ONLINE APPENDIX:

EFFECTS OF OPIOID-RELATED POLICIES ON OPIOID UTILIZATION, NATURE OF MEDICAL CARE, AND DURATION OF DISABILITY

Descriptive Figures by State

Figures A.1-A.5 provide graphical depictions of the evidence on how opioid prescribing changed in the states that adopted PDMPs (shorthand for must-access PDMPs) or limits on initial opioid prescriptions, relative to other states. These graphs are only descriptive. They do not account for other sources of changes in outcomes (including federal policies or regulations), nor do they lend themselves to precise estimation of the effects of the policy changes, or statistical inference (assessing whether the changes associated with policies are statistically significant). Perhaps even more important, they do not separately estimate the effects of one policy (e.g., PDMPs) controlling for the effects of the other policy (e.g., initial prescribing limits).

Panel A of Figure A.1 shows average MME for all claims, for the pre- and post-policy change period for each state that adopted a PDMP.[1] We also show a pair of bars averaging across the control states (labeled "Controls"), defining the pre- and post-periods based on the median month of the policy change for the states that adopted the policy. The states are ranked based on the change in opioid prescribing between these two periods (smallest to largest). Consistent with Figure 1 in the main paper, the graph shows MME per claim declining in all treated states, as well as in the control states where the policy did not change. The decrease in the control states may reflect the effect of federal regulations that are common across all states. For most of the states that adopted PDMPs, though, the decline was larger than in the control states that did not adopt PDMPs (the states to the right of the control states in the figure), suggesting that PDMPs reduced MME.[2]

Panel B shows similar evidence, but for limits on initial opioid prescriptions. Again, we see that MME per claim fell in all states that adopted these limits. But MME per claim also fell in the control states, and the decline in about one-half of the treated states was smaller than the decline in the control states, indicating a lack of clear evidence that limits on initial opioid prescriptions reduced MME for all claims.

Figure A.2 shows the same kind of analysis, but for the outcome of whether any opioids were prescribed. In Panel A, for the effects of PDMPs, we again see declines for all treated states and the control states, although the decline in most of the treated states was smaller than in the control states. In Panel B, for initial prescribing limits, there is again no clear evidence of a difference in the change in the outcome—in this case, any opioid prescribing—associated with adopting initial prescribing limits. All states show a decline, but the decline is smaller in most of the treated states than in the control states. Thus, there is little indication that must-access PDMPs or initial prescribing limits reduced the likelihood that opioids were prescribed.

Figure A.3 shows the number of opioid prescriptions, still for all claims. In Panel A, for the effects of PDMPs, we again see that the outcome declined for all states, with the decline smaller in most of the treated states than the control states. In Panel B, for initial prescribing limits, the decline is also smaller in most of the treated states. Thus, there is little indication that PDMPs or prescribing limits reduced the number of opioid prescriptions.

Figure A.4 turns to evidence on claims with opioids, in this case for MME. In Panel A, for the effects of PDMPs, there is rather clear evidence of larger declines in the treated states. Compared with the

[1] For the pre-policy period, we show information for injuries that occurred between 24 and 12 months prior to the policy implementation, to avoid showing estimates for claims with partial policy exposure.

[2] Cross-referencing with Table 1 in the main paper, one can also see that the states that were early adopters of must-access PDMPs tended to have larger declines in average MME, a result confirmed in the statistical analysis presented in this online appendix.

control states, the decline in MME per claim with opioids is larger for all treated states except one. In Panel B, for initial prescribing limits, there is some heterogeneity, but the decline is generally larger in the treated states. Thus, this evidence suggests that both policies may have reduced MME for claims with opioids.

Figure A.5 reports evidence for the number of opioid prescriptions for claims with opioids. In Panel A, for the effects of PDMPs, we see evidence that the decline was larger in most treated states than in the control states. In Panel B, for initial prescribing limits, we see a similar finding, so both panels suggest that the policies reduced the number of prescriptions for claims with opioids.

We next present similar figures for measures of problematic opioid prescribing. Panel A of Figure A.6 reports evidence for the proportion of claims with longer-term prescribing among claims with opioids. The graph shows that for most states, the decline in longer-term prescribing was larger in states that adopted PDMPs. Panel B shows similar evidence, but for limits on initial opioid prescriptions. We see no clear evidence that these initial limits affected longer-term prescribing. For initial prescribing limits, the change in the control states is roughly in the middle of the distribution of changes between the two periods.

Figure A.7 presents the evidence for the second measure of problematic use—more than 90 days of opioids prescribed. In Panel A, the decline in this problematic use measure is generally larger in the states that adopted PDMPs. In Panel B, for initial prescribing limits, the comparison between treated and control states also suggests that the decline tends to be larger in the treated states.

Figure A.8 presents the evidence for the third measure of problematic use—daily dose exceeding 120 mg. In Panel A, this measure fell more in states that adopted PDMPs, relative to the control states, although the evidence is fairly balanced as there are a number of treated states where this measure fell by less. In Panel B, there is less evidence that initial prescribing limits reduced this measure, as it actually increased in some treated states but fell in the control states—overall suggesting no clear evidence of an effect of initial prescribing limits.

Figures A.9-A.11 show similar information, but for all claims (and looking only at PDMPs). None of these figures paints a crystal clear picture. There were more treated states with larger declines in problematic use than in the control states, but in each case there were a number of states with smaller declines. This heterogeneity might give us some pause in drawing strong conclusions about the effects of PDMPs on problematic opioid prescribing for the set of all claims.

As just noted, these graphs are useful in providing evidence on how heterogeneous effects might be across states, which is relevant to the question of how meaningful an estimate of the "average" effect of an opioid prescription policy across states is. We read the preceding figures as indicating that there is not too much heterogeneity, although there are some exceptions that need to be kept in mind when interpreting our results in the main paper.

Timing of Other Policies

Table A.1 provides information for the other policies that we use in robustness checks of our analyses. We list information on whether states had treatment guidelines and whether those treatment guidelines were mandatory. In our robustness analysis, we include controls for mandatory treatment guidelines, mandatory treatment guidelines and/or utilization review for opioid prescriptions or chronic pain, and whether states introduced a mandatory drug formulary.

Duration of Initial Prescriptions Before and After Implementation of Days of Supply Limits

Since overall prescribing per claim is not the immediate target of policies limiting initial opioid prescriptions, it is informative to consider changes in the measure most directly targeted by limits on initial opioid prescriptions—the number of days of supply for the first opioid prescription after an injury. Figure A.12 shows the percentage of initial opioid prescriptions that were above the days of supply limits before and after the limits were implemented, ranked by the days of supply limits (3, 4, 5, 7, 10, or 14

days of supply). For each state, we show the percentage of first opioid prescriptions that were for more days than the limit set in the regulations. A higher bar means that more prescriptions had days supplied beyond the limit. We find that limits on initial opioid prescriptions were likely to affect a sizable number of prescriptions in most states, although the effect varies across states—the states that imposed shorter days' supply limits had a higher percentage of prescriptions that would be affected by such limits. Consider Florida, Kentucky, and Wisconsin, which adopted the most stringent (3 days) limits (see Table 1 in the main paper). In these states, more than 60 percent of opioid prescriptions were for more than 3 days. In states with a 7 days of supply limit, between 25 and 52 percent of prescriptions prior to the policy implementation were for more than 7 days of supply. In the two analysis states with 10 or 14 days of supply limits (Tennessee and Nevada), only about 10 percent of prescriptions were above that limit, suggesting that days of supply limits above 10 or 14 days are likely to affect only a small number of prescriptions.

The figure also shows that prescriptions above the limit were common before the limits were introduced and remained common after the effective date of the regulations. This likely reflects exceptions to the limits discussed in the main text. At the same time, the policy does appear to have had an effect—the percentage of prescriptions above the limit decreased. In most states, the decrease in the percentage of prescriptions above the limit was greater than in the control states.

Robustness Checks

We conducted a number of robustness checks and estimated a number of alternative specifications to verify that our main conclusions hold up under reasonable alternative ways to alter our statistical models, which they do. Many of those estimates are presented in Tables A.2-A.4 (along with the original estimates from the main paper). We summarize our robustness analyses here.

Sensitivity to changing partial policy exposure weights

In our main specification, we estimate effects of the policies using one way of capturing the gradual increase in policy exposure depending on timing of the injury relative to when the policy became effective. Here, we consider an alternative approach, computing the partial exposure weights or values from data on the timing of opioid prescriptions. We estimate the percentage of prescriptions that were exposed to the policy if the policy was implemented in each of the quarters within a year after an injury, and use those values to indicate partial implementation (using the data on pre-treatment observations). We find that 53 percent of prescriptions were subject to the policy when the policy was in effect for 3 out of the 4 quarters after an injury, 30 percent when the policy was in effect for 2 out of the 4 quarters after an injury, and 14 percent when the policy was in effect for 1 out of the 4 quarters postinjury. Estimates using these weights, rather than 75, 50, and 25 percent, are provided in column (2) of Tables A.2-A.4. (In either case, the weight is 1 (100 percent) when the policy was in effect for all 4 quarters.) The estimates are very similar to the estimates from the main specification, which are repeated in column (1) of Tables A.2-A.4.

Estimates using 6 months of maturity data

Shifting to using data at 6 months of maturity allows us to extend the injury dates that we include by 6 months through September 2018 (with the latest evaluation date of March 21, 2019), and to explore sensitivity of the results to a different window. This allows us to observe the full implementation of the policies for a few more states that adopted must-access PDMPs and limits on initial opioid prescriptions between April and September 2018. Estimates that use 6-month maturity data are presented in column (3) of Tables A.2-A.4. For most measures, the implied percentage change effects are very similar to what we find in our main specification (the absolute effects are smaller, as we would expect from the shorter maturity). Note that we do not estimate models for longer-term opioid prescribing in the 6-month maturity data since this measure is defined using 12 months of postinjury experience.

Estimates that exclude California

Thumula et al. (2019) documented that California had one of the largest decreases in opioid utilization between 2012 and 2016 for claims at 24 months of maturity. The authors attribute this change to the strengthening of the independent medical review (IMR) process for resolution of medical disputes, and the California Workers' Compensation Institute (CWCI) estimated that about one-third of the pharmaceutical IMRs were about opioids (David and Bullis, 2019). Columns (4) and (5) of Tables A.2-A.4 provide estimates that exclude California from the analysis to see if the results are sensitive to an exclusion of a large state that represents 20 percent of the workers' compensation benefits paid in the country. We find that some of the estimates that we present in our main analysis are sensitive to whether we exclude California, and we find that estimates are less precise when the samples include California. However, our main findings are unchanged, although we find stronger effects of PDMPs on longer-term opioid prescribing for all claims.[3]

Estimates without controls for population weights

In our main specification, we use weights reflecting the number of claims with opioid prescriptions in each state. This gives a larger weight to more populous states and makes the estimates representative of workers (or their claims). As an alternative, we also present specifications that do not weight by number of prescriptions, giving each state an equal weight and making the estimates representative of states. These estimates are presented in column (6) of Tables A.2-A.4. Again, the estimates are robust.

