Illegal drug market responses to state recreational cannabis laws

Angélica Meinhofer, PhD[a] Adrian Rubli, PhD[b]

a. Department of Population Health Sciences, Weill Cornell Medicine, New York, United States
b. Department of Business Administration, Instituto Tecnológico Autónomo de México (ITAM), Mexico City, Mexico

Running Head: Cannabis legalization and illegal markets

Word Count: 3,485

Declaration of Interest: Authors have no relevant or material financial interests that relate to the research described in this paper. Dr. Meinhofer acknowledges support from the National Institute on Drug Abuse P30DA040500 and K01DA051777. Dr. Rubli acknowledges support from the Asociación Mexicana de Cultura, AC. Authors acknowledge research assistance from Jean-Yves Gérardy, Marcos Santos, and Daniela Soto.

Corresponding Author
Angélica Meinhofer, PhD
Department of Population Health Sciences
Weill Cornell Medicine
425 East 61st Street, Suite 301
New York, NY 10065
E-mail: anm4001@med.cornell.edu
Tel: 787-238-3399

ABSTRACT

Background and Aims: In the United States, 15 states and the District of Columbia have implemented recreational cannabis laws (RCLs) legalizing recreational cannabis use. We aimed to estimate the association between RCLs and street prices, potency, quality and law enforcement seizures of illegal cannabis, methamphetamine, cocaine, heroin, oxycodone, hydrocodone, morphine, amphetamine, and alprazolam.
Design: We pooled crowdsourced data from 2010-2019 Price of Weed and 2010-2019 StreetRx, and administrative data from the 2006-2019 System to Retrieve Information from Drug Evidence (STRIDE) and the 2007-2019 National Forensic Laboratory Information System (NFLIS). We employed a difference-in-differences design that exploited the staggered implementation of RCLs to compare changes in outcomes between RCL and non-RCL states.
Setting and cases: 11 RCL and 40 non-RCL U.S. states.
Measures: The primary outcome was the natural log of prices per gram, overall and by self-reported quality. The primary policy was an indicator of RCL implementation, defined using effective dates.
Findings: The street price of cannabis decreased by 9.2% [β=-0.092; 95% confidence interval (CI)=-0.15,-0.03] in RCL states after RCL implementation, with largest declines among low-quality purchases [β=-0.195; 95%CI=-0.282,-0.108]. Price declines were accompanied by a 93% [β=-0.93; 95%CI=-1.51,-0.36] reduction in law enforcement seizures of cannabis in RCL states. Among illegal opioids, including heroin, oxycodone, and hydrocodone, street prices increased and law enforcement seizures decreased in RCL states.
Conclusions: Recreational cannabis laws in US states appear to be associated with illegal drug market responses in those states, including reductions in the street price of cannabis. Changes in the street prices of illegal opioids analyzed may suggest that the markets in RCL states for other illegal drugs are not independent of legal cannabis market regulation.

Keywords: cannabis prices, recreational cannabis laws, illegal drug markets

INTRODUCTION

Cannabis liberalization is one of the major developments in drug policy over the past decade. Canada and Uruguay became the first countries to legalize recreational cannabis and many others have decriminalized or legalized medical cannabis [1]. In the United States, the Federal government classifies cannabis as a controlled substance in Schedule I. Substances in this schedule have no accepted medical use. At the state level, however, 15 states and the District of Columbia have passed recreational cannabis laws (RCLs) allowing individuals ages 21+ to possess, use, and supply limited amounts of cannabis for recreational purposes [2]. Washington and Colorado became the first states to legalize cannabis production, sale and use in 2012 [3]. RCLs follow other cannabis liberalization policies, starting with decriminalization in Oregon in 1973 and medical cannabis legalization (MCL) in California in 1996. Previous studies of cannabis liberalization policies have focused on MCLs and cannabis utilization or healthcare measures, reaching somewhat mixed findings. While there is limited evidence of changes in cannabis measures among teenagers, some studies have found increases among adults [4-14]. Existing RCL studies have found increases in cannabis measures among adults [15,31].

