Online Supplementary Materials

Table S1. Effective Dates of Prescription Drug Monitoring Programs (PDMPs)

State	Date of PDMP Enactment	PDMP Policies Specific to Benzodiazepines		PDMP Policies Specific to Prescription Opioids	
		Date of PDMP Data Access for Benzodiazepines	Date of Mandatory Use of PDMP Data for Benzodiazepines	Date of PDMP Data Access for Prescription Opioids	Date of Mandatory Use of PDMP Data for Prescription Opioids
Alabama	Q2 2004	Q3 2007	NA	Q3 2007	NA
Alaska	Q2 2008	Q1 2012	NA	Q1 2012	After 2016
Arizona	Q3 2007	Q4 2008	Q3 2011	Q4 2008	Q3 2011
Arkansas	Q1 2011	Q1 2013	Q3 2015	Q1 2013	Q3 2015
California	Q3 2003	Q1 2010	NA	Q3 2009	NA
Colorado	Q2 2005	Q1 2008	NA	Q1 2008	Q4 2013
Connecticut	Q2 2006	Q3 2008	Q4 2015	Q3 2008	Q4 2015
Delaware	Q3 2010	Q3 2012	Q3 2012	Q3 2012	Q3 2012
District of Columbia	Q1 2014	Q4 2016	NA	Q4 2016	NA
Florida†	Q2 2009	Q4 2011	NA	Q4 2011	NA
Georgia	Q2 2011	Q2 2013	Q3 2014	Q2 2013	Q3 2014
Hawaii	Before 1999	Q1 2012	NA	Q1 2012	NA
Idaho	Q2 2000	Q2 2000	NA	Before 1999	NA
Illinois	Q3 1999	Q4 2009	NA	Q1 2008	NA
Indiana	Q1 2006	Q3 2007	NA	Q3 2007	Q3 2014
Iowa	Q2 2006	Q1 2009	NA	Q1 2009	NA
Kansas	Q2 2008	Q2 2011	NA	Q2 2011	NA
Kentucky	Before 1999	Q3 1999	Q3 2012	Q3 1999	Q3 2012
Louisiana	Q2 2006	Q1 2009	NA	Q1 2009	Q3 2014
Maine	Q2 2003	Q1 2005	After 2016	Q1 2005	After 2016

Maryland	Q2 2011	Q1 2014	NA	Q1 2014	NA
Massachusetts	Q3 2010	Q1 2011	Q1 2013	Q1 2011	Q1 2013
Michigan	Q1 2002	Q1 2003	NA	Q1 2003	NA
Minnesota	Q2 2007	Q2 2010	NA	Q2 2010	Q3 2013
Mississippi	Q2 2006	Q2 2006	Q4 2013	Q4 2005	Q4 2013
Missouri	NA	NA	NA	NA	NA
Montana	Q2 2011	Q4 2012	NA	Q4 2012	NA
Nebraska	Q2 2011	Q1 2016	NA	Q1 2009	NA
Nevada	Before 1999	Before 1999	Q4 2007	Before 1999	Q4 2007
New Hampshire	Q2 2012	Q4 2014	NA	Q4 2014	Q3 2016
New Jersey	Q1 2008	Q1 2012	NA	Q1 2012	Q4 2015
New Mexico	Q3 2004	Q3 2005	Q4 2012	Q3 2005	Q3 2012
New York	Before 1999	Q2 2013	Q3 2013	Q2 2013	Q3 2013
North Carolina	Q3 2005	Q4 2007	NA	Q4 2007	Q1 2012
North Dakota	Q2 2007	Q2 2007	Q2 2014	Q2 2007	Q2 2014
Ohio	Q4 2004	Q4 2006	Q4 2011	Q4 2006	Q4 2011
Oklahoma	Before 1999	Q3 2006	Q4 2010	Q3 2006	Q4 2010
Oregon	Q3 2009	Q3 2011	NA	Q3 2011	NA
Pennsylvania	Before 1999	Q3 2016	Q3 2015	Q3 2016	Q3 2015
Rhode Island	Q4 2001	Q3 2012	NA	Q3 2012	Q1 2013
South Carolina	Q2 2006	Q2 2008	NA	Q2 2008	Q2 2016
South Dakota	Q3 2010	Q1 2012	NA	Q1 2012	NA
Tennessee	Before 1999	Q1 2007	Q1 2013	Q1 2007	Q1 2013
Texas	Before 1999	Q2 2012	Q3 2015	Q2 2012	Q3 2015
Utah	Before 1999	Before 1999	NA	Before 1999	Q2 2016
Vermont	Q2 2006	Q2 2009	Q4 2013	Q2 2009	Q4 2013
Virginia	Q2 2002	Q2 2006	NA	Q2 2006	Q3 2015
Washington	Q2 2007	Q1 2012	NA	Q1 2012	Q3 2013
West Virginia	Before 1999	Q4 2004	NA	Q4 2004	Q2 2012
Wisconsin	Q2 2010	Q2 2013	After 2016	Q2 2013	After 2016