Specifications that control for other policies

We performed a number of other analyses testing whether our results hold when we add more policy controls. Column (7) of Tables A.2-A.4 shows estimates for our main policy measures when we add controls for three other opioid-related policies: mandatory treatment guidelines, mandatory pain treatment guidelines, and drug formularies. The estimates for the main policies do not change much when we include additional policy controls.

In addition, in Panel A of Tables A.5 through A.7, we show the estimates for these additional policies. We generally find little evidence of effects of treatment guidelines and opioid treatment guidelines. While we find strong negative estimates for drug formularies, the data for this measure often do not satisfy the parallel trends assumption necessary to interpret the estimates as causal; when we look at the event-study graphs for this measure, we find substantial divergence in pre-policy trends between states that adopted this policy and states that did not. As an example, see Figure A.13 for the substantial divergence in pre-policy trends for drug formulary policy for MME for all claims.[4]

Heterogeneous effects by year of policy adoption

Panels B and C of Tables A.5-A.7 show estimates from specifications that allow the effects of policies to vary by year of policy adoption. Panel B shows results by year of adoption of PDMPs while Panel C shows results by year of adoption of limits of initial opioid prescription. For both policies, we find stronger effects in states that were the first ones to implement policies, and sometimes a different direction of the effect in more recent years. For example, we find that PDMPs introduced in 2012-2013

[3] We study the effects of must-access PDMPs but often refer to these as simply "PDMPs."
[4] The event-study graphs for other policy measures are available upon request.

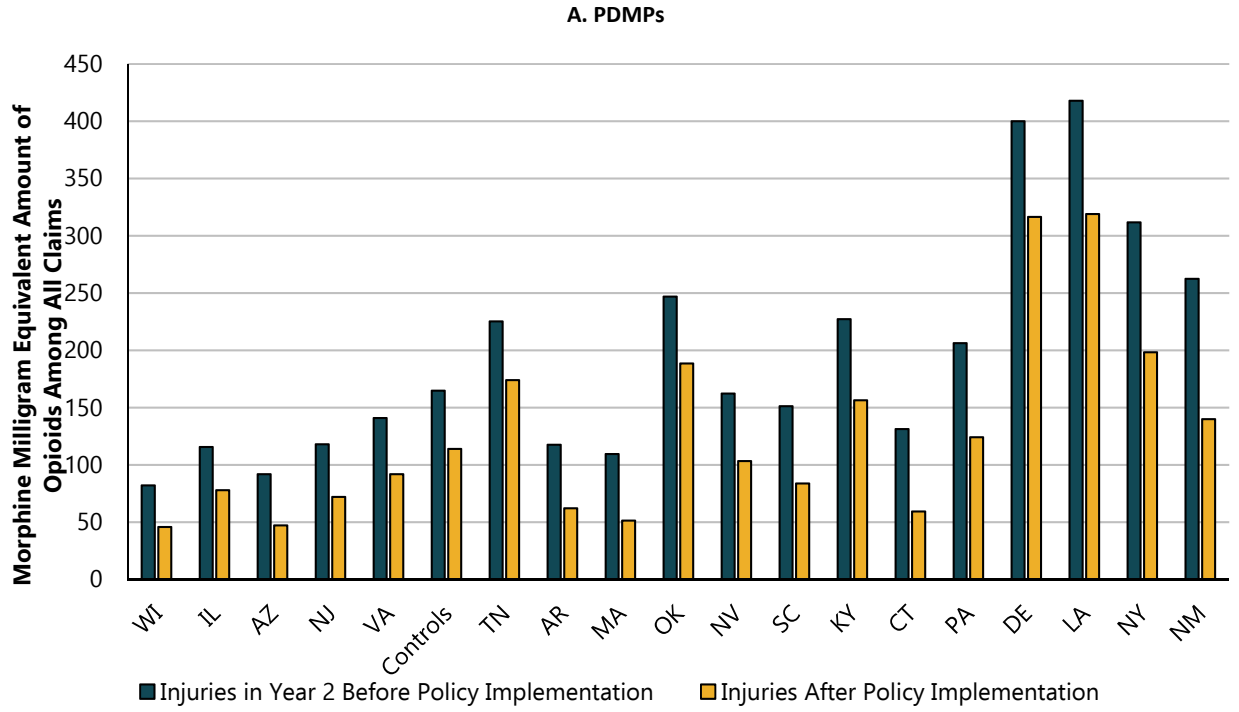
resulted in a 37 percent decrease in MME per claim for all claims,[5] while PDMPs implemented in 2014-2015 resulted in a 3 percent decrease in MME per claim for all claims, and PDMPs implemented in 2016-2018 resulted in an 8 percent increase in MME per claim for all claims. The estimates for claims with opioids are similar—26, 4, and 1 percent decreases, respectively. This is also consistent with the finding discussed for event studies that showed that estimates of policy effects strengthen as more time passes after policy implementation. This may also suggest that the states that were the first adopters had the biggest problems with opioid prescribing, which contributed to a bigger response to a policy change.

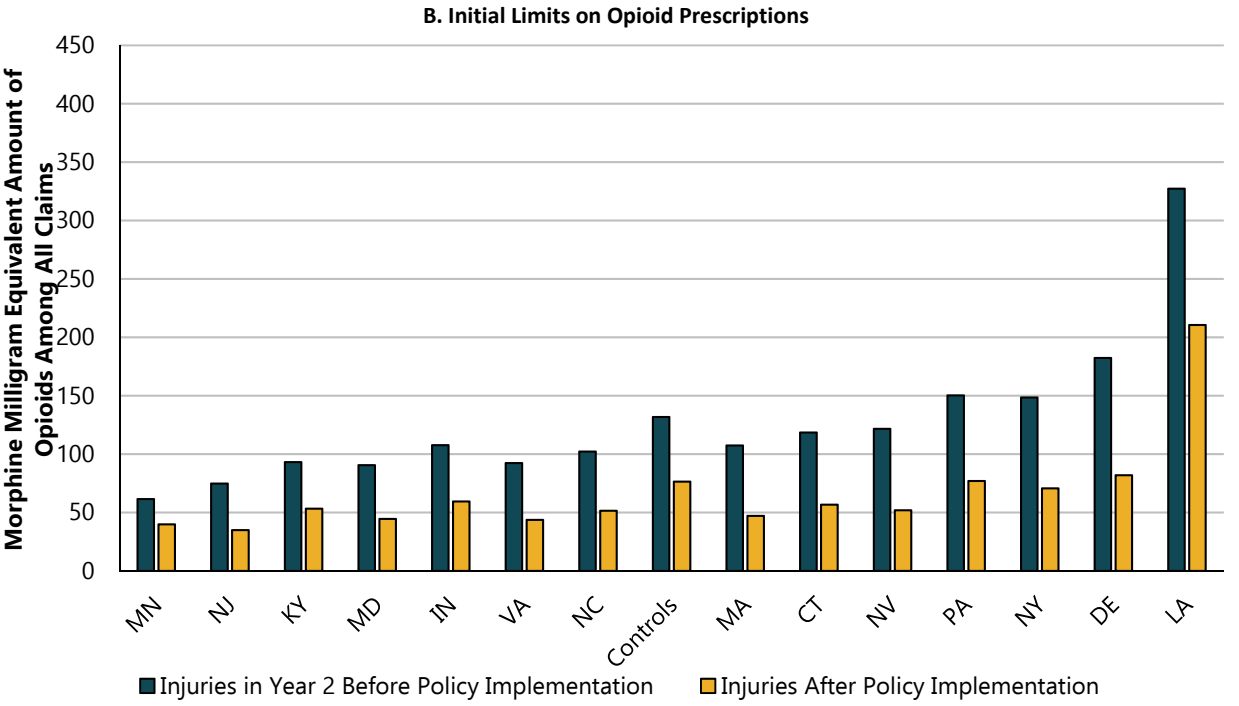
Robustness to leaving out one state at a time

We also verified that our estimates of the effects of PDMPs and initial prescribing limits on our measures of opioid utilization do not change substantially when we change the sample to exclude one state at a time. This suggests that our estimates are not driven by experience in a single state. Figures displaying these results are available upon request.

[5] We estimate this percentage effect by dividing the coefficient presented in Table A.5 by the mean of the dependent variable: 61.64/167.48 = 37 percent. The other percentage changes are estimated similarly.

Figure A.1 MME for All Claims

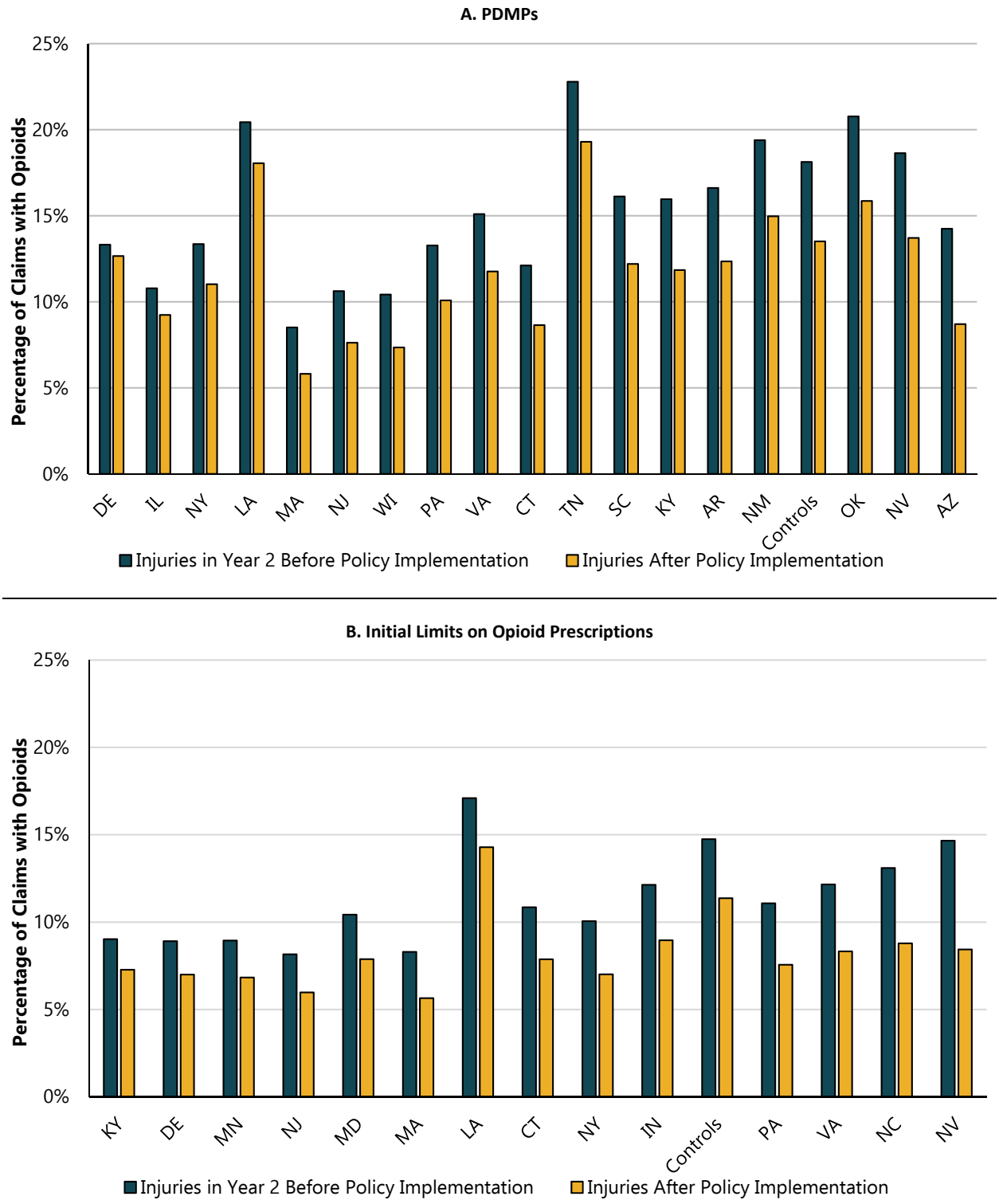




Notes: Average for claims at 12 months of maturity. We show measures for injuries that occurred in months 12 to 24 before policy implementation and for injuries that occurred within 12 months after policy implementation. For the control group, we use the median policy implementation month in the sample. States are sorted by change in measure from before to after policy implementation.