There is considerable debate regarding cannabis legalization, with concerns that RCLs may increase the use of cannabis and other drugs in vulnerable populations [16-20]. Supporters argue that legalization would improve access to safer cannabis products, reduce racial disparities in cannabis possession arrests, reduce law enforcement costs, and generate tax revenue [20]. The magnitude of these benefits will directly depend on the extent to which legal cannabis market regulation succeeds at replacing the illegal cannabis market. Two important factors influencing the success of any regulation are the technology of production and the price elasticity of demand. Cannabis is relatively easy to grow and does not require industrial processing; as such, it can be produced by nearly anyone. This threatens the government's ability to eliminate the illegal cannabis market and fully attain the expected benefits of legalization. A third factor is the interdependence between cannabis and other illegal drugs. Consumers and producers of cannabis may also be consumers and producers of other illegal drugs. As such, RCLs may affect other illegal drug markets.

The impact of cannabis legalization on illegal drug markets is theoretically ambiguous. On the demand side, legalization should induce legal consumption among prior users of illegal cannabis now facing lower costs of obtaining cannabis in the legal market, as well as among new users initially reluctant to consume illegal cannabis but willing to do so legally. In turn, illegal

cannabis consumption should decrease after legalization, leading to potential reductions in illegal prices and quantities. Demand may increase in both markets if legalization induces positive perceptions of cannabis, further enhancing legal consumption but offsetting expected declines in illegal prices and quantities. Net cannabis consumption (legal and illegal) and the share corresponding to the legal market will depend on government regulations and their effect on consumer transaction costs, both monetary and non-pecuniary, of obtaining cannabis in the legal versus the illegal market. Legalization may also induce changes in the demand for other illegal drugs, increasing consumption of complements and reducing consumption of substitutes.

On the supply side, legalization will induce market entry of legal cannabis producers. Illegal producers may decide to remain in the illegal market, become legal producers, or exit the market altogether, leading to reductions in quantities and potentially price increases due to market concentration. Exit decisions will depend on legal market regulation and its effect on the relative cost of remaining an illegal producer. For instance, if legalization imposes costly licensing requirements, illegal producers may stay in the illegal sector. Alternatively, legalization may reduce illegal cannabis prices through increases in legal and "gray" cannabis production or reductions in illegal producer/distributor costs. Changes may occur through the diversion of legally produced cannabis into the illegal market, substitution from foreign to domestic production, and lower law enforcement risks. The net direction of these adjustments is difficult to predict and will depend on the size of the illegal market and the price elasticity of demand. For instance, if market regulations imply stringent control over cannabis transactions, heavy users (price-inelastic) may be deterred from joining the legal market, and in turn, illegal producers could potentially increase illegal prices even as the illegal market decreases. Cannabis legalization may also induce changes in the supply of other illegal drugs. Under economies of scope (i.e., lower costs due to diversification in production), costs could increase for illegal producers. Likewise, if law enforcement efforts are shifted towards other drugs, the relative increase in riskiness of illegal drug production could increase costs. If costs are passed on to consumers, then illegal drug prices may increase.

Taken together, the net effect of cannabis legalization on illegal drug markets is an empirical question. Existing evidence is scarce and focuses on MCLs. Studies using illegal drug measures have documented increases in cannabis arrests and decreases in heroin measures after MCL implementation, especially in states with medical cannabis dispensaries [9,21]. A study found modest increases in illegal cannabis potency in states with medical cannabis dispensaries

[22], while another found reductions in the price of illegal cannabis after MCL implementation [23]. RCL studies have focused on prices, quality, and potency in the legal cannabis market, finding initial short-run increases in legal prices followed by declines as the market stabilized [3,24-25]. One RCL study considered a measure of overall cannabis prices that captured legal and illegal purchases with a sample of N=308 medical and recreational cannabis users in 2013-2014, N=153 of which reported prices. Authors found different patterns in prices during the first five months after legalization [3].

