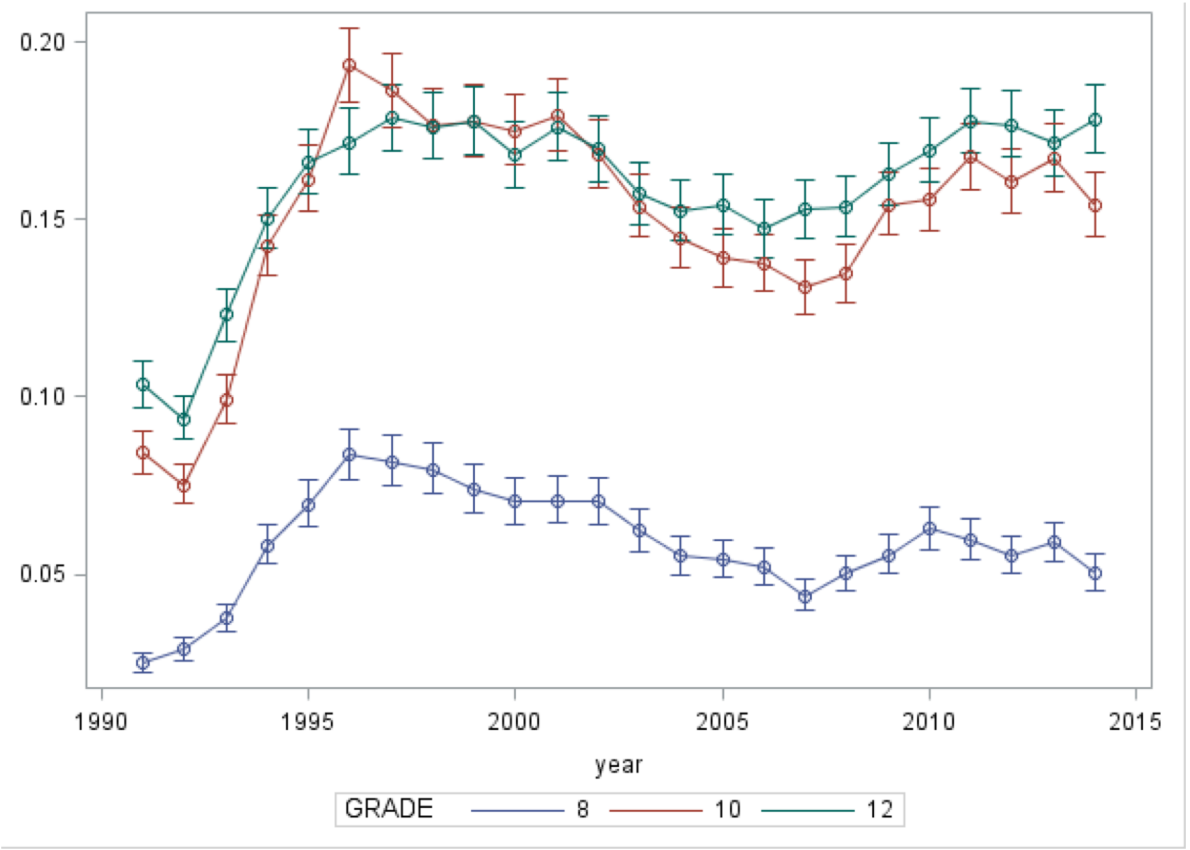
- National Survey on Drug Use and Health (NSDUH)
  - Designed to produce estimates of drug and alcohol use prevalence, as well as drug use patterns and their consequences, in the general U.S. civilian population aged 12 and older.
- Every year 17,500 youth (12-17 yr olds), 17,500 young adults (18-25 yr olds) and 18,800 adults 26+.
- Years: 2002-03, 2004-05, 2006-07, 2008-09, 2010-11

Sampling design

- Design allows for computation of estimates by State in all 50 States plus the District of Columbia (DC).
- Multi-stage probability sampling designs are used to collect the annual cross sectional surveys.
- The survey employs a 50 state design with an independent multistage area probability sample for each state and the District of Columbia (DC).
- Sample size in each state is ~ 300 in 42 states and ~800 in 8 largest states in each age group.

