The Effect of Medical Marijuana Laws on Self-reported Health and Subjective Well-being: *Feeling Restless, Weak, Unsatisfied, and yet Having a Good Time*

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Motivation

- Medical Marijuana Laws (MMLs) in the United States
  - Medical benefits of marijuana: mitigating nausea and vomiting for cancer patients with chemotherapy treatment, stimulating appetite for HIV/AIDS patients, and reducing pain and anxiety (Joy et al. 1999; Goldenberg et al. 2017; McCormick et al. 2017)
  - First introduced in California in 1996
  - Now 31 states have legalized marijuana for medical purposes
  - Since 2012, 9 states have legalized recreational use of marijuana
- Effects of MMLs on various outcomes
  - Marijuana consumption (Chu 2014, 2015; Pacula et al. 2015)
  - Other substance use (Wen et al. 2015)
  - Traffic fatalities (Anderson et al. 2013)
  - Obesity (Sabia et al. 2017)
  - Education (Chu and Gershenson 2018)
  - Labor market outcomes (Ullman 2016)

Research Question

1. Do MMLs lead to better health?
   - How well-rested the respondent felt when he/she woke up on the diary day?
   - Self-reported health status

2. Do MMLs improve subjective well-being?
   - The Cantril ladder (life evaluation)
   - The U-index
   - Net affect
   - Happiness
   - Pain
   - Sadness
   - Stress
   - Tiredness
   - Meaningfulness

Literature: Effects of MMLs on

- Marijuana consumption: mixed findings
  - An increase in marijuana use and possession arrest rates among adults (Pacula et al. 2015; Chu 2014, 2015; Wen et al. 2015)
  - No discernable effect (Dills et al. 2017)

  - Higher prevalence rates of marijuana use or marijuana initiation among adolescents (Pacula et al. 2015; Wall et al. 2011, Cerdá et al. 2012; Stolzenberg et al. 2016; Wen et al. 2015)
  - No such effects among youth (Anderson and Rees 2014; Anderson et al. 2015; Smart 2015; Choo et al. 2014; Williams et al. 2015; Wall et al. 2016; Lynn-Landman et al. 2013)

=> Perhaps due to the heterogeneity among state MMLs, different data sources and methods (Pacula and Smart 2017)

Literature: Effects of MMLs on

- Risky behaviors: mixed findings
  - Decrease cigarette smoking (Choi et al. 2017)
  - Decrease heroin arrest rates (Chu 2015)
  - Increase the frequency of binge drinking for adults (Wen et al. 2015)

  - But alcohol is a substitute of marijuana (Anderson et al. 2013)
  - No association between MMLs and substance use (Dills et al. 2017)

Literature: Effects of MMLs on Other Outcomes

- Positive: MMLs decrease
  - Traffic fatalities (Anderson et al. 2013)
  - Workplace fatalities (Anderson et al. 2018)
  - Suicide rates among men aged 20-39 (Anderson et al. 2014)
  - Opioid overdose (Powell et al. 2018; Bachhuber et al. 2014; Shi 2017)
  - Prescription pain medication (Bradford and Bradford 2016, 2017)
  - Probability of obesity (Sabia et al. 2017)
  - Number of days with mental health problems (Kalbfuß et al. 2018)
  - Improve self-rated health among seniors (Nicholars and Maclean 2016)

- Negative
  - Less time on education among college students (Chu and Gershenson 2018)
  - Lower labor market productivity (Sabia and Nguyen 2016)
  - Higher rates of cardiac death (Abouk and Adams 2018)
  - Higher rates of social security disability insurance claiming (Maclean et al. 2018)

Literature: Recreational Marijuana Consumption and SWB

- Evidence is inconclusive
  - Marijuana use and dependence is related to
    - more depressive disorders (Allen and Holder 2014; Field et al. 2001; Fleming et al. 2008; Durdle et al. 2008; Pedersen 2008)
    - lower life satisfaction/happiness (Georgiades and Boyle 2007; Gruber et al. 2003; Looby and Earleywine 2007), especially for heavy users (Moore et al. 2007)
  - Marijuana users have higher life satisfaction than non-users (Barnwell et al. 2006) and heavy users enjoy it more than occasional users (Kouri et al. 1995)
  - Among adolescents marijuana is a coping mechanism to alleviate anxiety stress and depression (Buckner et al. 2007; Potter et al. 2011) and to promote social affiliation and bonding (Nail et al. 1974)

=> The consumption of marijuana is endogenous, and confounding with other drug use or risky behaviors, and its dependence often happens simultaneously with negative events

Possible Mechanisms

1. Patients who use medical marijuana for treatment can improve their SWB through MMLs: older adults and people with poor health
2. MMLs may affect SWB through the spillover effect on the recreational marijuana use: college students
   - Mitigate depression and promote social contact=> Enhance SWB
   - More consumptions or higher prevalence rate exacerbates depression=> Lower SWB
3. Impact of MMLs on other substance use or risky behaviors
   - Drinking is correlated with lower life satisfaction
   - Smokers have lower SWB than non-smokers

