Prescription Drugs and Medical Marijuana

University of Alabama

November 8, 2016

Last Class

- The health economics of bads such as drinking excessive alcohol and smoking cigarettes.
- Often times, bad behaviors lead to negative externalities. For example, smoking cigarettes causes members of the general public to breath in potentially harmful secondhand smoke.
- These negative externalities lead to a loss in efficiency due to social costs, and there may be a role of the government to make up for this loss through taxation.
- Excise taxes are an effective way to discourage people from consuming bads.
- Studies have found that smokers "pay their way," while heavy drinkers do not (due to the loss of human life through DUI fatalities).

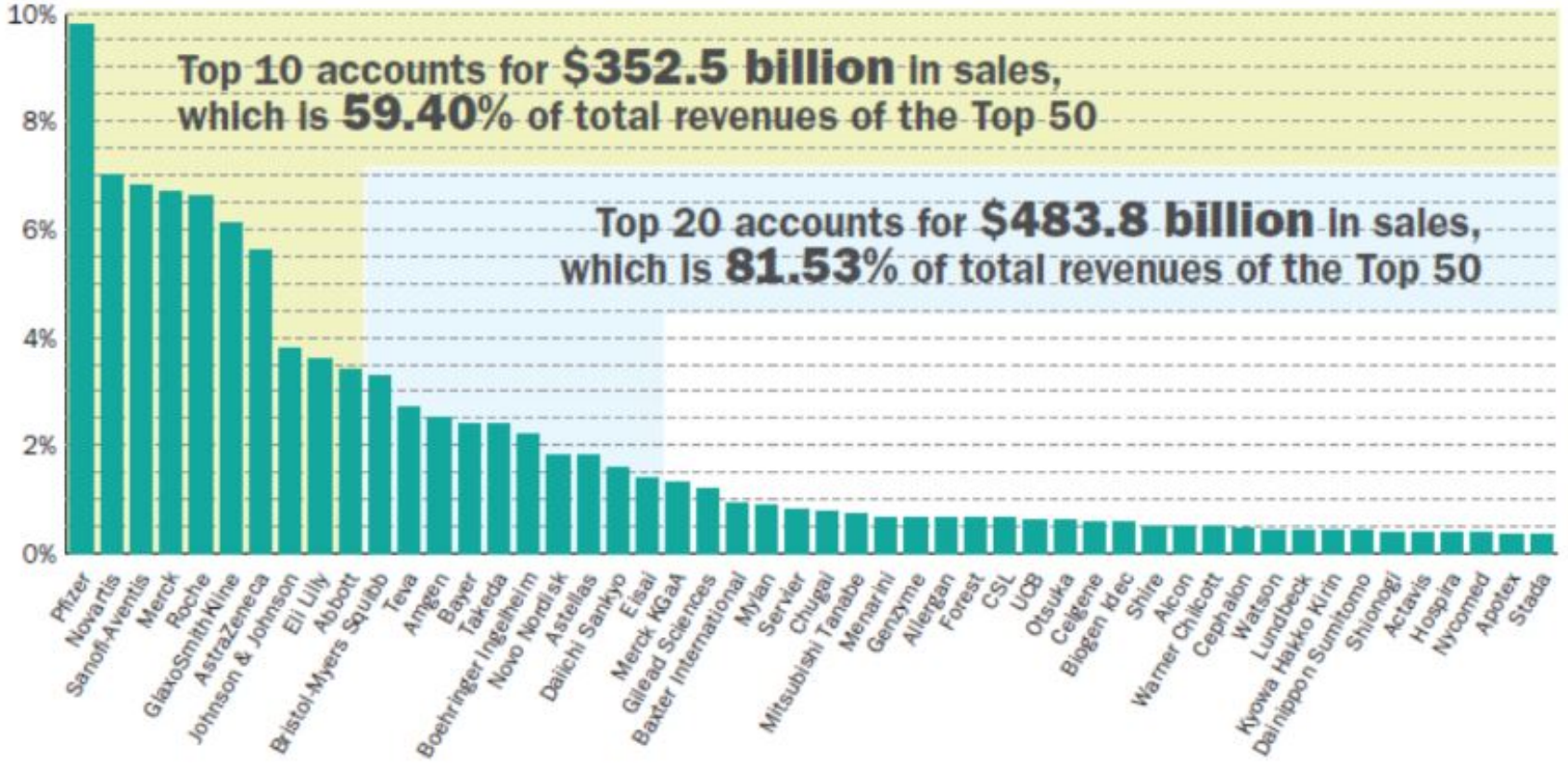
Prescription Drugs

- Prescription drugs and the pharmaceutical industry occupy increasingly important places in the health economy.
- Drugs are used to treat many diseases and conditions. Examples include chemotherapy for cancer, steroids for skin diseases, psychotropic drugs for mental health problems, beta-blockers for heart disease, clot busters or stroke, protease inhibitors for AIDS.
- Breakthroughs in the prescription drug industry have led to successful treatment of numerous diseases that previously went untreated.
- Despite these successes, the U.S. pharma industry has encountered intense media and legislative scrutiny.