Key: MME: morphine milligram equivalent amount of opioids; PDMPs: must-access prescription drug monitoring programs.

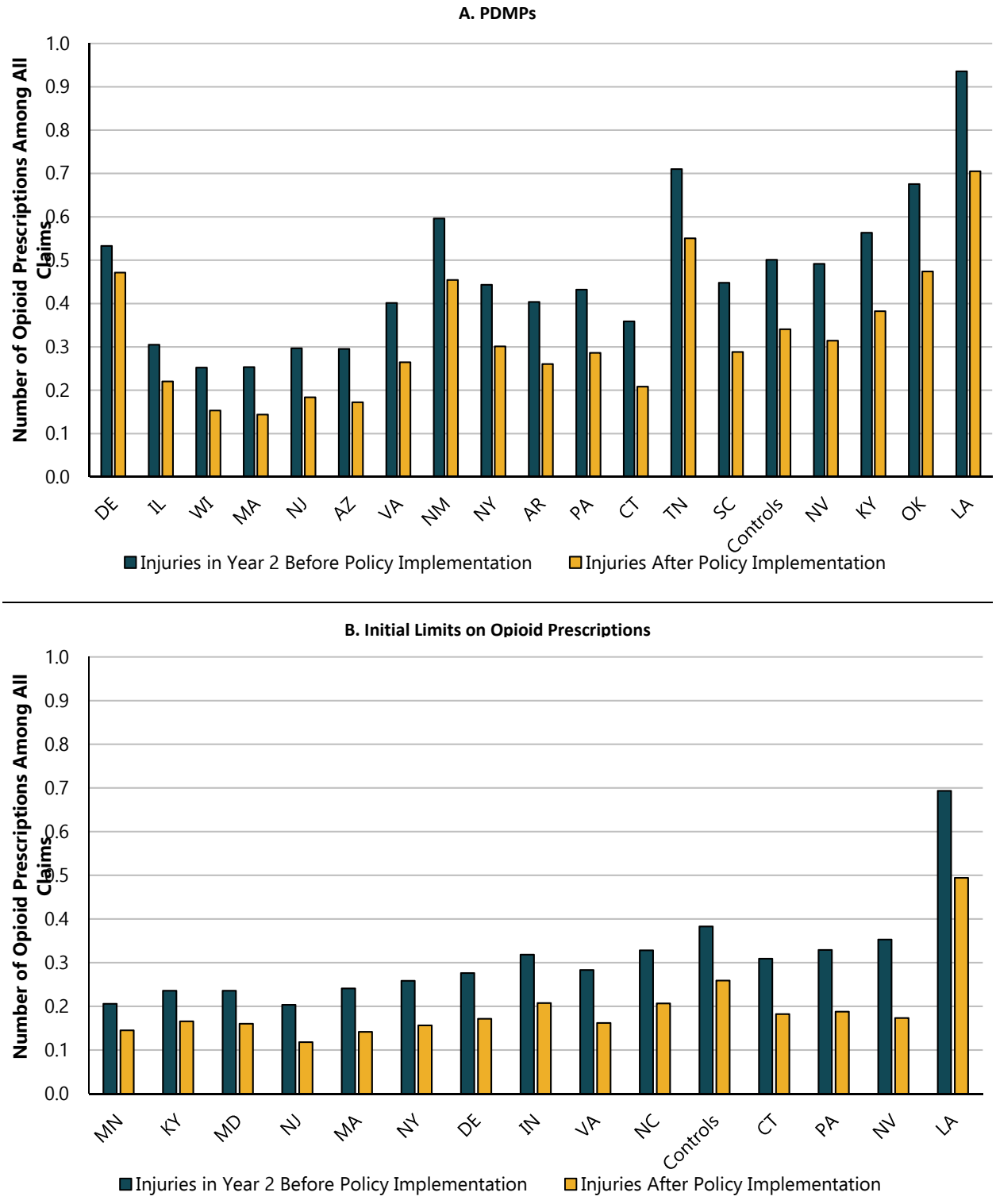
Figure A.2 Any Opioids (all claims)



Notes: Average for claims at 12 months of maturity. We show measures for injuries that occurred in months 12 to 24 before policy implementation and for injuries that occurred within 12 months after policy implementation. For the control group, we use the median policy implementation month in the sample. States are sorted by change in measure from before to after policy implementation.

Key: PDMPs: must-access prescription drug monitoring programs.

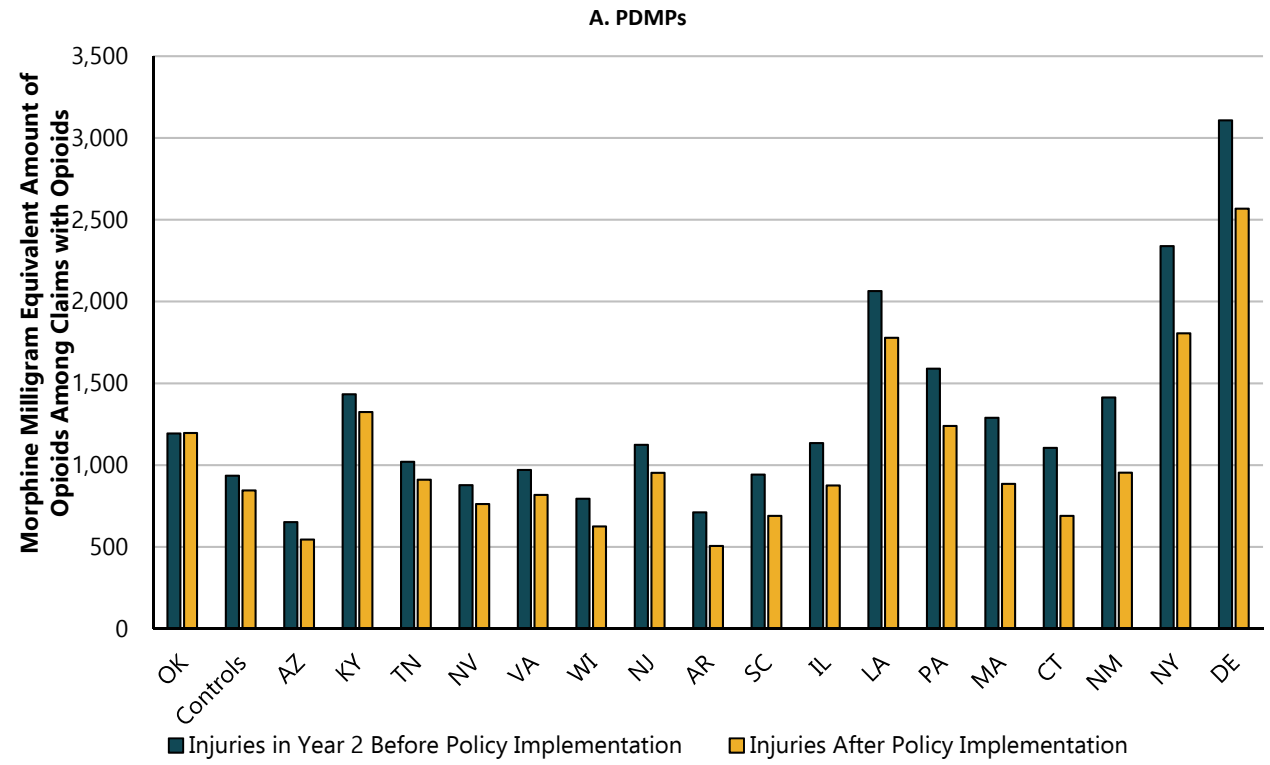
Figure A.3 Number of Opioid Prescriptions (all claims)

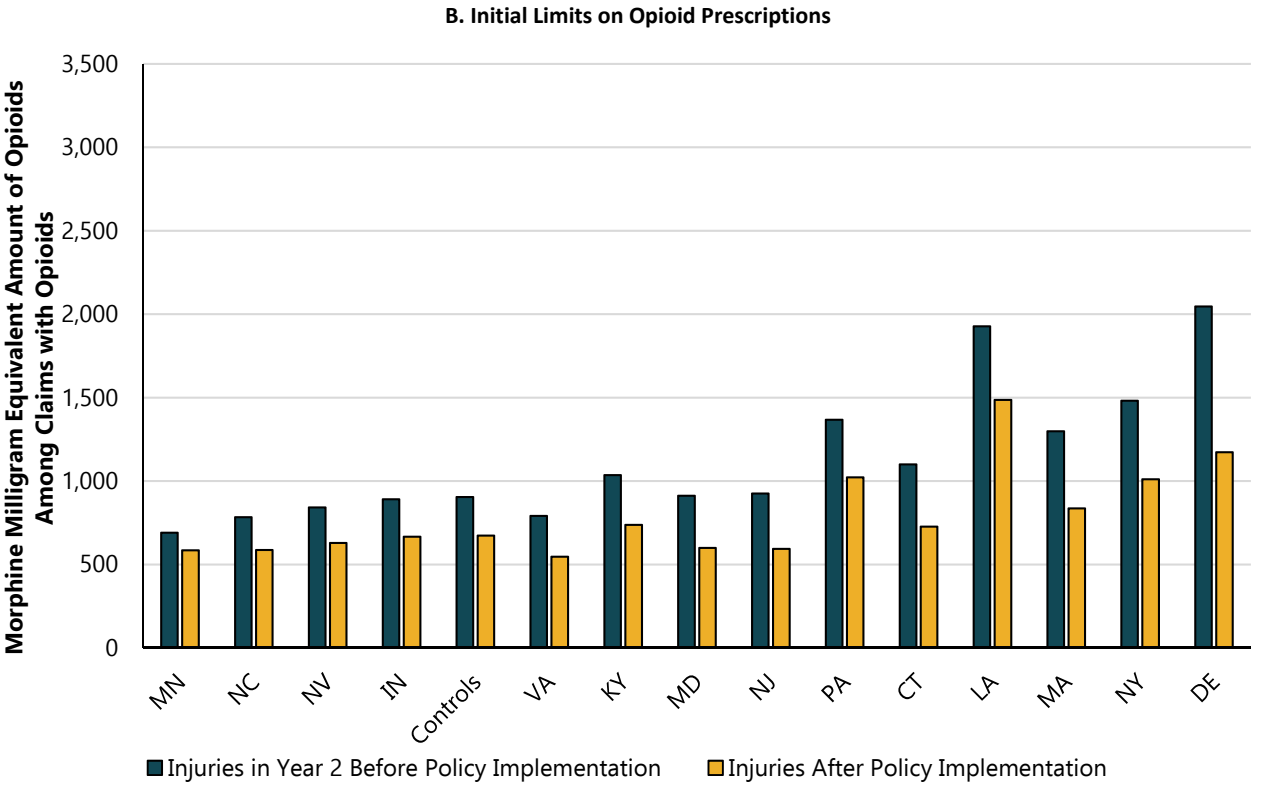


Notes: Average for claims at 12 months of maturity. We show measures for injuries that occurred in months 12 to 24 before policy implementation and for injuries that occurred within 12 months after policy implementation. For the control group, we use the median policy implementation month in the sample. States are sorted by change in measure from before to after policy implementation.