Elucidating the impact of RCLs on illegal drug markets is important for designing successful regulation that maximizes the benefits of legalization, and for developing effective public health and criminal justice strategies that mitigate potential harms. In this exploratory study, we aimed to estimate the association between RCL implementation and street prices, quality, potency, and law enforcement submissions of illegal cannabis and other illegal drugs. These outcomes reflect illegal producers' supply, technology of production, and costs, as well as consumers' willingness to pay for illegal drugs, making them good indicators of illegal drug market responses to legalization. We pooled administrative and crowdsourced data and exploited the staggered implementation of RCLs with a difference-in-differences design. We contribute to the literature by studying the impact of RCLs on the illegal cannabis market, which remains largely understudied; considering the market for other illegal drugs, which may not be independent of the illegal cannabis market; analyzing street price data with thousands of observations, which are difficult to obtain; examining potency and quality proxies, which have important public health implications; and generating the most up-to-date estimates.

METHODS

Data and Measures

Cannabis Street Prices

Cannabis street prices were drawn from 2010-2019 Price of Weed (POW), a crowdsourcing website (http://www.priceofweed.com) that reports information on illegal cannabis purchases anonymously submitted by consumers. Information includes street prices, amount, self-reported quality (high/medium/low), date of submission, and location (state/city). Previous studies have used POW [26-28]. We retrieved historical POW submissions going back to 2010 with Internet archive Wayback Machine, which uses web crawlers to gather data on over 330 billion publicly

available webpages [29]. POW data were archived about three times per month, although sometimes this number was higher or lower. We analyzed the proportion of purchases considered high-quality and the price per gram, overall and by quality (high versus low/medium). We kept positive prices and dropped outliers using interquartile range (IQR) criteria to minimize measurement error from incorrectly entered data. Low outliers were identified as prices below Q1−1.5*IQR and high outliers as above Q3+1.5*IQR. The submission date was used as a proxy for purchase date.

Illegal Drug Street Prices

Illegal drug street prices were drawn from the 2006-2019 Drug Enforcement Agency's (DEA) System to Retrieve Information on Drug Enforcement (STRIDE). STRIDE reports drug data collected by undercover agents (purchases, seizures), including prices and potency on a 1-100 scale for lab-analyzed drugs. We restricted the sample to data from undercover purchases since prices were unobservable for other forms of collection. We analyzed prices per gram and potency for cocaine, heroin, and methamphetamines, which had the largest sample size. Additionally, we stratified prices by median potency to identify heterogeneous effects. We kept positive prices and dropped outliers. Some price observations were missing the corresponding potency measures, leading to a slightly smaller sample size for the latter. Lastly, we constructed potency-adjusted prices under the expected purity hypothesis (Appendix A), dividing observed prices per gram by the average potency by state-year-amount, and then scaled by total average potency [49].

Prescription Drug Street Prices

Prescription drug street prices were drawn from 2010-2019 StreetRx (https://streetrx.com), which operates under the Researched Abuse, Diversion, and Addiction-Related Surveillance System [30]. StreetRx enables real-time, anonymous collection of diverted prescription drug prices. Variables collected included drug name, active ingredient, date of purchase, price, milligram strength, formulation, bulk purchase, city, and state. We analyzed street prices per milligram for amphetamines, oxycodone, hydrocodone, morphine, and alprazolam, which had the largest sample sizes. We kept positive prices and dropped outliers.

Law Enforcement Submissions

Law enforcement submissions (i.e. seizures) of illegal drugs were drawn from the 2007-2019 DEA's National Forensic Laboratory Information System (NFLIS). NFLIS systematically collects drug identification results from drug cases submitted to federal, state, and local forensic laboratories. These laboratories analyze drugs secured in law enforcement operations across the country, making NFLIS an important resource in monitoring illegal drug trafficking. The participation rate, defined as the percentage of the national drug caseload represented by laboratories that have joined NFLIS, is 98.5%. We generated state-year submission counts per 100,000 persons for cannabis, cocaine, heroin, methamphetamine, amphetamine, oxycodone, hydrocodone, morphine, and alprazolam.

Recreational Cannabis Laws

RCL implementation was defined using effective dates, drawn from ProCon and previous studies (Appendix A, Table-A1). We constructed an indicator equal to one if a submission occurred after RCL implementation and zero otherwise. The indicator "turned on" from zero to one starting the year-month-day of RCL implementation for POW and StreetRx, as both datasets identified exact submission date. STRIDE identified submissions in a year-month and NFLIS in a year; therefore, the indicator "turned on" starting the year-month and the year of RCL implementation, respectively.