Profitability

- Firms of the pharma industry have been among the largest and most profitable businesses in the U.S.
- As recently as 2001, the drug industry ranked first in various measures of profitability among *Fortune's* industry groupings.
- Negative publicity, litigation problems, widespread efforts to contain drug spending, and loss of patent protection of several major drugs are serious threats to profitability.
- Nevertheless, the 12 pharma firms among the *Fortune 500* in 2009 reported a median profit of 20% on revenues and 23% on stockholders' equity. These were among the highest of all industries.

Revenue Distribution of Top 50



* Figures are rounded

Profitability

- A trade-off exists between promoting profitability of pharma firms and the regulation of their practices. Perhaps by promoting profitability firms will remain innovative, but it is important to not allow firms to dishonestly take advantage of consumers.
- The study of industry regulation and competition among pharma firms is called pharmacoeconomics. This includes cost-benefit, cost-effectiveness, and cost-utility analyses.
- Pharmacoeconomics also studies the role of pharma products in the production of health, drug pricing issues including price discrimination by sellers and price regulation by the government, pharmaceutical research on the determinants of innovation and the effects of price regulation on innovation, and cost containment through use of generic products.

Expenditures on Health Care Services and Supplies, Percentage Share by Category, 1960–2000

Category	*1960*	*1970*	*1980*	*1990*	*1995*	*1998*	*1999*	*2000*
Hospital care	36.9%	41.0%	43.5%	38.0%	36.1%	34.1%	33.4%	32.8%
Physician services	21.0	20.8	20.2	21.7	20.4	23.1	23.0	22.8
Prescription drugs	10.7	8.2	5.1	5.6	5.9	7.8	8.8	9.7
Nursing home care	3.2	6.2	7.6	7.5	7.8	8.0	7.6	7.3
All other	28.2	23.8	23.6	27.2	29.8	26.8	27.2	27.4

Notes: Data from the Centers for Medicare and Medicaid Services, National Health Accounts, various years. Expenditures exclude research and construction. "All other" includes dental and other professional services, home health care, nonprescription drugs and medical durables, vision products, net cost of private health insurance and government public health activities.

Share of Prescription Drug Spending by Source of Payment, Selected Years, 1965–1998

Year	*Out-of-Pocket*	*Private Insurance*	*Medicaid*	*Other*
1965	92.6%	3.5%	0.0%	3.9
1970	82.4	8.8	7.6	1.2
1975	75.4	12.2	10.8	1.6
1980	66.0	20.1	11.7	2.2
1985	55.4	29.9	11.8	2.9
1990	48.3	34.4	13.5	3.8
1995	33.9	46.8	15.8	3.4
1996	31.6	48.8	16.1	3.5
1997	29.1	50.8	16.5	3.6
1998	26.6	52.7	17.1	3.6

Source: Report to the President: Prescription Drug Coverage, Spending, Utilization and Prices (Washington: DHHS, April 2000, Table 2-30).

Prescription Drug Spending

- Expenditures on prescription drugs have risen faster than overall health spending, hence increasing the sector's share of health care spending.
- In 2014, prescription drug spending in the U.S. was over $350 billion, making up about 10% of overall health spending. In the last couple of years, we have witnessed sharp rises in prescription drug spending. Part of this rise has been driven by new breakthrough drugs to treat Hepatitis C.
- The rise is prescription drug spending from 2010 to 2014 are estimated to be due to:
  - 10% from population growth.
  - 30% from increases in prescriptions per person.
  - 30% from overall, economy-wide inflation.
  - 30% from a rise in either price increases of drugs or change in composition of prescriptions toward more expensive drugs.

Competition

- Just as is the case with any industry, we view competition as a good thing that helps keep prices low and promotes consumer welfare.
- The many complexities of the pharmaceutical industry including brand name vs generic drug competition, direct to physician advertising, patents and copyrights to drugs, and regulation by the government give us the sense that the industry is somewhat anti-competitive.
- Within the public and the media, the pharmaceutical industry is often labeled as a greedy industry that stifles competition.

Competition in Various Industries

NAICS Code	Industry	C_4	C_8	HHI	N	Shipments (in $ billions)
325412	Pharmaceutical preparation mfg.	36	53	530	731	114.7
311230	Breakfast cereal mfg.	78	91	2,521	45	9.1
324110	Petroleum refineries	41	64	640	88	193.5
334111	Electronic computer mfg.	76	89	2,662	934	32.3
334220	Radio & TV broadcasting & wireless	43	55	584	823	32.1
325510	Paint and coating mfg.	37	55	505	1,149	19.9
325611	Soap and detergent mfg.	61	72	2,006	699	16.6
336111	Automobile mfg.	76	94	1,910	164	88.1
336112	Light truck & utility vehicle mfg.	96	100	W	69	137.1
336411	Aircraft mfg.	81	94	W	184	64.3

Note: W = withheld to avoid disclosure of individual firm data. The undisclosed HHI value will undoubtedly be very high.

Source: U.S. Bureau of the Census, 2002 Economic Census, "Concentration Ratios: 2002," Report EC02-31SR-1 (May 2006).

Barriers to Entry

1. Patent protection in the pharma industry is a classic example of a barrier to entry.
   - A new pharmaceutical product hits the market, and to gain protection from competition the firm will adopt a strategy of surrounding the product with patents on many variations of that product.
2. Another barrier to entry is related to advertising and promotion.
   - If advertising increases brand loyalty, then it leads to a barrier to entry for other brands.
   - Pharmaceutical promotion is unique in that much of the marketing is geared toward physicians as opposed to patients.
   - Critics of this style of promotion worry that it may lead to financial arrangements that encourage the physician to prescribe a particular product, possibly in place of cheaper substitutes.