   => Depends on whether marijuana is a complement or substitute of other substance

Contributions

- Using the American Time Use Well-being Modules, first study that directly assesses the impact of MMLs on SWB and one of a few studies that evaluate the health effect of MMLs

- Compared to prior studies on cannabis and SWB, we exploit a more plausible source of exogenous variation in marijuana consumption—the state-level policy changes in MMLs—to detect the effects of marijuana use on health outcomes and SWB

- We analyze the heterogeneous effect of MMLs across different subgroups, and provide evidence that MMLs affect two subgroups—people with poor health and college students—extraordinarily differently

Data: ATUS WB Modules 2010, 2012, 2013

- Three randomly selected activities for each respondent from the ATUS (a 24-hour time diary)
- For each selected activity, the respondent was asked
  - To rate happiness, pain, sadness, stress, tiredness, and meaningfulness from 0 to 6, where a 0 means no feeling and a 6 means the strongest feeling
  - Whether the respondent was interacting with anyone during the activity
- 2012 and 2013 ATUS WB Module: a standard life-evaluation question using the Cantril ladder (10-step ladder)
- Four general health questions
  - Self-rated general health status
  - How well-rested the respondent felt when he/she woke up on the diary day
  - Whether the respondent took any pain medication on the diary day
  - Whether the respondent was ever diagnosed with hypertension

Dependent variables

- How well-rested the respondent felt when he/she woke up on the diary day: very rested, somewhat rested, a little rested, and not at all rested
- Self-rated general health status: excellent, very good, good, fair, and poor; 5-point scale (5 for excellent and 1 for poor)

- The Cantril ladder
- Weighted averages of measures of SWB over the three episodes per respondent
  - The U-index: An episode is unpleasant if the highest rating on any of the three negative affect dimensions (pain, sadness, and stress) is strictly greater than the rating of the positive affect dimension (happiness)
  - Net affect: Difference between the positive emotion and the average of the negative ones
  - Happiness, pain, sadness, stress, and meaningfulness

Estimation: Difference in differences

$$Outcome_{ist} = \alpha MML_{st} + \beta RML_{st} + \gamma X_{ist} + \delta_t + \theta_s + \theta_s t + \varepsilon_{ist}$$

- MML_{st}: 1 if medical marijuana laws in effect in state s in year t
- RML_{st}: 1 if recreational marijuana laws in effect
- X_{ist}: female dummy; age and its square; race/ethnicity; education; school enrollment; number of children; marital status; employment status; family income; metropolitan status; immigrant; number of disabilities; holiday; days of the week; and month
- δ_t: year fixed effects
- θ_s: state fixed effects
- $\theta_s t$: state-specific linear year time trends
- Standard errors clustered at the state level
- Full sample: 34,340 individuals

Estimation

- Additional controls in the Cantril ladder and SWB estimations
  - Self-rated health status
  - How well-rested the respondent felt when he/she woke up on the diary day
  - Whether the respondent took any pain medication on the diary day
  - Proportion of time the respondent was interacting with anyone during the all activities (only for SWB)
- Identification
  - Six states (Arizona, Connecticut, Delaware, Massachusetts, New Hampshire, and New Jersey) and D.C. that changed their MMLs between 2010-13

Table 2 Effects of MMLs on how well-rested the respondent felt when he/she woke up on the diary day

	(1)	(2)	(3)	(4)
	Very rested	Somewhat rested	A little rested	Not at all rested
Poor health				
MML	0.328**	0.079	-0.472***	0.065
	(0.134)	(0.165)	(0.167)	(0.153)
Observations	1,473	1,473	1,473	1,473
50 or older				
MML	0.067**	-0.029	-0.032	-0.006
	(0.030)	(0.040)	(0.020)	(0.029)
Observations	15,186	15,186	15,186	15,186
College students				
MML	-0.260**	0.365***	-0.068	-0.038
	(0.099)	(0.119)	(0.069)	(0.065)
Observations	1,907	1,907	1,907	1,907
Full sample				
MML	-0.034	-0.009	0.044**	0.000
	(0.021)	(0.017)	(0.019)	(0.013)
Observations	34,340	34,340	34,340	34,340

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Table 3 Effects of MMLs on self-rated health