Complications in MML analysis…

- Complication #1
  - Not all MMLs passed at same time
  - No clear "before" and "after" for DID analysis.
  - Analysis will need to account for historical trends in MJ use!



Complications (contd.)

- Complication #2: For states that passed laws prior to 2002 (e.g CA) we have no "before" data in this sample, only "after" data
- Complication #3: For states that passed laws after 2011 (e.g NY) we have no "after" data in this sample, only "before" data*
- Because of these complications, can't directly use DID analysis
  - Instead, use regression models that approximate DID analysis

Results for adolescent marijuana use related to MML

	paper	data	Sampling	age range	years	states	unit of analysis	Pre-post effect of MML
1	Wall et al. 2011	NSDUH	household	12-17	2002-2008	50	state	Not examined
2	Harper et al 2012	NSDUH	household	12-17	2002-2008	50	state	slight **decrease** not significant
3	Wen et al 2015	NSDUH	household	12-20	2002-2011	50	individual	slight **decrease** not significant
4	Stolzenberg et al 2015	NSDUH	household	12-17	2002-2011	50	state	large **increase** and highly significant
5	Hasin et al 2015	MTF	school	12-20	1991-2014	48	individual	**decrease** in 8th graders significant
6	Anderson et al 2015	YRBS	school	15-20	1993-2011	50	individual	slight **decrease** not significant
7	Lynn-Landsman et al 2013	YRBS	school	15-20		4 MML	individual	**no change**
8	Choo et al 2014	YRBS	school	15-20	1991-2011	5 MML	individual	**no change**
9	Pacula et al	NLSY97	individual (longitudinal)	<21	1997-2006	8 MML	individual	**no change**

COLUMBIA UNIVERSITY | MAILMAN of PUBLIC

Contents lists available at ScienceDirect

International Journal of Drug Policy

journal homepage: www.elsevier.com/locate/drugpo

Research paper

The effect of medical cannabis laws on juvenile cannabis use

Lisa Stolzenberg *, Stewart J. D'Alessio, Dustin Dariano

Florida International University, United States

ABSTRACT

Background: A number of states in the United States legally allow the use of cannabis as a medical therapy to treat an illness or to alleviate symptoms. Concern persists as to whether these types of laws are increasing juvenile recreational cannabis use. It is also plausible that medical cannabis laws engender an escalation of illicit non-cannabis drug use among juveniles because cannabis is frequently considered to be a gateway drug.

Methods: This study uses longitudinal data drawn from the National Survey on Drug Use and Health for the 50 U.S. states and a cross-sectional pooled-time series research design to investigate the effect of medical cannabis laws on juvenile cannabis use and on juvenile non-cannabis illicit drug use. Our study period encompasses five measurement periods calibrated in two-year intervals (2002–2003 to 2010–2011). This research design is advantageous in that it affords us the ability not only to assess the effect of the implementation of medical cannabis laws on juvenile drug use, but also to consider other state-specific factors that may explain variation in drug use that cannot be accounted for using a single time series.

Results: Findings show that medical cannabis laws amplify recreational juvenile cannabis use. Other salient predictors of juvenile cannabis use at the state-level of analysis include perceived availability of cannabis, percent of juveniles skipping school, severity of perceived punishment for cannabis possession, alcohol consumption, percent of respondents with a father residing in household, and percent of families in the state receiving public assistance. There is little empirical evidence to support the view that medical cannabis laws affect juveniles' use of illicit non-cannabis drugs.

Conclusion: Based on our findings, it seems reasonable to speculate that medical cannabis laws amplify juveniles' use of cannabis by allaying the social stigma associated with recreational cannabis use and by placating the fear that cannabis use could potentially result in a negative health outcome.