Regulation

- The pharmaceutical industry is one of the most heavily regulated of all industries, and it is regulated by the Food and Drug Administration (FDA).
- Following a public scandal over adulterated food products and dangerous medicines with unknown contents, the government introduced the Food and Drug Act of 1906. This law only required food and medicines to have proper labeling.
- Requirements for testing and safety were introduced later with the Federal Food, Drug, and Cosmetic Act of 1938.
- Regulatory control began to accelerate in the late 1950s after the thalidomide tragedy (a morning sickness drug for pregnant women led to severe birth defects in babies). In 1962, the FDA was given increased control over the introduction of new products.

Regulation

The FDA review process has become a lengthy and complex one:

- Upon the creation of a new drug, the firm conducts preclinical animal studies involving short term toxicity and safety tests.
- The firm next must file an application with the FDA to conduct clinical trials.
- If approved the trials are conducted in three phases: Phase I begins with small groups of healthy volunteers and focuses on safety and dosage. Phase II involves a larger number of subjects with a specific condition and focuses on efficacy of the drug. Phase III trials are conducted on thousands of patients and focus both on safety and efficacy.
- If these trials indicate safety and efficacy, the company submits a New Drug Application (NDA), and the FDA reviews the application. This review usually takes more than a year, and the total development time for a new product stands at about 14 years.

Consumer Protection vs Innovation

- There is an obvious trade-off between aims to protect consumers from harmful products and encouraging rapid innovation in the pharmaceutical industry.
- The economic approach is to weigh the gains in safety and efficacy against the cost of delaying patients from utilizing useful products. Economists also express concern about the potential stifling of innovation caused by regulation and its adverse effects on competition.
- In the mid-1970s, the FDA developed policies to speed up the review process for "important" drugs. Important drugs make it to the market about three years sooner than other drugs.
- A 2008 cost-benefit analysis found that more rapid access to drugs saved between 140,000 to 310,000 life-years from 1992-2002 compared to an upper bound of 56,000 life-years lost due to harmful effects of drugs before they were withdrawn from the market.

FDA Incentives

- So it is clear that the FDA delay is likely a deadly one, preventing many patients from receiving drugs that would likely help their conditions. So why does no one in the media complain of the FDA delay?
- FDA drug reviews are immune from legal liability, but they may be embarrassed by congressional hearings and media condemnations when they make mistakes.
- When a child takes a drug and suffers from a harmful but rare side effect, this tends to be discussed heavily within the media, particularly if the child ends up dying. The FDA is the blamed culprit for allowing the unsafe drug to hit the market.
- FDA officials are anxious to avoid such negative scrutiny that might damage their careers and reputations.

FDA Incentives

- Consider the same child as before, except this time the child is suffering from a sickness for which there is no drug available. The FDA has restricted numerous potential drugs from hitting the market.
- The child still dies here, but does the media make a huge deal out of this? The FDA might just claim that it "must hold the unproved drug until safety questions and risks to public health are resolved."
- No one who could counter such claims would be in a position to do so. Hence, the bad consequences of disallowing the drug would not be identifiable.
- As a result, FDA officials are much less concerned with this type of error, and are disproportionately concerned with errors resulting from a drug being made available to the market.

	Drug Is Beneficial	Drug Is Harmful
FDA Allows the Drug	Correct Decision	Type 1 Error: Allowing a harmful drug. Victims are identifiable and traceable, and might appear on *Oprah*. Error is self-correcting.
FDA Does Not Allow the Drug	Type 2 Error: Disallowing a beneficial drug. Victims are not identifiable and scarcely even acknowledged in the abstract. Error is not self-correcting.	Correct Decision

FDA Incentives

- Any policy that reduces either a Type I or a Type II error without increasing the other type is a good policy.
- The FDA reforms of the late 1990s related to user fees have reduced the number of Type II errors without increasing the number of Type I errors.
- Although more drugs have been withdrawn in recent years, it is solely due to the fact that more drugs have been accepted. Type II errors should not only be acknowledged, but perhaps should be considered more harmful than Type I errors. Friedrich Hayek stressed that the strength of an economic system is in its ability to correct its own errors.
- Type I errors are obviously self-correcting, however this is not the case with Type II errors. Due to lack of public pressure to correct these errors, Type II errors can continue to occur over time. Type II errors are not self-correcting.

Other Concerns with the FDA

Consider an Example.

- Suppose Company A discovers and produces a life-saving medicine. Over time, the company's executives realize the unique value they are providing consumers, and decide they should raise prices by 400%.
- Companies B, C, and D are attracted to the market due to the high profit margins, and they believe that they can produce a similar product at a cheaper price.
- Company A has been in the game for quite a while, and it also has former employees that work at the FDA. Company A also has quite a large budget for lobbying.

Other Concerns with the FDA

- Company B successfully develops a similar product, but it has to be approved by the FDA and is stalled out in a 10-year approval process.
- Company C also develops a similar product, but find themselves in court because Congress has passed strict patent laws preventing competing products in the marketplace.
- Company D was able to replicate Company A's product at a cheaper price as well, but the only insurance company that will cover it is based in Alabama, and hence only Alabama residents can buy this insurance.
- In this particular example, the free market tried to provide consumers with another competing alternative, but due to Company A's connections with the FDA and other government bureaucrats, government intervention stifled welfare-promoting competition.