Wyoming	Q1 2003	Q3 2013	NA	Q3 2013	NA

Notes: † Florida was excluded from this study.

Data sources:

NAMSDL: http://www.namsdl.org/prescription-monitoring-programs.cfm

PEW: https://www.pewtrusts.org/en/research-and-analysis/data-visualizations/2018/when-are-prescribers-required-to-use-prescription-drug-monitoring-programs

Table S2. Sensitivity Analysis Results Including PDMP Policies Specific to Prescription Opioids and Pill Mill Laws, 1999-2016.

	Logged Drug Overdose Death Rate involving Benzodiazepines		Logged Drug Overdose Death Rate involving Prescription Opioids		Logged Drug Overdose Death Rate involving Benzodiazepines and Prescription Opioids	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Coefficients (95% Confidence Intervals)					
PDMP Data Access for Benzodiazepines	-0.064 (-0.97, 0.84)	-0.069 (-0.99, 0.85)	-0.010 (-0.25, 0.23)	-0.0052 (-0.23, 0.22)	0.11 (-1.06, 1.29)	0.11 (1.09, 1.30)
Mandatory Use of PDMP Data for Benzodiazepines		0.083 (-0.44, 0.61)		0.14 (-0.098, 0.38)		0.14 (-0.44, 0.72)
PDMP Data Access for Prescription Opioids	-0.13 (-1.05, 0.79)	-0.13 (-1.06, 0.80)	-0.075 (-0.35, 0.20)	-0.078 (-0.34, 0.19)	-0.40 (-1.56, 0.76)	-0.40 (-1.58, 0.78)
Mandatory Use of PDMP Data for Prescription Opioids		-0.18 (-0.58, 0.22)		0.012 (-0.13, 0.16)		-0.26 (-0.78, 0.26)
PDMP Enactment	0.16 (-0.22, 0.54)	0.15 (-0.22, 0.53)	-0.11 (-0.28, 0.061)	-0.11 (-0.28, 0.059)	0.14 (-0.29, 0.56)	0.12 (-0.31, 0.55)
Pill Mill Law Enactment	-0.32 (-0.68, 0.038)	-0.29 (-0.65, 0.079)	-0.20 (-0.42, 0.027)	-0.24* (-0.46, -0.014)	-0.60** (-1.00, -0.20)	-0.55* (-0.96, -0.14)
Medicaid Expansion as Part of Affordable Care Act	0.14 (-0.25, 0.53)	0.16 (-0.23, 0.56)	0.15 (-0.067, 0.36)	0.13 (-0.072, 0.34)	-0.020 (-0.43, 0.39)	0.0069 (-0.41, 0.42)
Number of Active Physicians per 1,000 Population	0.012 (-0.016, 0.041)	0.012 (-0.017, 0.040)	0.0039 (-0.011, 0.018)	0.0041 (-0.011, 0.019)	0.017 (-0.011, 0.044)	0.016 (-0.011, 0.043)
Poverty Rate	-0.011 (-0.043, 0.021)	-0.011 (-0.043, 0.021)	0.0062 (-0.020, 0.032)	0.0053 (-0.021, 0.031)	0.0067 (-0.037, 0.050)	0.0068 (-0.036, 0.050)
Median Household Income	0.011	0.010	-0.0054	-0.0050	0.024	0.023