Analysis

We estimated difference-in-differences models with ordinary least squares regressions and clustered standard errors by state. We employed a natural logarithm transformation of the right-skewed outcomes. Estimates from the logarithmic transformation can be interpreted as an approximation to the relative percent change in outcomes when multiplied by 100. The main independent variable was the RCL indicator. Each model controlled for state fixed-effects to account for time invariant differences between states and year-quarter fixed-effects to account for seasonality and nationwide trends in outcomes.[1] Year-quarter fixed-effects could help mitigate bias from nationwide drug policies directly or indirectly affecting illegal drugs (i.e. hydrocodone rescheduling). We also controlled for indicators of pain clinic laws, prescription drug monitoring program operations and mandates, MCLs, and MCL dispensaries. StreetRx allowed controlling for bulk purchases, which are potentially related to price discounts.

[1] NLFIS analyses incorporate year fixed-effects as the unit of observation is a state-year.

Appendix A includes more details on the models, measures, and datasets. As this study was not pre-registered, results should be considered exploratory.

We evaluated the sensitivity of main findings in several ways and found these were generally stable (Appendix B). First, we plotted RCL lag and lead estimates based on event study regressions (Figures B1-B4), which allowed to evaluate whether the strength of the association changed over time and inspect the parallel trends assumption required for difference-in-differences models to recover causal estimates.[2] Additionally, we reported full regression output (Table-B1); considered alternative modeling approaches, outlier criteria, and unit of analyses (Table-B2); used alternative RCL definitions including the time when commercial sales began (Table-B3); and assessed whether a single RCL state could be driving findings (Table-B4). We also evaluated whether the impact of RCLs varied by features of the legal cannabis market, including the commercial sales license application fee and the number of licensed dispensaries per capita (medical/recreational), which may be a better measure of legal cannabis availability (Table-B5). Similar checks using the other datasets are also reported (Tables B6-B13). Event study plots and time trends based on simple summary statistics are in Appendix C.

RESULTS

Table-1 reports summary statistics for RCL and non-RCL states. With few exceptions, street prices were generally lower and law enforcement submissions were higher in RCL states relative to non-RCL states. Figure-1 plots median cannabis street prices, showing declines after RCL implementation. Tables 2-5 report difference-in-differences estimates.

RCL implementation was associated with a 9.2% [β=-0.092; 95%CI=-0.154,-0.030] average decline in the price of illegal cannabis during the entire post-RCL period (Table-2). This association was driven by a 19.5% decline [β=-0.195; 95%CI=-0.282,-0.108] in low-quality cannabis prices. The coefficient for high-quality price was small and statistically insignificant, although significance was sensitive to outlier definitions as some specifications reflected price increases (Appendix B, Table-B2). The proportion of high-quality purchases did not change.

RCL implementation was also associated with a significant increase of 64% [β=0.643; 95%CI=0.217,1.069] in heroin prices (Table-3). Cocaine and methamphetamine prices were insignificant. We explored the association by potency and found significant increases in high-

[2] Other assumptions include no spillovers to comparison units, stable composition of comparison and treatment units, and that treatment is unrelated to outcomes at baseline.

potency cocaine prices [β=0.166; 95%CI=0.022,0.310] as well as in high-potency [β=0.538; 95%CI=0.178,0.899] and low-potency [β=0.837; 95%CI=[-0.0014,1.676] heroin prices. Heroin potency increased by 54% [β=0.537; 95%CI=0.172,0.902] and methamphetamine potency decreased by 11% [β=-0.110; 95%CI=[-0.167,-0.052]. Lastly, we found significant increases in potency-adjusted cocaine [β=0.127; 95%CI=0.008,0.245] and heroin [β=0.294; 95%CI=[-0.026,0.614] prices.

Table-4 shows increases in oxycodone [β=0.073; 95%CI=0.017,0.130] and hydrocodone [β=0.051; 95%CI=0.023,0.080] prices. Morphine was the only illegal prescription opioid without significant effects, although the sample was smaller. Estimates for amphetamines and alprazolam were statistically insignificant.