Summary

- The pharmaceutical industry is growing at a fast pace, and it remains one of the most profitable industries in the U.S.
- Though the industry is led by a few firms, it is not necessarily an industry with little competition.
- That being said, the industry differs by the fact that it is regulated by the FDA.
- There is a trade-off between consumer safety and the encouragement of rapid innovation. The FDA has an incentive to limit Type I errors, but it does not have much of an incentive to prevent Type II errors.
- The FDA might also create incentives related to special interest groups, which may inevitably harm competition.

The War on Drugs

- The U.S. spends over $50 billion annually to fight the war on drugs.
- The amount of arrests related to drugs in 2014 was over 1.5 million, and about 1.3 million of these were related to possession only.
- In 2014, the number of people that were incarcerated in federal, state, and local prisons and jails was over 2.2 million (1 out of every 111 adults). This is the highest incarceration rate in the world.
- Despite using and selling drugs at similar rates to whites, blacks and hispanics make up about 57% of those incarcerated for drug related crimes.
- Since 2006, there have been more than 100,000 people killed in Mexico's drug war.

Marijuana

- In 2015, there were about 650,000 people arrested for crimes related to marijuana, and about 90% of these were due to possession only.
- There are currently 25 states plus D.C. that allow the use of medical marijuana, and there are 20 states that have decriminalized marijuana possession in small amounts.
- There are 4 states that have legalized the taxing and regulation of marijuana (Alaska, Colorado, Oregon, and Washington).
- If drugs were legalized and taxed in similar ways as alcohol and cigarettes, it would create an estimated tax revenue of $50 billion.

Marijuana Legalization

- Variation in the legalization of marijuana across states and across time creates the grounds for a natural experiment.
- This variation can be used to study many questions.
- Empirical questions include:
  - Does marijuana legalization lead to more consumption of marijuana?
  - Does marijuana legalization lead to more or less consumption of alcohol and cigarettes (are they complements or substitutes)?
  - Is marijuana a "gateway" drug, i.e. does better access to marijuana lead to more consumption of harder drugs?
  - There are infinitely many more.

Medical Marijuana

- Because marijuana legalization is relatively new, studies on the topic are limited.
- Medical marijuana has been around longer, so there is more work that has been done to analyze policy impacts of using marijuana as a medicine.
- There are an estimated 2.6 million medical marijuana users in the U.S. residing in 25 different states.
- Medical marijuana laws can vary across states. Every state that currently allows medical marijuana requires a licensed physician to recommend the drug, and requires that it only be done when the patient exhibits a legitimate illness.
- In most cases, marijuana is distributed at a dispensary, while in rarer cases home cultivation is allowed.

Medical Marijuana

- By classifying marijuana as a schedule I controlled substance, the federal government has concluded that marijuana has "no currently accepted medical value."
- A growing body of evidence, however, suggests that marijuana can serve as an antiemetic and appetite stimulant to relive nausea and vomiting induced by chemotherapy and anorexia associated with HIV/AIDS.
- Other studies have found evidence that marijuana may aid in pain relief for patients with fibromyalgia and in treatment of multiple sclerosis, epilepsy, dementia, and Tourette's.
- This growing medical evidence propelled many states toward a more tolerant legal approach to medical marijuana.

Early Studies of Medical Marijuana Policy

"Medical Marijuana Laws Reduce Prescription Medication Use in Medicare Part D," *Health Affairs,* 2016.

By Ashley C. Bradford and W. David Bradford

"The Effect of Medical Marijuana Laws on Marijuana, Alcohol, and Hard Drug Use," *Journal of Health Economics,* 2015.

by Hefei Wen, Jason M. Hockenberry, and Janet R. Cummings

"The Effect of Medical Marijuana Laws on Body Weight," *Health Economics*, 2015.

By Joseph J. Sabia, Jeffrey Swigert, and Timothy Young

Does Marijuana substitute for other Rx drugs?

"Medical Marijuana Laws Reduce Prescription Medication Use in Medicare Part D," *Health Affairs*, 2016.

By Ashley C. Bradford and W. David Bradford

Bradford and Bradford (2016)

- How does the implementation of state-level medical marijuana laws change prescribing patterns and program and patient expenditures in Medicare Part D for prescription drugs approved by the FDA?
- To answer these questions, they use data from the Medicare Part D Prescription Drug Event Standard Analytic File covering the years 2010-2013.
- This data set contains information on all prescription drugs paid for under Medicare Part D.
- Each record in the data represents a specific drug prescribed by a physician in a given year.

Bradford and Bradford (2016)

Their difference-in-difference model takes the form:

$$y_{istd} = \alpha_d + X_{st}\beta + MML_{st}\delta + v_i + \tau_t + \alpha_s + \varepsilon_{istd},$$

where

- y_{istd} is prescriptions filled or daily doses filled by physician i, in county s, in year t for the dth diagnosis category.
- X_{st} are county characteristics.
- MML_{st} is an indicator for whether a medical marijuana law was in place in county s in year t.
- v_i is a vector of physician practice specialty indicator variables.
- τ_t and α_s are time and county dummies.