Central Question

- Why did Stolzenberg et al. get different findings using the same data?
- The result:

Contents lists available at ScienceDirect

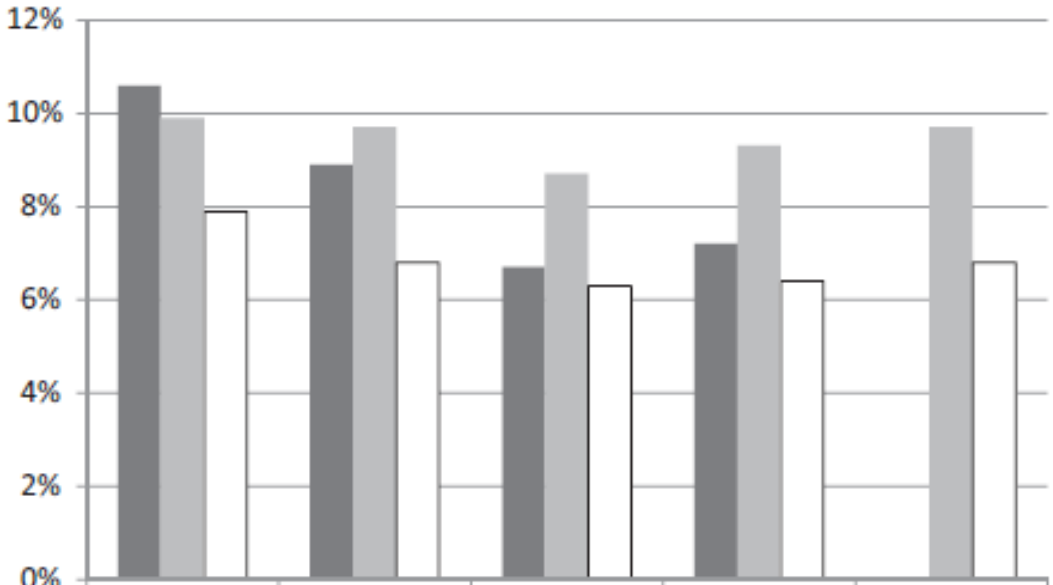
International Journal of Drug Policy

journal homepage: www.elsevier.com/locate/drugpo

Commentary

Prevalence of marijuana use does not differentially increase among youth after states pass medical marijuana laws: Commentary on Stolzenberg et al. (2015) and reanalysis of US National Survey on Drug Use in Households data 2002–2011

Melanie M. Wall [a,c,d,*], Christine Mauro [a], Deborah S. Hasin [b,c,d], Katherine M. Keyes [b], Magdalena Cerda [e], Silvia S. Martins [b], Tianshu Feng [f]



	2002-03	2004-05	2006-07	2008-09	2010-11
Before law	10.6%	8.9%	6.7%	7.2%	
After law	9.9%	9.7%	8.7%	9.3%	9.7%
No law	7.9%	6.8%	6.3%	6.4%	6.8%

Fig. 1. Percent cannabis use during past month among youth 12–17 years of age in states with and without legalized medical cannabis laws. *Note*: There is no data bar for the 2010–2011 time period because all the states that were going to pass a medical cannabis law had done so by 2011.

Replication of means shown in Figure 1 in Stolzenbergh et al including the specific states contributing to those means.

YEAR	MML	N	Mean MJ Use	Std Dev	State abbreviations
02-03	No MML	34	7.93	1.28	
	Before MML	8	10.04	2.05	AZ DE MI MT NJ NM RI VT
	After MML	8	9.67	1.04	AK CA CO HI ME NV OR WA
04-05	No MML	34	6.93	1.03	
	Before MML	6	8.22	1.56	AZ DE MI NJ NM RI
	After MML	10	8.95	1.73	AK CA CO HI ME MT NV OR VT WA
06-07	No MML	34	6.44	1.05	
	Before MML	4	6.54	0.82	AZ DE MI NJ
	After MML	12	8.40	1.35	AK CA CO HI ME MT NV NM OR RI VT WA
08-09	No MML	34	6.55	1.22	
	Before MML	3	6.98	0.72	AZ DE NJ
	After MML	13	8.71	0.79	AK CA CO HI ME MI MT NV NM OR RI VT WA
10-11	No MML	34	6.84	1.48	
	Before MML	0	NA	NA	
	After MML	16	9.66	1.53	AK AZ CA CO DE HI ME MI MT NJ NV NM OR RI VT WA

The Problem…

- States with higher use passed MML earlier.
- MT, RI, and VT were the 3 highest use states and they were the first to pass MML and move from the before to after mean bar.
- Even if there is absolutely no change in MJ use, the after mean will go up and the before mean will go down.
- Inappropriate comparison.