Key: PDMPs: must-access prescription drug monitoring programs.

Figure A.4 MME (claims with opioids)

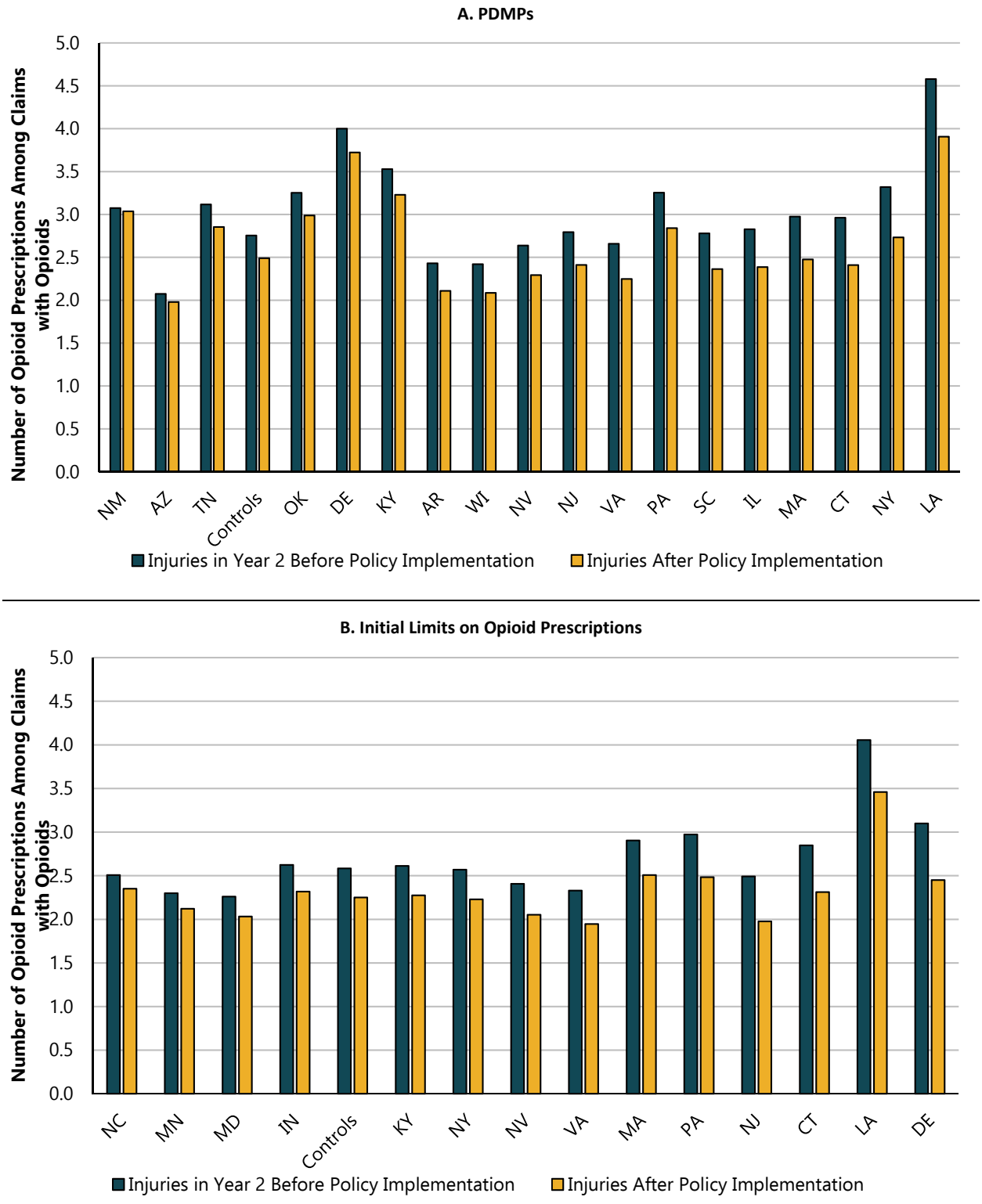




Notes: Average for claims at 12 months of maturity. We show measures for injuries that occurred in months 12 to 24 before policy implementation and for injuries that occurred within 12 months after policy implementation. For the control group, we use the median policy implementation month in the sample. States are sorted by change in measure from before to after policy implementation.

Key: MME: morphine milligram equivalent amount of opioids; PDMPs: must-access prescription drug monitoring programs.

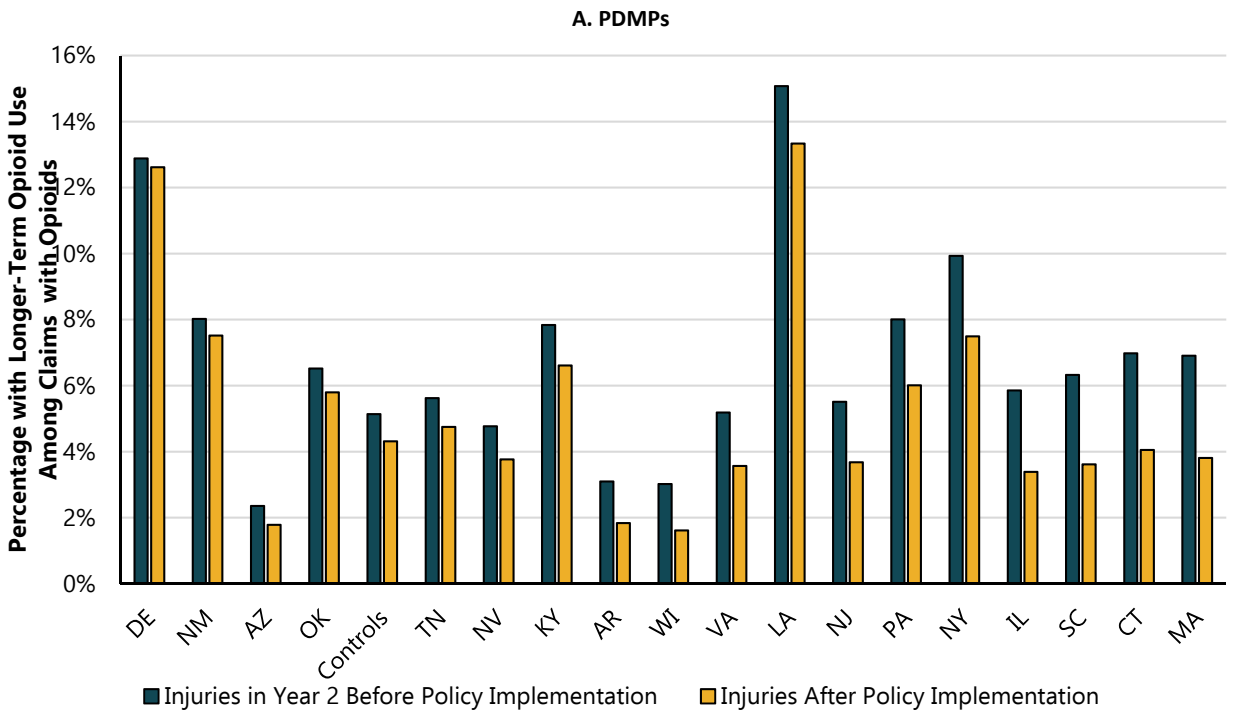
Figure A.5 Number of Opioid Prescriptions (claims with opioids)

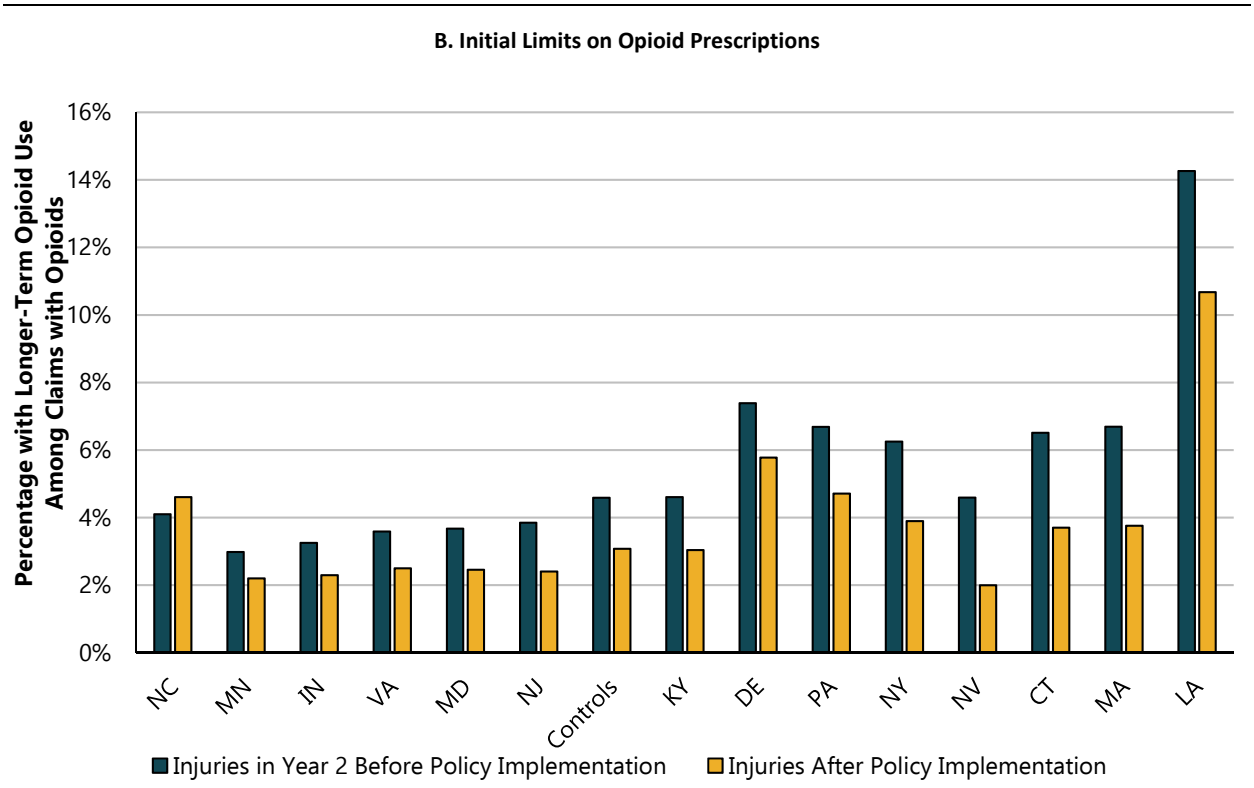


Notes: Average for claims at 12 months of maturity. We show measures for injuries that occurred in months 12 to 24 before policy implementation and for injuries that occurred within 12 months after policy implementation. For the control group, we use the median policy implementation month in the sample. States are sorted by change in measure from before to after policy implementation.