Table 6: Daily doses prescribed for diagnoses in Medicare Part D, only states that changed or never had MML during 2010-2013

	Anxiety	Depression	Glaucoma	Nausea	Pain
	All Drugs (approved on-label and in class with at least one on-label option)				
State MML is effective	-801.8***	-431.5***	18.1	-569.9***	-2095.1***
	(-12.02)	(-6.52)	(0.48)	(-12.07)	(-15.89)
	Drugs with FDA approval (on-label) for some ICD-9 code in condition area				
State MML is effective	-1112.0***	-1186.0***	1036.5***	-115.5***	-218.3***
	(-18.17)	(-15.78)	(4.54)	(-4.53)	(-7.63)
	Drugs without FDA approval (off-label) for any ICD-9 code in condition area				
State MML is effective	-368.3***	-215.4***	-50.4***	-528.4***	-2285.0***
	(-9.30)	(-7.21)	(-3.54)	(-13.91)	(-16.18)

	Psychosis	Seizures	Sleep	Spasticity
	All Drugs (approved on-label and in class with at least one on-label option)			
State MML is effective	-754.7***	-577.7***	-542.4***	-40.0**
	(-10.52)	(-12.09)	(-11.89)	(-2.09)
	Drugs with FDA approval (on-label) for some ICD-9 code in condition area			
State MML is effective	-743.8***	-187.8***	-192.0***	-88.5***
	(-14.35)	(-8.28)	(-13.60)	(-6.25)
	Drugs without FDA approval (off-label) for any ICD-9 code in condition area			
State MML is effective	-523.0***	-486.4***	-488.3***	-9.55
	(-10.41)	(-12.40)	(-11.47)	(-0.52)

Data are aggregated to all prescriptions in disease category by physician. Other variables included but not shown are: county HHI for daily doses; percent of state using marijuana; prescriber sex; percent of county below FPL; county median household income; number of deaths in county; number of emergency department visits in Medicare; unemployment rate in county; percent of population enrolled in Medicare; county total population; percent of county population in urban area, 2010; percent county population that is Black; percent county population that is Hispanic; percent county population that is other race; physicians per capita; and state and year indicators. Standard errors are clustered at the physician level.

* p<0.10, ** p<0.05, *** p<0.01

Table 7: Estimated annual dollar change in Medicare spending from MML, unduplicated across all conditions, by year for the average state and total for the program

	Change for Average State	Change for Total Program
2010	-7,989,304.18	-103,860,954.39
2011	-7,418,913.27	-111,283,699.06
2012	-7,944,388.20	-119,165,822.94
2013	-8,530,636.54	-153,551,457.67
For all years	-31,883,242.19	-487,861,934.07

Data is using all drugs in the classes of confirmed on-label indications. Estimates from model on all states except AK and HI with clustering at the physician level. Last row calculates the change in total 2010-2013 net Medicare expenditures for non-duplicated changes in use; cost savings were assigned to the diagnosis with the smallest estimated daily dose change.

Bradford and Bradford (2016)

- Studies the effect of medical marijuana laws on the prescription of other drugs payed for by Medicare Part D.
- Finds that the introduction of medical marijuana laws led to decreases in daily prescribed doses of drugs treating seven different categories of illness (anxiety, depression, nausea, pain, psychosis, seizures, sleep disorders, and spasticity).
- Medical marijuana laws actually led to increases in daily prescribed doses of drugs treating glaucoma. They claim that though marijuana is widely cited as a treatment for glaucoma, the reduction in intra-ocular pressure only lasts for about an hour. So new patients that learn about the potential benefits from marijuana are likely to seek prescription of another drug.
- They estimate that due to MMLs, enrollees spent $165 million less as a result of changed prescribing behaviors.

Effects on Alcohol and Hard Drug Consumption

"The Effect of Medical Marijuana Laws on Marijuana, Alcohol, and Hard Drug Use," *Journal of Health Economics,* 2015.

by Hefei Wen, Jason M. Hockenberry, and Janet R. Cummings

Wen et al. (2015)

- Despite the growing consensus about the relief medical marijuana can bring for a range of serious illnesses, concerns have been voiced that medical marijuana laws (MMLs) may give rise to increased marijuana use in the general population and increased use of other substances.
- Between 2004 and 2011, seven states implemented MMLs.
- This paper studies whether these policy expansions of medical marijuana led to increased marijuana consumption among the general population, excessive alcohol use, and hard drug use.
- Data comes from the restricted-access version of the National Survey on Drug Use and Health (NSDUH).

Wen et al. (2015)

Dependent Variables:

- An indicator for whether a person used marijuana in the past month.
- An index variable from 0-30 assessing the number of days during the past month that a respondent used marijuana.
- An indicator for whether a person used marijuana for the first time during the past year.
- An indicator for whether a person is classified as abuse of or dependence on marijuana during the past year.
- Other similar outcomes for alcohol consumption, measures of binge drinking, past-month cocaine and heroin use, and past-year initiation of the two drugs.