Using descriptive stats to examine change

- Appropriate analysis of changes in marijuana use after passage of MML should compare the mean marijuana use prevalence in states before the passage of MML to the mean of those **same** states after the passage of MML (*ideally while accounting for time trends…*)
- But Stolzenberg et al. did not do that. Each bar for before and after MML passage represents a different set of states.

Table 1: Mean past-month marijuana use in 12-17 year olds for the 8 states that passed MML between 2002-2011.

state	Year MML passed	period	# of years[b]	Average MJ Use	change (post- pre)
AZ	2010	pre	4	7.3%	
		post	1	8.2%	0.9%
DE	2011	pre	4	7.7%	
		post	1	10.6%	2.9%
MI	2008	pre	3	8.1%	
		post	2	8.0%	-0.0%
MT	2004	pre	1	12.1%	
		post	4	9.5%	-2.5%
NJ	2010	pre	4	6.4%	
		post	1	8.0%	1.6%
NM	2007	pre	2	9.7%	
		post	3	9.1%	-0.6%
RI	2006	pre	2	10.8%	
		post	3	10.0%	-0.9%
VT	2004	pre	1	13.3%	
		post	4	11.3%	-2.0%
Aggregated[a]		pre		9.44%	
		post		9.35%	-0.1%

[a] Aggregated results average over all 8 states which passed MML during 2002-2011 by taking simple average of pre use and simple averages of post use.
[b] # of years is number of NSDUH datapoints available pre or post MML passage. Each NSDUH datapoint represents aggregation of two years.

The average rate of marijuana use increased in 3 states (AZ, DE, NJ) but decreased in 5 states (MI, MT, NM, RI, VT).

Overall average within state change = -0.1%

Modeling the pre-post effect

Stolzenberg Model (Model 1):

$Y_{jt} = b_0 + b_1 * MML_{jt} + state_j + time_t + e_{jt}$

- Y_{jt} = prevalence of MJ use in state j in year t
- MML_{jt} = 0/1 if state j does not (does) have MML in year t

b_1 will provide our estimate of the causal effect of MML

This model **does not account** for fact that states that haven't pass laws have very different MJ prevalences than states that have eventually gone on to pass laws.

- both treated as MML=0 in this model

The remedy…

Model 2

$$Y_{jt} = b_0 + b_1 * MML_{jt} + state_j + time_t + e_{jt}$$

MML now a three level time varying predictor:

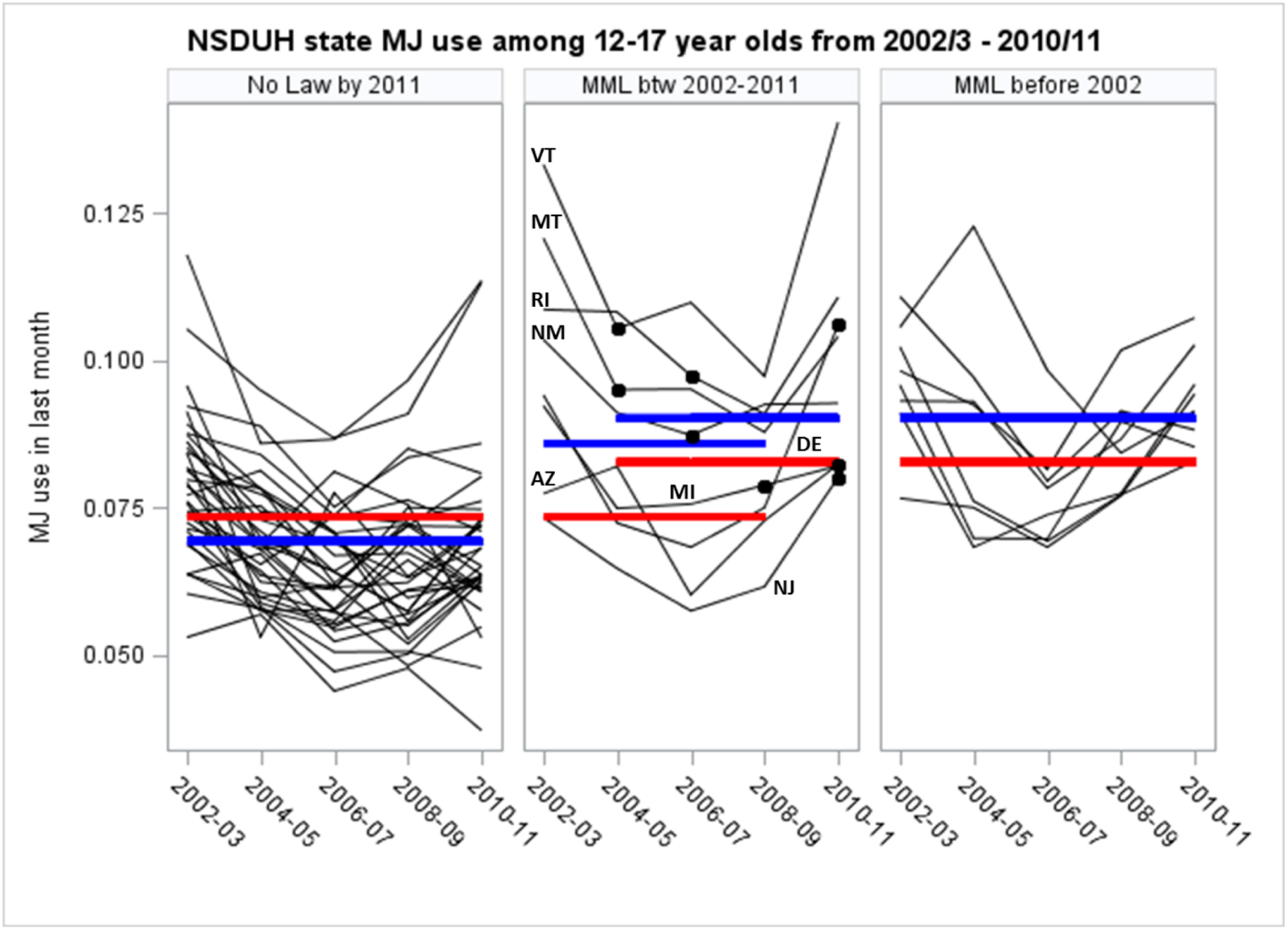
1. Never
2. Before
3. After

We will compare Group 3 to Group 2 (After.Vs. Before)!

Comparing model results

Models	b_1	se	p-value
Model 1 (Stolzenberg model)	0.93%	0.25%	0.0002
Model 2 (After vs. Before)	0.43%	0.28%	0.123

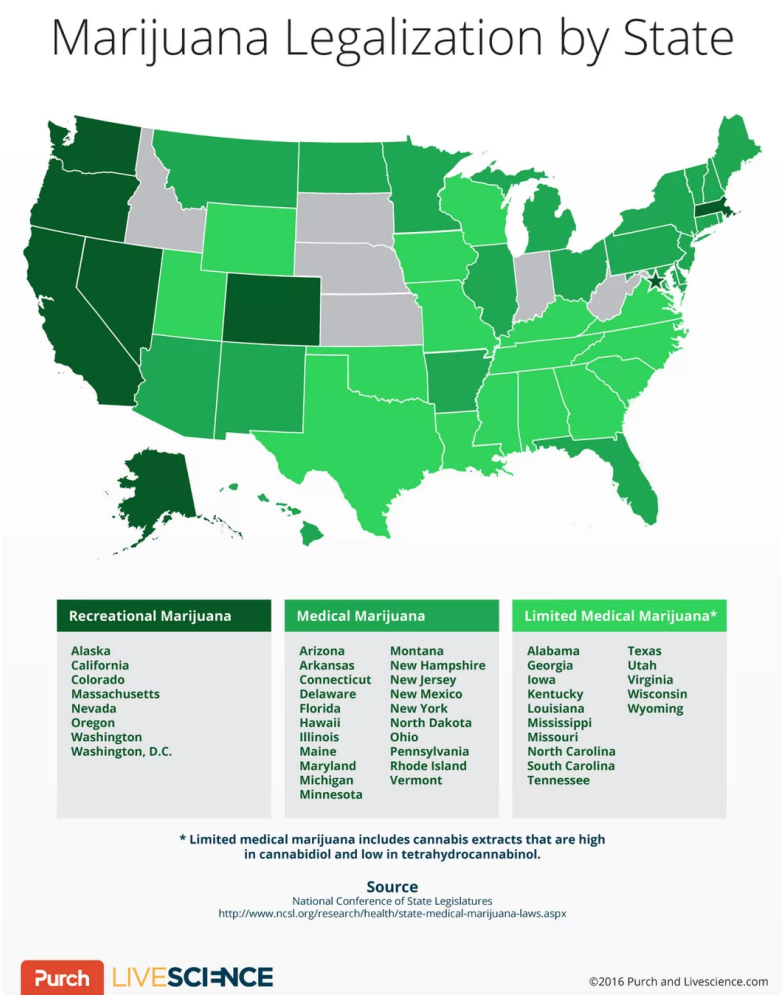
Red is Model 1 (Stolzenberg), Blue is Model 2