Table-5 shows large declines in law enforcement submissions per 100,000 persons across multiple illegal drugs, with largest reductions for cannabis [β=-0.93; 95%CI=-1.51,-0.36]. Estimates for cocaine, amphetamine, and alprazolam were insignificant.

When assessing whether the strength of the association varied across different legal market features, we found that cannabis price reductions were largest in RCL states with higher rates of licensed dispensaries and lower commercial sales license application fees (Appendix B, Table-B5). Similarly, heroin effects were larger in these RCL states (Appendix B, Table-B9).

DISCUSSION

This study provides the most comprehensive evidence to date of the association between RCLs and various characteristics of illegal drug markets. Exploiting a rich collection of data sources and a robust difference-in-differences design, we documented several key findings.

First, RCL implementation was associated with reductions in the price of illegal cannabis, with effects concentrated among low-quality purchases. We found no impacts on the proportion or price of high-quality purchases. Price reductions align with a basic prediction that RCLs may reduce illegal cannabis demand as consumers move towards legal markets. Supply-side mechanisms include greater legal and diverted cannabis availability through increases in domestic production, along with lower risks of prosecution by law enforcement [23]. Indeed, previous studies and police reports suggest that legalization has been accompanied by increases in domestic production, diversion of legal cannabis to the illegal market, reductions in illegal cannabis imports from Mexico, and difficulties in differentiating legal from “gray” marijuana

operations which hinders enforcement efforts (i.e. challenges determining probable cause and search and seizure procedures) [42,46-48,52]. All these forces may lead to reductions in illegal cannabis prices. Since we cannot observe cannabis potency, documented price declines possibly understate the true magnitude on potency-adjusted prices, assuming RCLs increase potency. Not surprisingly, RCL states with higher licensed dispensaries per capita and lower commercial sales license application fees displayed greatest declines in illegal cannabis prices. Stringent regulation may create high compliance costs for legal producers relative to the costs and risks associated with remaining an illegal producer [20]. Together, our findings show that not all illegal cannabis markets were equally impacted by RCLs and provide insights into market segments that may remain active post-legalization. A key policy implication is that imposing regulatory hurdles on legal markets might be a less effective approach for eliminating illegal cannabis markets [20].

Second, we established an association between RCLs and illegal opioids, showing increases in heroin prices and potency and in illegal prescription opioid prices. Growth in potency and potency-adjusted heroin prices suggests that potency can largely but perhaps not entirely explain price increases. While we cannot disentangle demand and supply forces, findings seem consistent with supply responses. The shrinking illegal cannabis market may have led to greater supplier costs and thus, opioid price increases if there are economies of scope in illegal production/distribution (i.e., lower average costs when diversifying production/distribution across various drugs). In this scenario, illegal producers/distributors of cannabis are also producers/distributors of other illegal drugs, and their market exit may lead to supply reductions and price increases for other illegal drugs. Indeed, Mexican drug trafficking organizations generally produce/distribute cannabis along with other drugs [41-42]. It is also possible that the relative risk of being in the illegal market increased if law enforcement efforts shifted from cannabis towards other illegal drugs [3], with prices affected accordingly. Lastly, market exit may have changed the composition of producers remaining in the illegal market.

We cannot fully rule out that demand increases contributed to opioid price increases. A recent study documented that among opioid-using adults, the odds of opioid use doubled on days that participants used cannabis, suggesting that opioids might be complements of cannabis [51]. However, evidence from other studies suggests that opioid measures decline after MCL implementation [21,32-36]. Our findings may inform the debate on whether opioid use decreases with cannabis liberalization, and suggest alternative mechanisms beyond substitution or complementarity patterns, including changes in law enforcement, prices, supply, and potency

[21,32-36,39,51]. Of note, as STRIDE prices are not representative and subject to other limitations discussed below [37-38], our associations may reflect these issues and should be interpreted with caution.