Wen et al. (2015)

Identification Strategy:

$$Y_{ist} = \alpha + \beta_1 MML_{st} + \beta_2 X_{1ist} + \beta_3 X_{2st} + \rho_s + \tau_t + \rho_s t + \varepsilon_{ist},$$

Where

- Y_{ist} is outcome variable for individual i, living in state s, in year t (i.e. marijuana, alcohol, or other drug consumption).
- MML_{st} is a policy indicator for the implementation of a medical marijuana law in a state s during year t.
- X_1 is a vector of individual-level covariates including age, age-squared, gender, race, self-assessed health, past-month cigarette smoking, family income, marital status, educational attainment, and employment status.
- X_2 is a vector of state-level economic measures including unemployment rate, median household income in the states, and alcohol excise tax rates in the states.
- ρ_s is a state fixed effect, τ_t is a time fixed effect, and $\rho_s t$ is a state-specific linear time trend.

Table 1. Effective Time of State Medical Marijuana Laws

MML States	(1) Approved	(2) Effective
2004-2010 (7 States)		
Vermont	2004/05	2004/07
Montana	2004/11	2004/11
Rhode Island	2005/06	2006/01
New Mexico	2007/03	2007/07
Michigan	2008/11	2008/12
New Jersey	2010/01	2010/10 (07)†
District of Columbia	2010/05	2010/07
1996-2003 (8 States)		
California	1996/11	1996/11
Washington	1998/11	1998/11
Oregon	1998/11	1998/12
Alaska	1998/11	1999/03
Maine	1999/11	1999/12
Hawaii	2000/06	2000/12
Colorado	2000/11	2001/06
Nevada	2000/11	2001/10
2010-2014 (7 States)		
Arizona	2010/11	2011/04
Delaware	2011/05	2011/07
Connecticut	2012/05	2012/05 (10)‡
Massachusetts	2012/11	2013/01
New Hampshire	2013/07	2013/07
Illinois	2013/08	2014/01
Maryland	2014/04§	2014/06

Table 4. Estimated Marginal Effect of Medical Marijuana Laws on Individual Marijuana & Alcohol Use

	(1)	(2)	(3)	(4)
	Age 12-20	Age 12-20	Age 21+	Age 21+
A. Marijuana Use Outcomes				
%Pr(Past-Month Marijuana Use)	0.11 (0.31) [10.1]	-0.62 (0.48) [10.2]	**1.40***** (0.26) [8.60]	**1.37*** (0.63) [8.60]
#Marijuana Use Days	-0.003 (0.01) [1.22]	-0.04 (0.05) [1.23]	**0.21***** (0.05) [1.19]	**0.14**† (0.08) [1.20]
%Pr(Marijuana Initiation)	**0.46**† **(0.26)** [7.09]	**0.32*** (0.17) [7.10]	**0.22**** (0.07) [0.68]	0.11 (0.11) [0.69]
%Pr(Marijuana Abuse/Dep.)	0.08 (0.27) [4.45]	0.03 (0.44) [4.45]	**0.32**† (0.18) [2.17]	**0.58*** (0.25) [2.15]
B. Alcohol Use Outcomes				
#Total Drinks‡	-0.35 (1.03) [8.90]	0.09 (2.78) [8.88]	0.16 (0.46) [19.5]	0.57 (1.33) [19.5]
#Alcohol Use Days	-0.02 (0.05) [1.35]	0.04 (0.08) [1.35]	0.03 (0.08) [4.88]	0.08 (0.11) [4.88]
#Binge Drinking Days	0.01 (0.03) [0.68]	0.08 (0.07) [0.68]	**0.10**** (0.03) [1.55]	**0.14**** (0.06) [1.54]
%Pr(Marijuana while Drinking)	-0.47 (0.29) [3.96]	-0.15 (0.52) [3.93]	**0.62**** (0.20) [4.04]	**0.89**† (0.54) [4.01]
State-Specific Linear Trend (ρ, t)	No	Yes	No	Yes
#Observations	≈ 183,600	≈ 183,600	≈ 219,400	≈ 219,400

Table 5. Estimated Immediate & Delayed Effect of Medical Marijuana Laws on Individual Alcohol Abuse/Dependence, Cocaine Use & Heroin Use

	(1)	(2)	(3)	(4)	(5)	(6)
	Age 12-20	Age 12-20	Age 12-20	Age 21+	Age 21+	Age 21+
%Pr(Alcohol Abuse/Dep.)	0.08 (0.63) [7.91]	-0.34 (0.32) [7.93]	-0.31 (0.47) [7.93]	0.73 (0.63) [10.7]	-0.53 (0.33) [10.8]	-0.04 (0.26) [10.8]
%Pr(Past-Month Cocaine Use)	-0.05 (0.22) [0.75]	0.08 (0.14) [0.74]	0.07 (0.09) [0.74]	0.19 (0.15) [1.08]	0.006 (0.13) [1.10]	-0.09 (0.14) [1.10]
%Pr(Cocaine Initiation)	0.10 (0.22) [1.66]	0.32 (0.31) [1.65]	-0.01 (0.29) [1.67]	0.02 (0.12) [0.66]	-0.18 (0.15) [0.67]	0.07 (0.10) [0.66]
%Pr(Past-Month Heroin Use)	0.006 (0.03) [0.09]	-0.02 (0.03) [0.09]	-0.02 (0.04) [0.09]	0.03 (0.04) [0.14]	0.02 (0.04) [0.14]	0.02 (0.05) [0.14]
%Pr(Heroin Initiation)	-0.06 (0.08) [0.22]	-0.01 (0.09) [0.21]	-0.04 (0.09) [0.21]	-0.01 (0.05) [0.14]	0.01 (0.04) [0.14]	-0.03 (0.05) [0.14]
Immediate/Delayed Effect	Contemporaneous	1-Year Lagged	2-Year Lagged	Contemporaneous	1-Year Lagged	2-Year Lagged
State-Specific Linear Trend $(\rho_s t)^{\ddagger}$	Yes	Yes	Yes	Yes	Yes	Yes
#Observations	≈ 183,600	≈ 183,600	≈ 183,600	≈ 219,400	≈ 219,400	≈ 219,400