Conclusion of the Re-Analysis

- Stolzenberg et al. mistakenly used information from the No Law states in their "before" group.
- This extremely biased comparison led to a conclusion of increased marijuana use among youth due to MMLs.
- To the uncritical eye, this conclusion seems plausible (and potentially worthy of media coverage and political sound bites).
- State MML are associated with higher rates of adolescent marijuana use, but to date, no major U.S. national dataset, including the NSDUH, supports they are a *cause* of such use.

Future Work



- How to model variability in MMLs?
  - Medicalized vs. non-medicalized
  - Dispensaries/Home Cultivation
- How to look at the interplay with other laws?
  - Recreational Marijuana
  - Decriminalization
- Examine impact on other substances
  - Tobacco, Opioids, etc.

Acknowledgements

- Melanie Wall
- Silvia Martins
- MML work group

- For more information on DID methods:
  - https://www.mailman.columbia.edu/research/population-health-methods/difference-difference-estimation

- THANK YOU!

Studies examining adolescent marijuana use related to MML

1. Wall MM, Poh E, Cerda M, Keyes KM, Galea S, Hasin DS. Adolescent marijuana use from 2002 to 2008: higher in states with medical marijuana laws, cause still unclear, Annals of Epidemiology 21(9): 714-6. **2011.**
2. Harper S, Strumpf EC, Kaufman JS. Do medical marijuana laws increase marijuana use? Replication study and extension. Annals of Epidemiology 22(3): 207-12. **2012**.
3. Lynne-Landsman, Sarah, Melvin Livingston, and Alexander Wagenaar. 2013. "Effects of State Medical Marijuana Laws on Adolescent Marijuana Use," 103 *American Journal of Public Health* 1500–6.
4. Choo, Esther K., Madeline Benz, Nikolas Zaller, Otis Warren, Kristin L. Rising, and K. John McConnell. 2014. "The Impact of State Medical Marijuana Legislation on Adolescent Marijuana Use," 55 *Journal of Adolescent Health* 160–6.
5. Wen H, Hockenberry JM, Cummings JR. The effect of medical marijuana laws on adolescent and adult use of marijuana, alcohol, and other substances. Journal of Health Economics, 42, 64-80. **2015.**
6. Hasin D, Wall M, Keyes K, Cerda M, Galea S, Schulenberg J, Feng T, OMalley P. Medical marijuana laws and adolescent marijuana use in the USA from 1991 to 2014: results from annual, repeated cross-sectional surveys. Lancet Psychiatry, 2(7), 601-608. **2015.**
7. Anderson DM, Hansen B, Rees DI. Medical Marijuana laws and teen marijuana use, American Law and Economics Review epub April 24, **2015.**
8. Stolzenberg L, D'Alessio S, Dariano D. The effect of medical cannabis laws on juvenile cannabis use. International Journal of Drug Policy, epub June 6 **2015.**
9. Pacula, Rosalie, David Powell, Paul Heaton, and Eric Sevigny. 2015. "Assessing the Effects of Medical Marijuana Laws on Marijuana Use: The Devil is in the Details," 34 *Journal of Policy Analysis and Management* 7–31. **2015**