Another key finding is that RCLs led to declines in law enforcement submissions of cannabis, as expected, but also of other drugs. Our findings coincide with studies documenting reductions in some types of index crimes after RCL implementation [31,44-45], and with police reports based on state data indicating reductions in cannabis-related crimes, arrests, and seizures [46-48]. Qualitative evidence from focus groups of police and prosecutors indicated a de-prioritization of cannabis crime by law enforcement [48]. While our data cannot elucidate the mechanisms, findings may result from a mechanical effect if a single seizure event captured various drugs, so that as law enforcement shifted away from cannabis control, other drugs were inevitably excluded. Alternatively, enforcement agencies may have changed their targeting strategies or relaxed their efforts. Finally, it is possible that reductions in law enforcement submissions reflected a decline in the supply of these illegal drugs, which may occur if there is market exit of illegal producers. We caution, however, that NFLIS data does not reflect all enforcement efforts nor the quantity of drugs seized [43].

Limitations

Our study has several limitations. First, crowdsourced data may be subject to sampling bias and thus, an imperfect measure of true prices and quality of illegal drugs. Populations with limited internet access may be underrepresented and systematically different from individuals submitting data. Second, administrative data from seizures or undercover agent purchases may also represent a selected sample, as federal and local agents may target certain areas with different probabilities or pay systematically different prices than typical buyers [37-38]. In STRIDE, only acquisitions sent to DEA laboratories for analysis are included [38]. Third, submissions could be of poor quality if prices/quality/potency are entered incorrectly or not available at all (i.e., POW does not report cannabis potency); if the date of submission and purchase differ considerably; and if self-reported quality categorizations in POW are inconsistent. Additionally, while POW and StreetRx explicitly instruct users to report “street” prices, it is possible that some users incorrectly submitted legal prices. Further, STRIDE sample size decreases over time, but especially in 2018-2019, possibly reflecting delays in reporting from law enforcement cases that are yet to be closed. Nevertheless, findings were robust to dropping 2018-2019 data (Appendix

B, Table-B13). Fourth, although prices are an important outcome, they reflect both demand and supply conditions. Thus, we cannot disentangle the forces driving our effects. Finally, it is possible that unobserved factors are confounding estimated associations.

CONCLUSION

RCLs were associated with illegal drug market responses. Findings are consistent with replacement of the illegal cannabis market by the legal cannabis market and with changes in other illegal drug markets, all of which have important consequences for social welfare. The specific pathways through which price effects occur and effects on consumption remain an avenue for future research. Policymakers implementing RCLs must account for illegal drug market responses when designing legal market regulation, and consider the differential impact of stringent versus relaxed regulatory approaches in modifying those responses.

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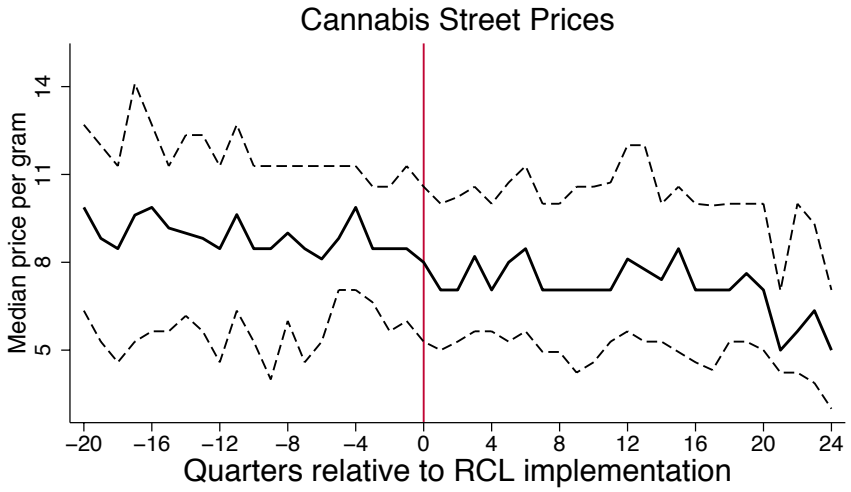

Figure 1. Median price of illegal cannabis in POW, by time since RCL implementation

Notes: POW, 2010-19. The outcome is the price per gram. The solid line represents the median price per gram and the dashed lines represent the first and third quartiles. Summary statistics are calculated for RCL states only, normalizing time periods relative to RCL implementation. RCL= Recreational cannabis laws.