Wen et al. (2015)

Conclusions:

- Medical marijuana laws increased experimentation with marijuana for the first time among adolescents and young adults aged 12-20, as well as led to increased use among those 21 and up that had already tried the drug previously.
- Among those 21 and up, MMLs led to a spillover effect on the frequency of binge drinking. This is evidence that marijuana and alcohol are complementary goods.
- MMLs had no effect on the consumption of cocaine and heroin. This is evidence that the "gateway" drug effect may not apply to medical marijuana.
- Factors such as these should be considered when deciding on policy issues related to medical and recreational marijuana.

Does marijuana impact body weight?

"The Effect of Medical Marijuana Laws on Body Weight," *Health Economics*, 2015.

By Joseph J. Sabia, Jeffrey Swigert, and Timothy Young

Sabia et al. (2015)

Do medical marijuana laws impact body weight, physical mobility, and diet?

- On one hand, if MML-induced marijuana use is effective in treating physical ailments, then they may lead to increased physical activity and a reduction in body weight. Also, if marijuana is a substitute for alcohol, then consumers may substitute away from a high-calorie beverage, and hence may lose weight.
- Alternatively, if marijuana use induces greater lethargy or stimulates appetite, or if marijuana and alcohol are complements, then MMLs could increase body weight.
- Also, if marijuana is a complement/substitute to either cigarettes or harder drugs such as cocaine or methamphetamine, then this could lead to decreases/increases in body weight (these latter three drugs are known appetite suppressants).

Sabia et al. (2015)

- Uses data from the Behavioral Risk Factor Surveillance System (BRFSS), a repeated cross-sectional nationally representative survey, over the years 1990-2012
- Outcome variables include BMI, a dummy for if the individual is obese, and variables measuring amount of time exercising or engaging in physical activity.
- Per usual, uses a difference-in-differences methodology to study the effect of plausibly exogeneous medical marijuana laws on outcomes.
- Explanatory variables include state-specific covariates such as unemployment rates, average wage rate, beer taxes, cigarette taxes, whether a state has a marijuana decriminalization law, food prices in states, as well as individual-level covariates including age, race, sex, marital status, and educational attainment.

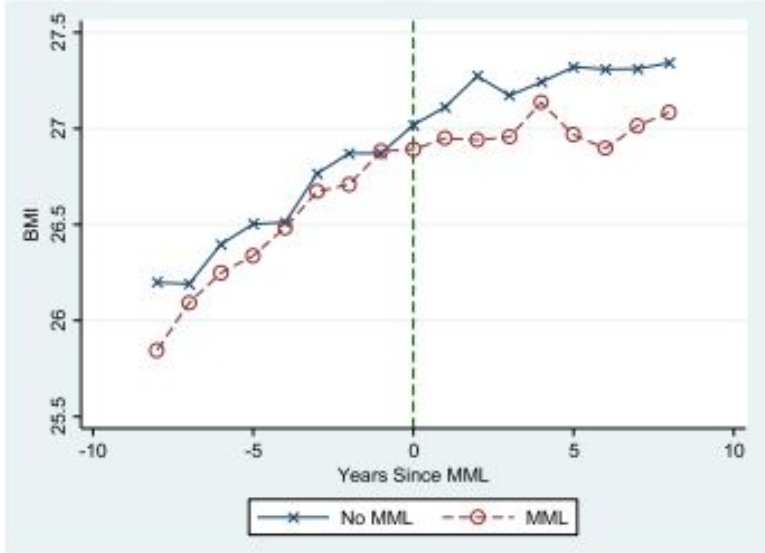


Figure 1. Event study of BMI before and after MML implementation

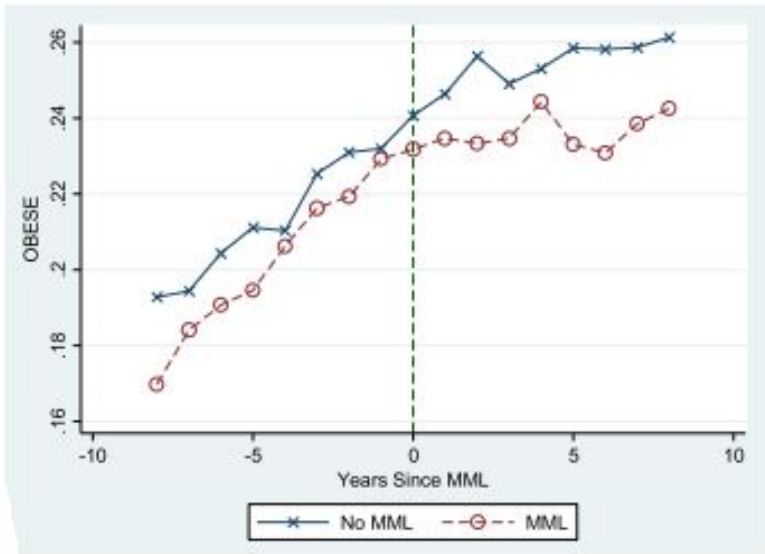


Figure 2. Event study of obesity before and after MML implementation

Table III. Difference-in-difference estimates of the relationship between MMLs and BMI