Key: PDMPs: must-access prescription drug monitoring programs.

Figure A.6 Longer-Term Opioid Prescribing (claims with opioids)

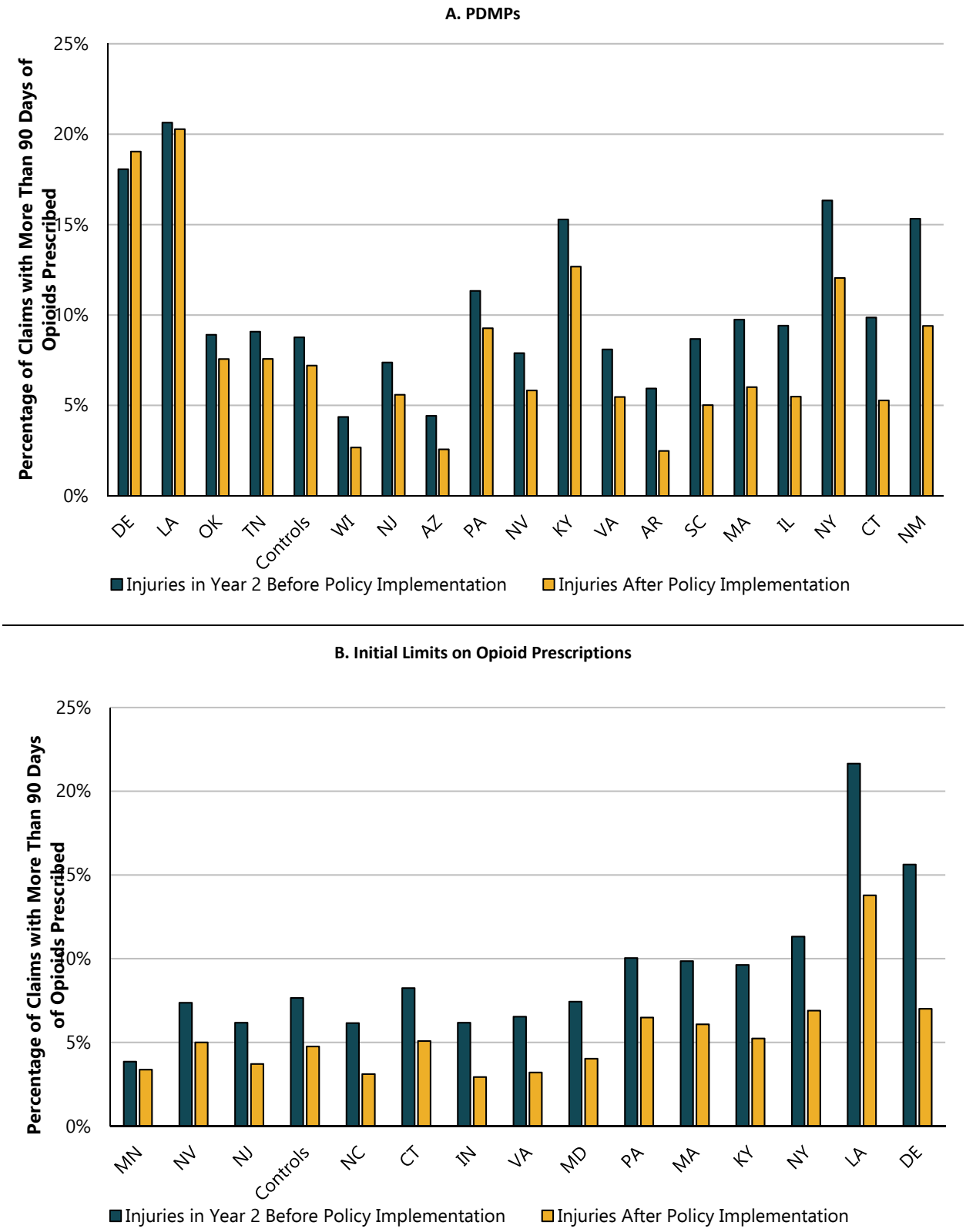




Notes: Average for claims at 12 months of maturity. We show measures for injuries that occurred in months 12 to 24 before policy implementation and for injuries that occurred within 12 months after policy implementation. For the control group, we use the median policy implementation month in the sample. States are sorted by change in measure from before to after policy implementation. Longer-term opioid prescriptions are defined as having prescriptions within the first three months after an injury and three or more filled opioid prescriptions between the 7th and 12th months after an injury.

Key: PDMPs: must-access prescription drug monitoring programs.

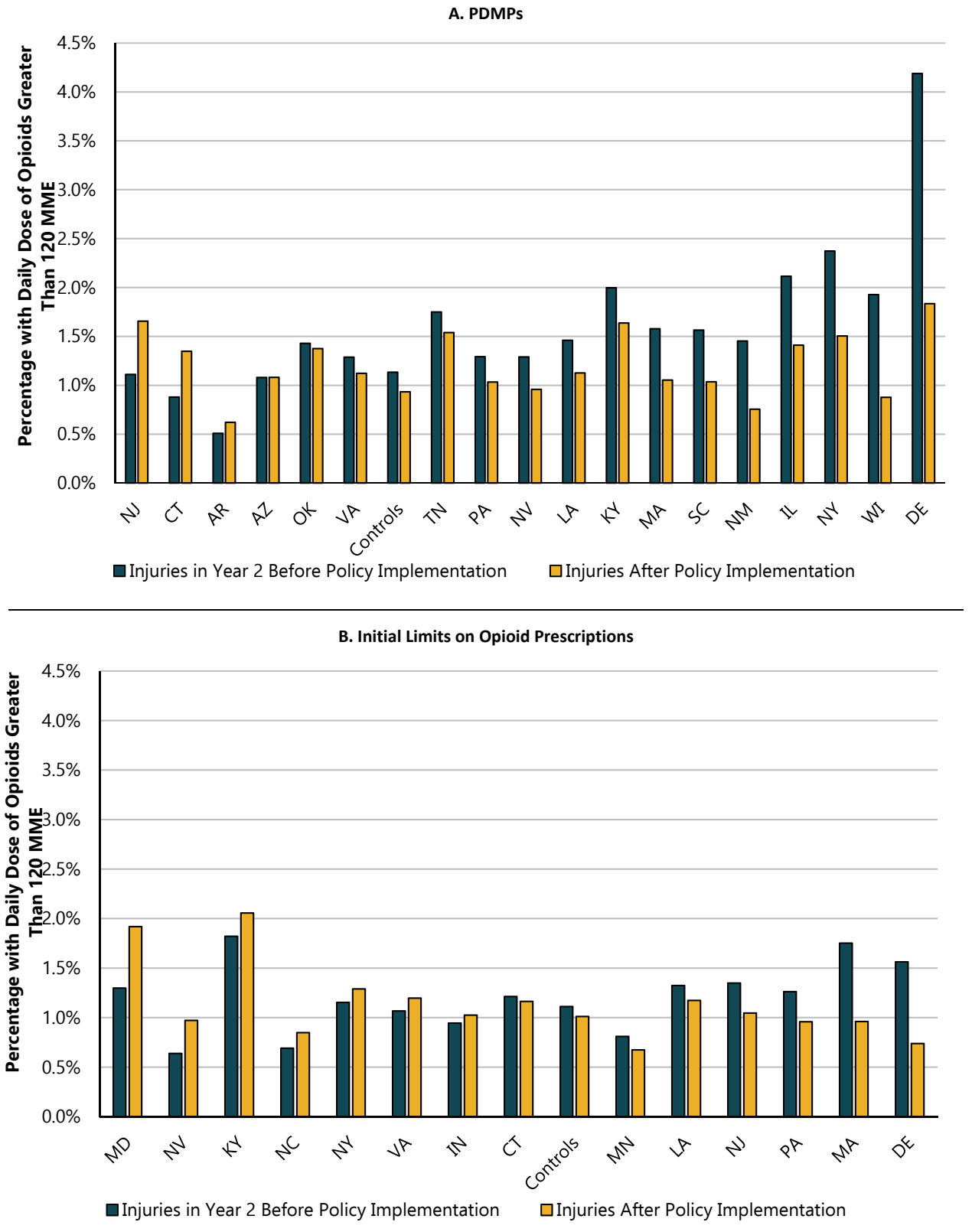
Figure A.7 More Than 90 Days of Opioids Prescribed (claims with opioids)



Notes: Average for claims at 12 months of maturity. We show measures for injuries that occurred in months 12 to 24 before policy implementation and for injuries that occurred within 12 months after policy implementation. For the control group, we use the median policy implementation month in the sample. States are sorted by change in measure from before to after policy implementation.

Key: PDMPs: must-access prescription drug monitoring programs.

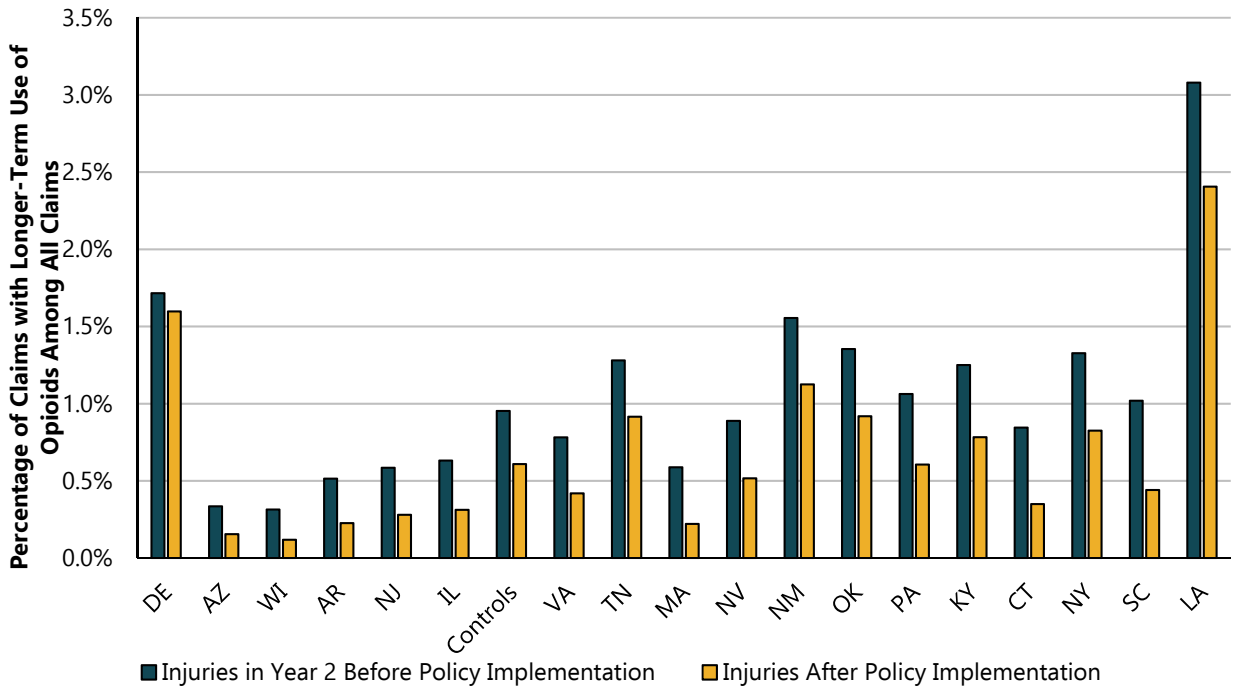
Figure A.8 Daily Doses Greater Than 120 mg (claims with opioids)



Notes: Average for claims at 12 months of maturity. We show measures for injuries that occurred in months 12 to 24 before policy implementation and for injuries that occurred within 12 months after policy implementation. For the control group, we use the median policy implementation month in the sample. States are sorted by change in measure from before to after policy implementation.