Table 1. Summary statistics

	RCL States			Non-RCL States		
	Mean/ proportion	SD	N	Mean/ proportion	SD	N
Cannabis						
High quality	0.50	0.50	18,121	0.49	0.50	54,679

Price per gram (full sample)	8.77	4.78	18,121	10.37	5.46	54,679
Price per gram (high quality)	9.43	4.57	9,065	11.51	4.86	26,724
Price per gram (low quality)	8.11	4.89	9,056	9.27	5.77	27,955
Law enforcement subs. per 100,000 persons	69.43	73.52	143	172.74	152.65	520
Cocaine						
Potency	53.97	21.69	2,790	51.74	21.98	16,145
Price per gram (full sample)	50.53	37.74	2,876	59.59	41.75	16,795
Price per gram (high potency)	53.84	40.12	1,491	67.05	46.63	7,942
Price per gram (low potency)	44.93	31.01	1,299	50.3	31.88	8,203
Potency-adjusted price	51.18	43.63	2,790	60.29	40.01	16,145
Law enforcement subs. per 100,000 persons	57.39	66.41	143	75.31	64.68	520
Heroin						
Potency	25.19	18.54	1,266	34.80	22.14	5,190
Price per gram (full sample)	132.37	190.68	1,522	214.50	212.49	5,782
Price per gram (high potency)	152.04	198.97	436	227.73	206	2,789
Price per gram (low potency)	116.63	178.98	830	164.08	165.27	2,401
Potency-adjusted price	193.02	281.9	1,266	210.37	225.95	5,190
Law enforcement subs. per 100,000 persons	48.47	48.77	143	35.66	42.54	520
Methamphetamine						
Potency	79.80	25.37	4,031	70.84	29.22	7,101
Price per gram (full sample)	41.69	24.23	4,049	64.10	38.36	7,245
Price per gram (high potency)	39.88	24.8	2,364	63.64	39.75	3,141
Price per gram (low potency)	43.84	22.08	1,667	64.21	36.21	3,960
Potency-adjusted price	42.72	33.23	4,031	79.71	69.2	7,101
Law enforcement subs. per 100,000 persons	59.13	64.00	143	95.47	105.86	520
Amphetamines						
Price per milligram	0.36	0.17	16,645	0.34	0.17	48,390
Law enforcement subs. per 100,000 persons	1.52	1.55	143	3.74	2.95	520
Oxycodone						
Price per milligram	0.83	0.50	12,650	0.88	0.48	35,498
Law enforcement subs. per 100,000 persons	8.58	9.19	143	15.21	16.10	520
Hydrocodone						
Price per milligram	0.66	0.33	11,665	0.72	0.33	27,171
Law enforcement subs. per 100,000 persons	4.40	4.52	143	12.45	14.73	520
Morphine						
Price per milligram	0.42	0.31	2,446	0.46	0.31	5,818
Law enforcement subs. per 100,000 persons	1.43	1.08	143	2.61	2.43	520
Alprazolam						
Price per milligram	3.87	2.52	4,948	3.94	2.49	13,432
Law enforcement subs. per 100,000 persons	3.88	3.71	143	13.01	12.51	520

Notes: Summary statistics are based on all available sample years. POW, 2010-2019. STRIDE, 2006-2019. StreetRx, 2010-2019. NFLIS, 2007-2019. Prices are in U.S. dollars. SD=Standard deviation. N=Sample size.

Table 2. Self-reported price and quality of illegal cannabis in POW

	Price per gram in dollars (natural log)			Quality (proportion)
	Overall	Low Quality	High Quality	High Quality
RCL	-0.092***	-0.195***	0.019	0.002
	[-0.154,-0.030]	[-0.282,-0.108]	[-0.039,0.076]	[-0.035,0.039]
N	72,800	37,011	35,789	72,800
States	51	51	51	51

Notes: POW, 2010-2019. Outcomes of interest are the natural log of prices per gram and the proportion of self-reported high-quality cannabis purchases. The unit of observation is an individual submission. Coefficients are based on a difference-in-differences approach. State clustered confidence intervals are in parentheses. ***$P < 0.01$; **$P < 0.05$; *$P < 0.10$.
RCL= Recreational cannabis laws. N=Sample size. States=Number of states observed in the sample.