in Thousand Dollars	(-0.016, 0.037)	(-0.016, 0.036)	(-0.022, 0.011)	(-0.022, 0.011)	(-0.0028, 0.050)	(-0.0031, 0.048)
Unemployment Rate	0.062 (-0.071, 0.19)	0.062 (-0.071, 0.19)	-0.0061 (-0.071, 0.059)	-0.0086 (-0.069, 0.052)	0.036 (-0.097, 0.17)	0.035 (-0.098, 0.17)
Constant	-2.23** (-3.85, -0.61)	-2.17** (-3.74, -0.59)	-0.57 (-1.68, 0.54)	-0.59 (-1.67, 0.50)	-3.63*** (-5.29, -1.97)	-3.54*** (-5.13, -1.95)
Number of State-Quarter Observations	3600	3600	3600	3600	3600	3600
Overall R^2	0.60	0.60	0.67	0.67	0.65	0.65

$*P < .05, **P < .01, ***P < .001$

Notes: Data were analyzed at state-quarter level. All regressions were also controlled for state indicators, year indicators, quarter indicators, and state-specific time trends. Standard errors were clustered at state level. Florida was excluded from this study.

Table S3. Sensitivity Analysis Results Using Negative Binomial Models, 1999-2016.

	Number of Drug Overdose Deaths involving Benzodiazepines		Number of Drug Overdose Deaths involving Prescription Opioids		Number of Drug Overdose Deaths involving Prescription Opioids and Benzodiazepines	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Incidence Rate Ratio (IRR) (95% Confidence Intervals)					
PDMP Data Access for Benzodiazepines	0.94 (0.83, 1.07)	0.94 (0.83, 1.07)	0.98 (0.90, 1.06)	0.98 (0.90, 1.06)	0.91 (0.80, 1.05)	0.91 (0.80, 1.05)
Mandatory Use of PDMP Data for Benzodiazepines		0.94 (0.80, 1.10)		1.00 (0.89, 1.12)		0.88 (0.75, 1.03)
PDMP Enactment	0.95 (0.83, 1.08)	0.95 (0.83, 1.08)	0.93 (0.85, 1.01)	0.93 (0.85, 1.01)	0.92 (0.80, 1.05)	0.92 (0.80, 1.05)
Medicaid Expansion as Part of Affordable Care Act	1.01 (0.85, 1.20)	1.01 (0.85, 1.19)	1.03 (0.92, 1.16)	1.03 (0.92, 1.16)	0.92 (0.77, 1.09)	0.91 (0.77, 1.09)
Number of Active Physicians per 1,000 Population	1.01 (1.00, 1.02)	1.00 (1.00, 1.01)	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)	1.02* (1.00, 1.03)	1.02* (1.00, 1.03)
Poverty Rate	0.99 (0.97, 1.02)	0.99 (0.97, 1.02)	1.01 (0.99, 1.02)	1.01 (0.99, 1.02)	0.99 (0.97, 1.02)	0.99 (0.97, 1.02)
Median Household Income in Thousand Dollars	1.01 (0.99, 1.02)	1.01 (0.99, 1.02)	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)	1.01 (0.99, 1.02)	1.01 (0.99, 1.02)
Unemployment Rate	1.02 (0.97, 1.07)	1.02 (0.97, 1.08)	1.02 (0.98, 1.05)	1.02 (0.98, 1.05)	1.03 (0.98, 1.09)	1.04 (0.98, 1.10)
Population, 100,000	0.96 (0.92, 1.01)	0.96 (0.92, 1.01)	0.96** (0.94, 0.99)	0.96** (0.94, 0.99)	0.95* (0.90, 1.00)	0.95* (0.90, 1.00)
Constant	16.87** (2.07, 137.55)	16.94** (2.06, 139.37)	35.89*** (10.44, 123.38)	35.90*** (10.39, 124.00)	22.03** (2.23, 217.38)	22.14** (2.26, 216.58)
Number of State-Quarter Observations	3600	3600	3600	3600	3600	3600