Key: MME: morphine milligram equivalent amount of opioids; PDMPs: must-access prescription drug monitoring programs.

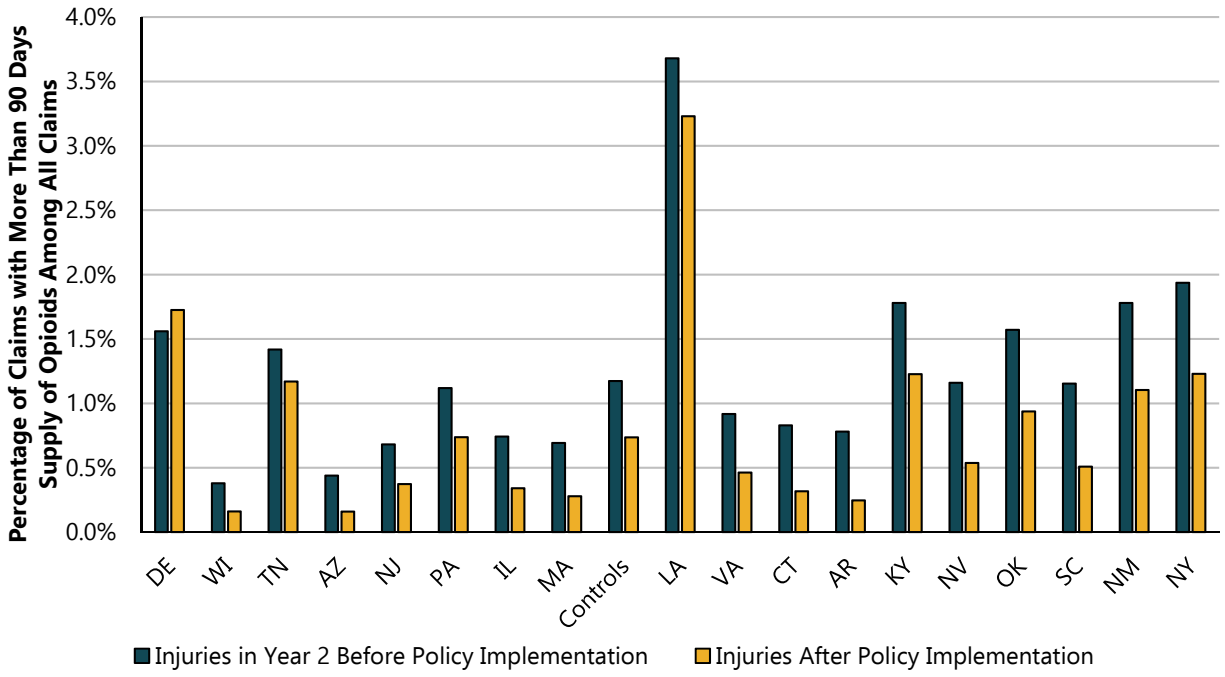
Figure A.9 Longer-Term Opioid Prescribing (all claims), PDMPs



Notes: Average for claims at 12 months of maturity. We show measures for injuries that occurred in months 12 to 24 before policy implementation and for injuries that occurred within 12 months after policy implementation. For control group, we use the median policy implementation month in the sample. States are sorted by change in measure from before to after policy implementation. Longer-term opioid prescriptions are defined as having prescriptions within the first three months after an injury and three or more filled opioid prescriptions between the 7th and 12th months after an injury.

Key: PDMPs: must-access prescription drug monitoring programs.

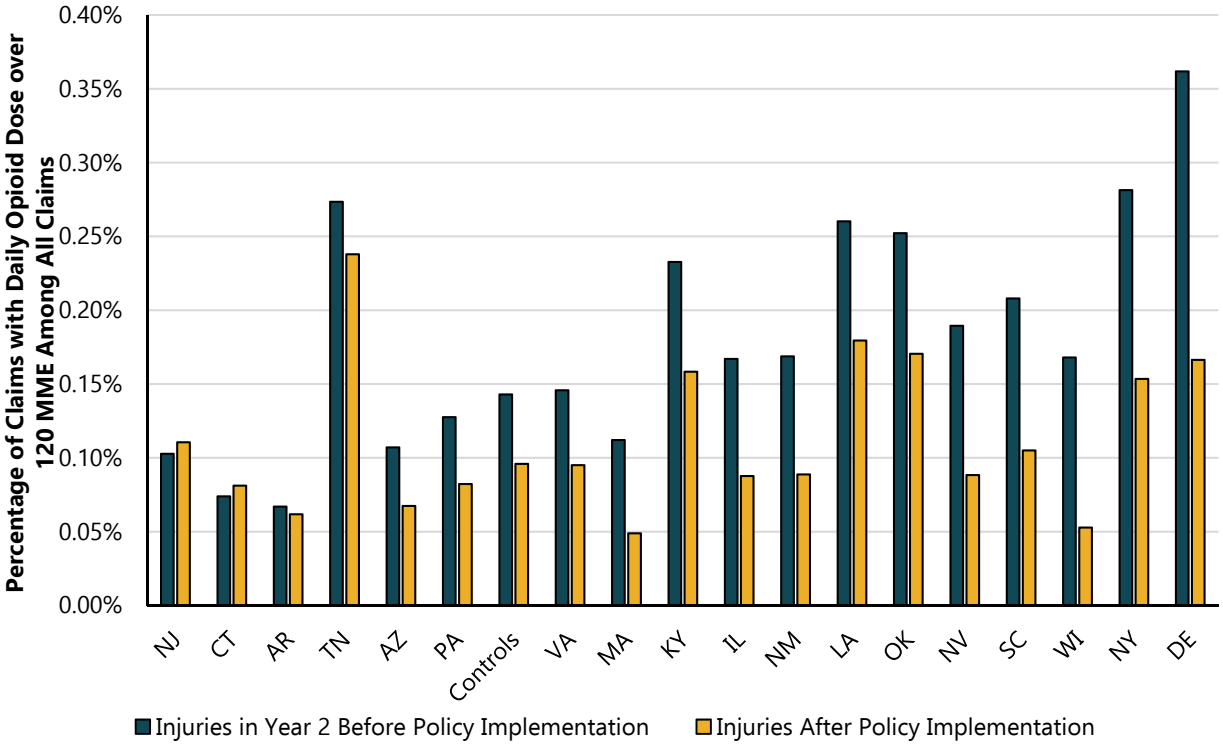
Figure A.10 More Than 90 Days of Opioids Prescribed (all claims), PDMPs



Notes: Average for claims at 12 months of maturity. We show measures for injuries that occurred in months 12 to 24 before policy implementation and for injuries that occurred within 12 months after policy implementation. For the control group, we use the median policy implementation month in the sample. States are sorted by change in measure from before to after policy implementation.

Key: PDMPs: must-access prescription drug monitoring programs.

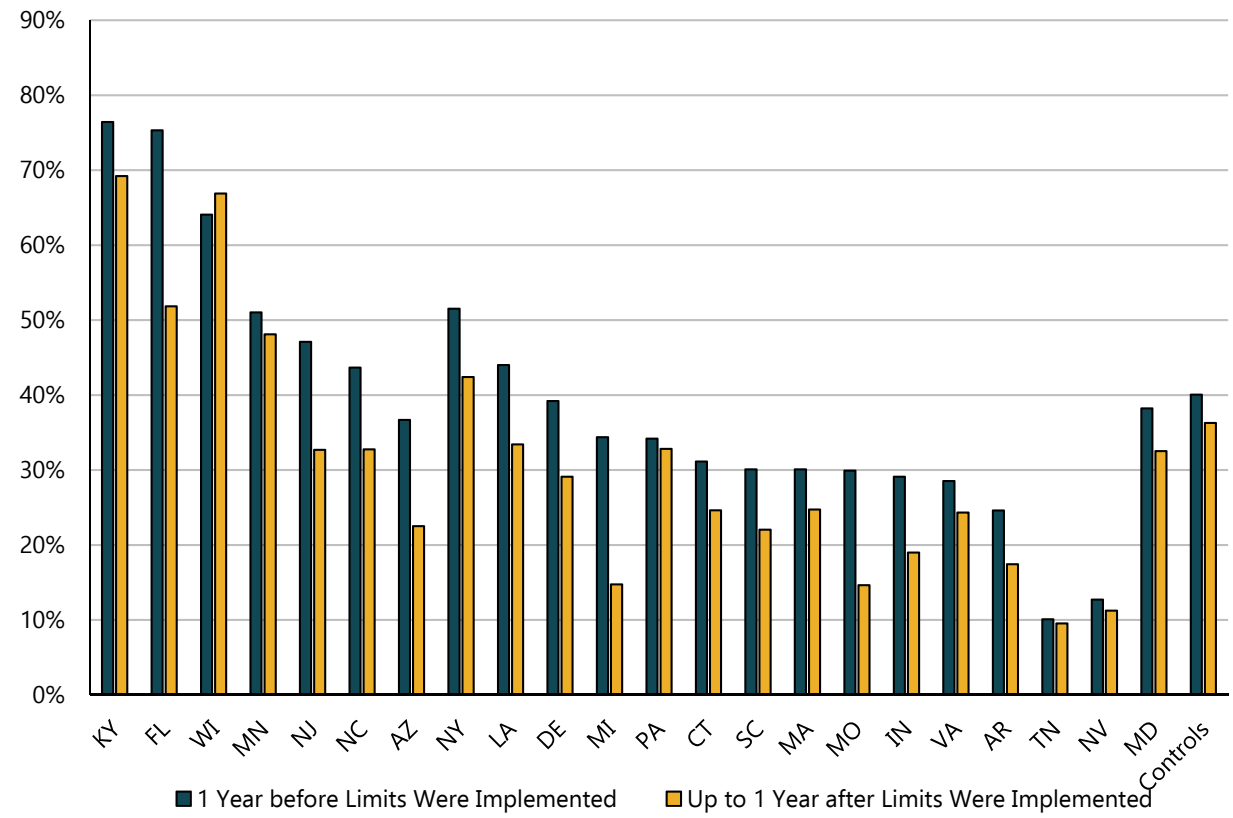
Figure A.11 Daily Doses Greater Than 120 mg (all claims), PDMPs



Notes: Average for claims at 12 months of maturity. We show measures for injuries that occurred in months 12 to 24 before policy implementation and for injuries that occurred within 12 months after policy implementation. For the control group, we use the median policy implementation month in the sample. States are sorted by change in measure from before to after policy implementation.