Table 3. Price and potency of illegal drugs in STRIDE

	Price per gram in dollars (natural log)			Potency (natural log)	Potency-adjusted price per gram (natural log)
	Overall	High Potency	Low Potency		
Panel A: Cocaine					
RCL	0.0326	0.166**	0.00347	-0.0376	0.127**
	[-0.114, 0.180]	[0.022, 0.310]	[-0.103, 0.110]	[-0.173, 0.0975]	[0.008, 0.245]
N	19,671	9,433	9,502	18,935	18,935
States	51	50	51	51	51
Panel B: Heroin					
RCL	0.643***	0.538***	0.837*	0.537***	0.294*
	[0.217, 1.069]	[0.178, 0.899]	[-0.0014, 1.676]	[0.172, 0.902]	[-0.026, 0.614]
N	7,304	3,225	3,231	6,456	6,456
States	48	45	48	48	48
Panel C: Methamphetamine					
RCL	-0.0911	-0.0402	0.0431	-0.110***	0.0123
	[-0.255, 0.0732]	[-0.198, 0.117]	[-0.0893, 0.176]	[-0.167, -0.052]	[-0.148, 0.173]
N	11,294	5,505	5,627	11,132	11,132
States	50	49	50	50	50

Notes: STRIDE, 2006-2019. Outcomes of interest are the natural log of prices per gram, the natural log of drug potency on a 1-100 scale, and the natural log of potency-adjusted prices. Potency-adjusted prices are calculated following the expected purity hypothesis. High potency is defined as above the drug-specific median and low potency as equal or below the median. The unit of observation is an individual submission. Coefficients are based on a difference-in-differences approach. State clustered confidence intervals are in parentheses. ***$P < 0.01$; **$P < 0.05$; *$P < 0.10$.
RCL= Recreational cannabis laws. N=Sample size. States=Number of states observed in the sample.

Table 4. Self-reported price of illegal prescription drugs in StreetRx

Price per milligram in dollars (natural log)					
	Amphetamines	Oxycodone	Hydrocodone	Morphine	Alprazolam
RCL	0.0012	0.0732**	0.0513***	0.0904	-0.0180
	[-0.018, 0.020]	[0.017, 0.130]	[0.023, 0.080]	[-0.044, 0.225]	[-0.067, 0.031]
N	65,035	48,148	38,836	8,264	18,380
States	51	51	51	51	51

Notes: StreetRx, 2010-2019. Outcomes of interest are the natural log of prices per milligram. The unit of observation is an individual submission. Coefficients are based on a difference-in-differences approach. State clustered confidence intervals are in parentheses. ***$P < 0.01$; **$P < 0.05$; *$P < 0.10$.
RCL= Recreational cannabis laws. N=Sample size. States=Number of states observed in the sample.

Table 5. Law enforcement submissions of illegal drugs per 100,000 persons (natural log)

	Cannabis	Cocaine	Heroin	Methamphetamine	Amphetamine	Oxycodone	Hydrocodone	Morphine	Alprazolam
RCL	-0.93***	-0.34	-0.64***	-0.49**	-0.33	-0.62***	-0.52***	-0.46**	-0.21
	[-1.51,-0.36]	[-0.80,0.12]	[-0.98,-0.30]	[-0.88,-0.10]	[-0.69,0.02]	[-1.01,-0.23]	[-0.88,-0.15]	[-0.81,-0.12]	[-0.62,0.19]
N	663	663	662	659	648	661	645	639	645
States	51	51	51	51	51	51	51	51	51

Notes: NFLIS, 2007-2019. Outcomes of interest are the natural log of law enforcement submissions per 100,000 persons. The unit of observation is a state-year. Coefficients are based on a difference-in-differences approach. State clustered confidence intervals are in parentheses. ***$P < 0.01$; **$P < 0.05$; *$P < 0.10$.
RCL= Recreational cannabis laws. N=Sample size. States=Number of states observed in the sample.