	(1)	(2)	(3)	(4)
Panel I: contemporaneous effects				
MML	−0.162*** (0.046)	−0.134*** (0.044)	−0.112*** (0.038)	−0.084** (0.034)
Panel II: lagged effects				
Year of law change	−0.117*** (0.036)	−0.100*** (0.035)	−0.105*** (0.037)	−0.088** (0.033)
1 year after MML	−0.078** (0.036)	−0.069** (0.032)	−0.067* (0.037)	−0.058 (0.043)
2 years after MML	−0.160*** (0.050)	−0.148*** (0.047)	−0.164*** (0.046)	−0.159*** (0.050)
3 years after MML	−0.159*** (0.053)	−0.137** (0.052)	−0.132** (0.051)	−0.134** (0.058)
4 years after MML	−0.060 (0.063)	−0.034 (0.059)	−0.014 (0.052)	−0.023 (0.057)
5+ years after MML	−0.243*** (0.069)	−0.203*** (0.070)	−0.157** (0.066)	−0.116* (0.061)
Mean BMI (MML = 0)	27.000	27.000	27.000	27.000
Demographic and economic controls	Yes	Yes	Yes	Yes
State policy controls	No	Yes	Yes	Yes
Food prices	No	No	Yes	Yes
State time trends	No	No	No	Yes
N	5,428,399	5,428,399	5,428,399	5,428,399

Note: Each column represents a result from separate unweighted regressions that include state and year fixed effects. Demographic and economic controls include gender, race (White, Black, and Hispanic), education, marital status, average wage by state and year (Current Population Survey), and state-level unemployment rate (Bureau of Labor Statistics Local Area Unemployment Statistics). State-level policy controls include marijuana decriminalization laws, zero-tolerance laws, and state-level alcohol and cigarette taxes. Food prices are collected from American Chamber of Commerce Research Association survey (ACCRA) and include prices for potatoes, bananas, lettuce, sweet peas, tomatoes, peaches, frozen corn, hamburger, pizza, and fried chicken. Standard errors are below each coefficient estimate in parentheses and are clustered by state. State time trends consist of interacting a linear time and a squared time variable with state fixed effects to generate a state-specific quadratic time trend.

*Significant at 10% level; **Significant at 5% level; ***Significant at 1% level.

Table IV. Difference-in-difference estimates of the relationship between MMLs and obesity

	(1)	(2)	(3)	(4)
Panel I: contemporaneous effects				
MML	−0.010*** (0.003)	−0.009*** (0.003)	−0.007** (0.003)	−0.005* (0.003)
Panel II: lagged effects				
Year of law change	−0.005 (0.003)	−0.004 (0.003)	−0.005 (0.003)	−0.003 (0.003)
1 year after MML	−0.006** (0.003)	−0.005** (0.002)	−0.005* (0.003)	−0.004 (0.003)
2 years after MML	−0.010** (0.004)	−0.009** (0.004)	−0.010*** (0.003)	−0.008** (0.003)
3 years after MML	−0.011*** (0.004)	−0.010** (0.004)	−0.009** (0.004)	−0.008* (0.005)
4 years after MML	−0.005 (0.004)	−0.004 (0.004)	−0.002 (0.004)	−0.001 (0.005)
5+ years after MML	−0.015*** (0.004)	−0.013*** (0.005)	−0.009** (0.004)	−0.005 (0.005)
Mean obesity (MML = 0)	0.240	0.240	0.240	0.240
Demographic and economic controls	Yes	Yes	Yes	Yes
State policy controls	No	Yes	Yes	Yes
Food prices	No	No	Yes	Yes
State time trends	No	No	No	Yes
N	5,428,399	5,428,399	5,428,399	5,428,399

Note: Each column represents a result from separate unweighted regressions that include state and year fixed effects. Demographic and economic controls include gender, race (White, Black, and Hispanic), education, marital status, average wage by state and year (CPS), and state-level unemployment rate (BLS LAUS). State-level policy controls include marijuana decriminalization laws, zero-tolerance laws, and state-level alcohol and cigarette taxes. Food prices are collected from ACCRA and include prices for potatoes, bananas, lettuce, sweet peas, tomatoes, peaches, frozen corn, hamburger, pizza, and fried chicken. Standard errors are below each coefficient estimate in parentheses and are clustered by state. State time trends consist of interacting a linear time and a squared time variable with state fixed effects to generate a state-specific quadratic time trend.

*Significant at 10% level; **Significant at 5% level; ***Significant at 1% level.

Sabia et al. (2015)

- Studies the impact of medical marijuana laws on body weight and obesity.
- Using a difference-in-differences methodology, they find a negatively significant effect of MMLs on outcomes of both BMI and obesity, indicating that the introduction of MML policies led to decreases in body weight.
- As far as mechanisms, for older individuals, MMLs seem to lead to more physical activity. For younger individuals, the decrease in body weight is related to a decrease in alcohol consumption (implying the marijuana and alcohol are substitutes).
- Note the differences in the alcohol related findings of Wen et al. (2015) and Sabia et al. (2015).

Next Class

Obesity and Nutrition