Key: MME: morphine milligram equivalent amount of opioids; PDMPs: must-access prescription drug monitoring programs.

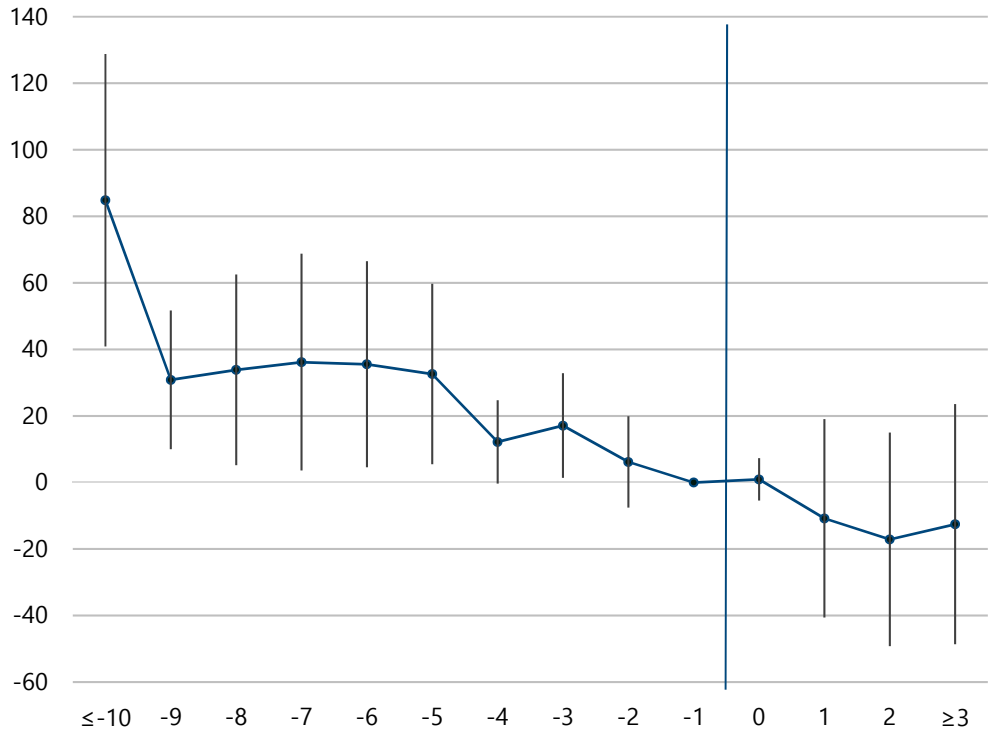
Figure A.12 Percentage of Initial Opioid Prescriptions Above Days of Supply Limit, by State



State	KY	FL	WI	MN	NJ	NC	AZ	NY	LA	DE	MI	PA	CT	SC	MA	MO	IN	VA	AR	TN	NV	MD	Controls
Limits on initial supply	3	3	3	4	5	5	5	7	7	7	7	7	7	7	7	7	7	7	7	10	14	N/A	N/A

Note: Sample includes initial opioid prescriptions filled one year before and up to one year after the limits on initial opioid prescriptions were implemented. In eight states (Arizona, Arkansas, Florida, Michigan, Missouri, South Carolina, Tennessee, and Wisconsin), we have less than one year of post-implementation data since the limits on initial opioid prescriptions were implemented after April 1, 2018. In Maryland, the law requires the lowest effective dose, without limiting the number of days supplied; for this state, we show the percentage of claims with more than seven days of supply of opioids. The states are ranked based on the days of supply limits for initial prescriptions. For the control state, we show the percentage of initial prescriptions with more than seven days of supply within one year before and after July 1, 2017.
Key: N/A: not applicable.

Figure A.13 Event-Study Regression for Drug Formularies for MME for All Claims



Notes: Average for claims at 12 months of maturity. We report estimates on quarterly leads and lags from date of implementation. The vertical lines indicate the beginning of the partial policy impact (quarter 0) and then the period when full impact begins (quarter 3). Ninety-five percent confidence intervals are shown as the vertical lines through the plotted points.
Key: MME: morphine milligram equivalent amount of opioids.

Table A.1 Effective Dates of Treatment Guidelines, Pain Treatment Guidelines, and Drug Formularies

State	Treatment Guidelines			Treatment Guides and/or Utilization Review for Opioid Prescriptions or Chronic Pain		Drug Formularies	
	Any Guideline?	Is It Mandatory?	Effective Date	Any Guideline?	Effective Date	Any Formulary?	Effective Date
Alabama	No	No		UR		No	
Arkansas	No	No		No		Yes	Jul 1, 2018
Arizona	Yes	Yes	Oct 1, 2018	Yes	Oct 1, 2016	Yes	Oct 1, 2018
California	Yes	Yes	Dec 1, 2004	Yes	Jul 18, 2009	Yes	Jan 1, 2018
Connecticut	Yes	No	Jan 1, 1996	Yes, no mandatory UR	Jul 1, 2012	No	
Delaware	Yes	No	May 23, 2008	Yes	May 23, 2008	Yes	Jan 4, 2013
Florida	Yes	Yes	Jan 1, 2003	No		No	
Georgia	No	No		No		No	
Hawaii	No	No		No		No	
Illinois	No	No				No	
Indiana	No	No		No		Yes	Jan 1, 2019
Iowa	No	No		No		No	
Kansas	Yes	No	Jan 1, 2008	Yes	Jan 1, 2008	No	
Kentucky	Yes	Yes	1996	No		Yes	Jul 1, 2019
Louisiana	Yes	Yes	Jul 13, 2011	Yes	Jul 13, 2011	No	
Maryland	No	No		No		No	
Massachusetts	Yes	No	1993	Yes	Jun 2016	No	
Michigan	No	No		No		No	
Minnesota	Yes	Yes	Jun 11, 2008	Yes	Jul 16, 2015	No	
Mississippi	No	No		Yes	Jun 14, 2017	No	
Missouri	No	No		No		No	
Nevada				Yes	1998	Yes, not mandatory	Jan 1, 2015
New Jersey	No	No		No		No	
New Mexico	Yes	No	Jul 1, 2013	No		No	
New York	Yes	Yes	Dec 1, 2010	Yes	Dec 15, 2014	Yes	Dec 5, 2019
North Carolina	No	No		Yes	May 1, 2018	No	
Oklahoma	Yes	No	Mar 1, 2012	Yes	Mar 1, 2012	Yes	Feb 1, 2014
Pennsylvania	No	No		Yes, not mandatory	Jul 16, 2018	No	
South Carolina	No	No		No		No	
Tennessee	Yes	Yes	Jan 1, 2016	Yes	Feb 28, 2016	Yes, but optional	Feb 28, 2016
Texas	Yes	Yes	May 1, 2007	Yes	May 1, 2007	Yes	Sep 1, 2011
Virginia	No	No		No		No	
Wisconsin	No	No		No		No	

Note: Source of guidelines information is Wang et al. (2019, Chapter 4) and Rothkin (2018, Tables 9 and 10).
Key: UR: utilization review.

Table A.2 Alternative Specifications for Our Preferred Estimates in Table 2

Alternative Specifications	(1) Main Specification	(2) Partial Policy Exposure Based on Number of Prescriptions	(3) Specification Using 6 Months of Maturity Data	(4) Specification Excluding California	(5) Specification Excluding CA without Population Weights	(6) Specification without Population Weights	(7) Specification with Controls for Other Policies
A. MME for all claims							
Must-access PDMP	-18.9324*	-19.9325*	-6.7541	-26.4308***	-27.6001***	-25.4814***	-18.7138**
	(9.6042)	(9.8383)	(4.9222)	(8.3879)	(7.3012)	(7.7279)	(8.5603)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	167.5	167.5	101.6	166.7	170.9	171.0	167.5
% effect for PDMPs	-11%	-12%	-7%	-16%	-16%	-15%	-11%
B. Any opioids for all claims							
Must-access PDMP	0.0102	0.0103	0.0096	0.0022	-0.0026	-0.0006	0.0040
	(0.0076)	(0.0076)	(0.0069)	(0.0058)	(0.0054)	(0.0058)	(0.0064)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	0.2	0.2	0.1	0.2	0.2	0.2	0.2
% effect for PDMPs	6%	6%	7%	1%	-2%	0%	2%
C. Number of opioid prescriptions among all claims							
Must-access PDMP	0.0107	0.0106	0.0130	-0.0147	-0.0260	-0.0194	-0.0092
	(0.0239)	(0.0237)	(0.0164)	(0.0172)	(0.0172)	(0.0189)	(0.0206)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	0.5	0.5	0.3	0.4	0.5	0.5	0.5
% effect for PDMPs	2%	2%	4%	-3%	-6%	-4%	-2%
D. MME for claims with opioids							
Must-access PDMP	-131.1257***	-139.4607***	-61.6130**	-136.2057***	-120.7370***	-117.8070***	-122.0477***
	(47.3257)	(50.0434)	(23.0927)	(48.3782)	(37.4161)	(37.7056)	(39.6998)
Limits on initial opioid Rx	-203.1554***	-205.5581***	-99.8518***	-228.0317***	-180.1472***	-171.9636***	-186.3750***
	(67.9767)	(71.6092)	(23.1877)	(63.2968)	(59.4812)	(58.8492)	(47.4234)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	1069.0	1069.0	714.1	1099.1	1106.4	1099.3	1069.0
% effect for PDMPs	-12%	-13%	-9%	-12%	-11%	-11%	-11%
% effect for initial limits	-19%	-19%	-14%	-21%	-16%	-16%	-17%
E. Number of opioid prescriptions among claims with opioids							
Must-access PDMP	-0.1531***	-0.1579***	-0.0936***	-0.1663***	-0.1315***	-0.1262***	-0.1461***
	(0.0361)	(0.0356)	(0.0181)	(0.0338)	(0.0280)	(0.0292)	(0.0338)
Limits on initial opioid Rx	-0.0555	-0.0512	-0.0242	-0.1131***	-0.0941**	-0.0759*	-0.0573
	(0.0556)	(0.0547)	(0.0245)	(0.0393)	(0.0427)	(0.0444)	(0.0551)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	2.8	2.8	2.3	2.9	2.9	2.8	2.8
% effect for PDMPs	-5%	-6%	-4%	-6%	-5%	-4%	-5%
% effect for initial limits	-2%	-2%	-1%	-4%	-3%	-3%	-2%

Notes: Estimates from state-level regressions for claims at 12 months of maturity (except column (3)), for injuries occurring October 2009–March 2018. Samples includes all claims, claims with opioids, or claims with more than seven days of lost work time (as indicated) aggregated to quarter of injury and state. Each observation is weighted by the number of claims represented. Controls are included for industry composition, average county-level unemployment rate, average county-level median household income, average county-level percentage disabled, and average county-level percentage without health insurance. We also control for state and quarter fixed effects.