	(1)	(2)	(3)	(4)	(5)	(6)
	Excellent	Very good	Good	Fair	Poor	Health
50 or older						
MML	0.051**	-0.103*	-0.004	0.080	-0.024	-0.032
	(0.024)	(0.052)	(0.060)	(0.050)	(0.021)	(0.111)
Observations	15,186	15,186	15,186	15,186	15,186	15,186
College students						
MML	-0.116	-0.199*	0.025	0.177***	0.113	-0.834***
	(0.120)	(0.101)	(0.228)	(0.044)	(0.115)	(0.306)
Observations	1,907	1,907	1,907	1,907	1,907	1,907
Full sample						
MML	0.033	-0.098***	0.010	0.060***	-0.004	-0.085***
	(0.030)	(0.035)	(0.054)	(0.019)	(0.020)	(0.022)
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Observations	34,340	34,340	34,340	34,340	34,340	34,340

Table 4 Effects of MMLs on the Cantril ladder

	(1)	(2)	(3)	(4)
	Poor health	50 or older	College students	Full sample
Specification 1				
MML	3.403***	-0.140	-1.403**	-0.206***
	(0.592)	(0.188)	(0.610)	(0.058)
Specification 2				
MML	2.896***	-0.325***	-1.082***	-0.200***
	(0.611)	(0.107)	(0.358)	(0.056)
Observations	894	9,813	1,170	21,580

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Table 5 Effects of MMLs on Subjective Well-being

Poor Health	(1) U-index	(2) Net affect	(3) Happiness	(4) Pain	(5) Sadness	(6) Stress	(7) Tiredness	(8) Meaningfulness
Specification 1								
MML	-0.219	1.066	0.348	-1.681***	-0.653*	0.179	-1.252***	-0.226
	(0.163)	(0.847)	(0.607)	(0.608)	(0.366)	(0.754)	(0.367)	(1.130)
Specification 2								
MML	-0.143	0.546	0.155	-1.343**	-0.410	0.580	-0.868**	-0.271
	(0.156)	(0.912)	(0.676)	(0.549)	(0.514)	(0.807)	(0.406)	(1.188)
Observations	1,473	1,473	1,473	1,473	1,473	1,473	1,473	1,473

50 or older	(1) U-index	(2) Net affect	(3) Happiness	(4) Pain	(5) Sadness	(6) Stress	(7) Tiredness	(8) Meaningfulness
Specification 1								
MML	-0.033	0.109	0.149	0.226	-0.028	-0.079	0.237	-0.151
	(0.045)	(0.298)	(0.176)	(0.147)	(0.235)	(0.198)	(0.245)	(0.123)
Specification 2								
MML	-0.030	0.069	0.121	0.206**	-0.007	-0.041	0.292	-0.181
	(0.044)	(0.218)	(0.159)	(0.093)	(0.180)	(0.183)	(0.252)	(0.119)
Observations	15,190	15,190	15,190	15,190	15,190	15,190	15,190	15,190

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	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
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Observations	15,190	15,190	15,190	15,190	15,190	15,190	15,190	15,190

Table 5 Effects of MMLs on Subjective Well-being

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
College students	U-index	Net affect	Happiness	Pain	Sadness	Stress	Tiredness	Meaningfulness
Specification 1								
MML	-0.128***	0.737*	0.710	0.360	-0.201	-0.239	0.396	0.204
	(0.031)	(0.427)	(0.525)	(0.258)	(0.172)	(0.360)	(0.282)	(0.757)
Specification 2								
MML	-0.186***	1.207**	0.933*	-0.078	-0.294	-0.449	0.081	0.317
	(0.050)	(0.453)	(0.505)	(0.344)	(0.194)	(0.368)	(0.443)	(0.807)
Observations	1,907	1,907	1,907	1,907	1,907	1,907	1,907	1,907

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Full sample	U-index	Net affect	Happiness	Pain	Sadness	Stress	Tiredness	Meaningfulness
Specification 1								
MML	-0.015	0.011	0.150**	0.216*	0.061	0.139	0.214***	-0.068
	(0.027)	(0.093)	(0.071)	(0.108)	(0.085)	(0.094)	(0.073)	(0.073)
Specification 2								
MML	-0.028	0.117	0.190**	0.122*	0.021	0.076	0.127*	-0.054
	(0.029)	(0.098)	(0.081)	(0.069)	(0.071)	(0.111)	(0.066)	(0.079)
Observations	34,347	34,347	34,347	34,347	34,347	34,347	34,347	34,347

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Conclusions

- MMLs improved the quality of sleep and life evaluation and reduced pain and fatigue among those whose self-assessed health status is poor

- The effects on the overall population are mostly negative: poorer sleep quality, worse health, and lower life evaluation, except that people still felt happier in their day-to-day activities

- The magnitudes of these effects are even larger among college students

=> These results suggest that MMLs had very large negative spillover effects on the general population by expanding recreational use of marijuana

Policy Implication & Limitations

- Our results underscore the need for policy makers to consider the potential SWB impacts of MMLs

- Limitations
  - Data covered a relatively short time period of four years

  - We have not yet fully incorporated three dimensions of MMLs: patient registration, home cultivation, and legalized dispensary

  - Too early to fully analyze the effect of RMLs