Pseudo R^2	0.28	0.28	0.28	0.28	0.30	0.30

*P < .05, **P < .01, ***P < .001

Notes: Data were analyzed at state-quarter level. All regressions were also controlled for state indicators, year indicators, quarter indicators, and state-specific time trends. Standard errors were clustered at state level. Florida was excluded from this study.

Table S4. Sensitivity Analysis Results Excluding West Virginia, 1999-2016.

	Logged Drug Overdose Death Rate involving Benzodiazepines		Logged Drug Overdose Death Rate involving Prescription Opioids		Logged Drug Overdose Death Rate involving Prescription Opioids and Benzodiazepines	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Coefficients (95% Confidence Intervals)					
PDMP Data Access for Benzodiazepines	-0.17 (-0.43, 0.094)	-0.17 (-0.43, 0.088)	-0.067 (-0.21, 0.072)	-0.063 (-0.20, 0.074)	-0.24 (-0.53, 0.061)	-0.24 (-0.54, 0.050)
Mandatory Use of PDMP Data for Benzodiazepines		-0.14 (-0.52, 0.24)		0.097 (-0.11, 0.31)		-0.21 (-0.52, 0.11)
PDMP Enactment	0.17 (-0.21, 0.55)	0.17 (-0.21, 0.55)	-0.11 (-0.28, 0.065)	-0.11 (-0.28, 0.064)	0.15 (-0.28, 0.58)	0.15 (-0.28, 0.58)
Medicaid Expansion as Part of Affordable Care Act	0.19 (-0.23, 0.60)	0.20 (-0.21, 0.61)	0.18 (-0.043, 0.40)	0.17 (-0.044, 0.38)	0.043 (-0.39, 0.48)	0.061 (-0.38, 0.50)
Number of Active Physicians per 1,000 Population	0.011 (-0.017, 0.039)	0.011 (-0.017, 0.039)	0.0033 (-0.012, 0.018)	0.0034 (-0.012, 0.019)	0.016 (-0.012, 0.044)	0.016 (-0.012, 0.043)
Poverty Rate	-0.013 (-0.047, 0.021)	-0.012 (-0.046, 0.022)	0.0040 (-0.024, 0.032)	0.0034 (-0.024, 0.031)	0.0028 (-0.044, 0.049)	0.0041 (-0.043, 0.051)
Median Household Income in Thousand Dollars	0.0093 (-0.019, 0.037)	0.0089 (-0.019, 0.037)	-0.0065 (-0.024, 0.011)	-0.0062 (-0.023, 0.011)	0.023 (-0.0050, 0.050)	0.022 (-0.0054, 0.050)
Unemployment Rate	0.080 (-0.052, 0.21)	0.082 (-0.052, 0.22)	0.0073 (-0.057, 0.072)	0.0059 (-0.056, 0.068)	0.070 (-0.061, 0.20)	0.073 (-0.061, 0.21)
Constant	-2.18* (-3.88, -0.47)	-2.17* (-3.87, -0.46)	-0.50 (-1.65, 0.65)	-0.50 (-1.65, 0.64)	-3.52*** (-5.29, -1.76)	-3.51*** (-5.27, -1.75)
Number of State-Quarter Observations	3528	3528	3528	3528	3528	3528

	0.58	0.58	0.66	0.66	0.64	0.64
Overall R^2						

*$P < .05$, ***$P < .001$

Notes: Data were analyzed at state-quarter level. All regressions were also controlled for state indicators, year indicators, quarter indicators, and state-specific time trends. Standard Errors were clustered at state level. Florida and West Virginia were both excluded from this analysis.