*, **, *** Statistically significant at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are clustered by state. To account for partial exposure for injuries for which the policy changed during the 12 months the data capture, we define the variable denoting the policy change as 1 if it was in effect for all 12 months of the postinjury exposure, 0.75 if it was in effect for 3 of the 4 quarters of postinjury exposure, 0.5 if it was in effect for 2 of the 4 quarters of postinjury exposure, and 0.25 if it was in effect for the last quarter of the 4 quarters of postinjury exposure. (The definition is different in column (2), as explained in the text.)

Key: MME: morphine milligram equivalent amount of opioids; PDMP: must-access prescription drug monitoring program; Rx: prescription.

Table A.3 Alternative Specifications for Estimates in Table 4

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Alternative Specifications	**Main Specification**	**Partial Policy Exposure Based on Number of Prescriptions**	**Specification Using 6 Months of Maturity Data**	**Specification Excluding California**	**Specification Excluding CA without Population Weights**	**Specification without Population Weights**	**Specification with Controls for Other Policies**
A. Longer-term opioid prescribing among all claims							
Must-access PDMP	-0.0001	-0.0001		-0.0010**	-0.0010**	-0.0008	-0.0007
	(0.0007)	(0.0007)		(0.0004)	(0.0004)	(0.0005)	(0.0006)
Observations	1,118	1,118		1,084	1,084	1,118	1,118
Mean of outcome variable	0.0097	0.0097		0.0092	0.0094	0.0095	0.0097
% effect for PDMPs	-1%	-1%		-11%	-11%	-8%	-7%
B. More than 90 days of opioids prescribed among all claims							
Must-access PDMP	-0.0002	-0.0002	-0.0000	-0.0009	-0.0010	-0.0008	-0.0006
	(0.0009)	(0.0009)	(0.0005)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	0.0111	0.0111	0.0058	0.0107	0.0108	0.0108	0.0111
% effect for PDMPs	-2%	-2%	0%	-8%	-9%	-7%	-5%
C. Daily dose greater than 120 mg among all claims							
Must-access PDMP	-0.0002	-0.0002	-0.0000	-0.0002	-0.0001	-0.0001	-0.0002
	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	0.0017	0.0017	0.0016	0.0018	0.0018	0.0018	0.0017
% effect for PDMPs	-12%	-12%	0%	-11%	-6%	-6%	-12%
D. Longer-term opioid prescribing among claims with opioids							
Must-access PDMP	-0.0070***	-0.0070***		-0.0080***	-0.0063***	-0.0058***	-0.0070***
	(0.0021)	(0.0021)		(0.0020)	(0.0020)	(0.0020)	(0.0020)
Limits on initial opioid Rx	-0.0009	-0.0010		-0.0055*	-0.0046*	-0.0029	-0.0006
	(0.0047)	(0.0049)		(0.0031)	(0.0026)	(0.0031)	(0.0043)
Observations	1,118	1,118		1,084	1,084	1,118	1,118
Mean of outcome variable	0.0601	0.0601		0.0590	0.0575	0.0575	0.0601
% effect for PDMPs	-12%	-12%		-14%	-11%	-10%	-12%
% effect for initial limits	-1%	-2%		-9%	-8%	-5%	-1%
E. More than 90 days of opioids prescribed among claims with opioids							
Must-access PDMP	-0.0046	-0.0046	-0.0032	-0.0074	-0.0033	-0.0021	-0.0048
	(0.0046)	(0.0046)	(0.0029)	(0.0044)	(0.0050)	(0.0051)	(0.0043)
Limits on initial opioid Rx	0.0005	0.0000	0.0001	-0.0089**	-0.0109*	-0.0074	0.0007
	(0.0076)	(0.0078)	(0.0029)	(0.0039)	(0.0054)	(0.0062)	(0.0071)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	0.1011	0.1011	0.0587	0.0939	0.0912	0.0921	0.1011
% effect for PDMPs	-5%	-5%	-5%	-8%	-4%	-2%	-5%
% effect for initial limits	0%	0%	0%	-9%	-12%	-8%	1%
F. Daily dose greater than 120 mg among claims with opioids							
Must-access PDMP	-0.0006	-0.0007	0.0007	-0.0006	-0.0002	-0.0002	-0.0010
	(0.0012)	(0.0012)	(0.0011)	(0.0013)	(0.0009)	(0.0009)	(0.0012)
Limits on initial opioid Rx	-0.0005	-0.0004	-0.0014	-0.0007	0.0008	0.0008	-0.0004
	(0.0012)	(0.0013)	(0.0011)	(0.0013)	(0.0019)	(0.0019)	(0.0011)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	0.0159	0.0159	0.0162	0.0159	0.0153	0.0153	0.0159
% effect for PDMPs	-4%	-4%	4%	-4%	-1%	-1%	-6%
% effect for initial limits	-3%	-3%	-9%	-4%	5%	5%	-3%

Notes: Estimates from state-level regressions for claims at 12 months of maturity (except column (3)), for injuries occurring October 2009–March 2018. Samples include all claims, claims with opioids, or claims with more than seven days of lost work time (as indicated) aggregated to quarter of injury and state. Each observation is weighted by the number of claims represented. Longer-term opioid prescriptions are defined as having prescriptions within the first three months after an injury and three or more filled opioid prescriptions between the 7th and 12th months after an injury. Controls are included for industry composition, average county-level unemployment rate, average county-level median household income, average county-level percentage disabled, and average county-level percentage without health insurance. We also control for state and quarter fixed effects. *, **, *** Statistically significant at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are clustered by state. To account for partial exposure for injuries for which the policy changed during the 12 months the data capture, we define the variable denoting the policy change as 1 if it was in effect for all 12 months of the postinjury exposure, 0.75 if it was in effect for 3 of the 4 quarters of postinjury exposure, 0.5 if it was in effect for 2 of the 4 quarters of postinjury exposure, and 0.25 if it was in effect for the last quarter of the 4 quarters of postinjury exposure. (The definition is different in column (2), as explained in the text.)
Key: PDMP: must-access prescription drug monitoring program; Rx: prescription.

Table A.4 Alternative Specifications for Estimates in Table 7

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Alternative Specifications	**Main Specification**	**Partial Policy Exposure Based on Number of Prescriptions**	**Specification Using 6 Months of Maturity Data**	**Specification Excluding California**	**Specification Excluding CA without Population Weights**	**Specification without Population Weights**	**Specification with Controls for Other Policies**
A. Weeks of temporary disability payments among all claims							
Must-access PDMP	0.0622	0.0676	0.0353	0.0436	0.0091	0.0148	0.0114
	(0.0638)	(0.0646)	(0.0325)	(0.0628)	(0.0718)	(0.0714)	(0.0509)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	2.8300	2.8300	1.8349	2.6805	2.6395	2.6708	2.8300
% effect for PDMPs	2%	2%	2%	2%	0%	1%	0%
B. Weeks of temporary disability payments among claims with more than 7 days of lost time							
Must-access PDMP	0.1455	0.1673	0.0794	0.0748	0.0491	0.0676	0.0359
	(0.1605)	(0.1615)	(0.0721)	(0.1633)	(0.1653)	(0.1625)	(0.1611)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	13.3415	13.3415	9.1871	12.8909	12.6983	12.7857	13.3415
% effect for PDMPs	1%	1%	1%	1%	0%	1%	0%
C. Claims with more than 7 days of lost work time among all claims							
Must-access PDMP	0.0013	0.0014	0.0014	0.0011	-0.0015	-0.0014	-0.0009
	(0.0029)	(0.0030)	(0.0026)	(0.0030)	(0.0033)	(0.0033)	(0.0022)
Observations	1,118	1,118	1,184	1,084	1,084	1,118	1,118
Mean of outcome variable	0.2115	0.2115	0.1988	0.2075	0.2037	0.2046	0.2115
% effect for PDMPs	1%	1%	1%	1%	-1%	-1%	0%

Notes: Estimates from state-level regressions for claims at 12 months of maturity (except in column (3)), for injuries occurring October 2009–March 2018. Samples include all claims, claims with opioids, or claims with more than seven days of lost work time (as indicated) aggregated to quarter of injury and state. Each observation is weighted by the number of claims represented. Controls are included for industry composition, average county-level unemployment rate, average county-level median household income, average county-level percentage disabled, and average county-level percentage without health insurance. We also control for state and quarter fixed effects. *, **, *** Statistically significant at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are clustered by state. To account for partial exposure for injuries for which the policy changed during the 12 months the data capture, we define the variable denoting the policy change as 1 if it was in effect for all 12 months of the postinjury exposure, 0.75 if it was in effect for 3 of the 4 quarters of postinjury exposure, 0.5 if it was in effect for 2 of the 4 quarters of postinjury exposure, and 0.25 if it was in effect for the last quarter of the 4 quarters of postinjury exposure. (The definition is different in column (2), as explained in the text.)

Key: PDMP: must-access prescription drug monitoring program.

Table A.5 Specifications with Additional Controls for Preferred Specifications in Table 2

	(1)	(2)	(3)	(4)	(5)
Outcome	**MME**	**Any Opioids**	**Number of Opioid Prescriptions**	**MME**	**Number of Opioid Prescriptions**
Sample	**All Claims**	**All Claims**	**All Claims**	**Claims with Opioids**	**Claims with Opioids**
A. Specifications with controls for other policies					
Must-access PDMP	-17.6218*	0.0091	0.0075	-122.0477***	-0.1461***
	(8.7960)	(0.0074)	(0.0229)	(39.6998)	(0.0338)
Limits on initial opioid Rx				-186.3750***	-0.0573
				(47.4234)	(0.0551)
Opioid treatment guidelines	-12.2263	0.0114	0.0337	-110.8029	-0.0306
	(18.1062)	(0.0094)	(0.0334)	(92.2759)	(0.0707)
Treatment guidelines	1.2952	-0.0109*	-0.0377*	49.6674	-0.0204
	(12.4744)	(0.0060)	(0.0208)	(61.9138)	(0.0653)
Drug formulary	-31.6755**	-0.0094	-0.0566	-63.3542**	-0.0745
	(15.4570)	(0.0154)	(0.0552)	(28.2738)	(0.0496)
Observations	1,118	1,118	1,118	1,118	1,118
Mean of outcome variable	167.48	0.161	0.460	1,069.00	2.85
B. Effects of must-access PDMPs by year of implementation					
Must-access PDMPs implemented in 2012–2013	-61.6351***	-0.0075	-0.0439	-274.7042*	-0.2243***
	(15.9740)	(0.0083)	(0.0263)	(138.8510)	(0.0726)
Must-access PDMPs implemented in 2014–2015	-5.4561	0.0175**	0.0261	-37.9700	-0.1257**
	(8.7476)	(0.0075)	(0.0260)	(48.8077)	(0.0552)
Must-access PDMPs implemented in 2016–2018	12.8660	0.0201	0.0548	-7.7418	-0.0453
	(12.0901)	(0.0122)	(0.0383)	(50.5397)	(0.0698)
Limits on initial opioid Rx				-231.3960***	-0.0638
				(73.2590)	(0.0589)
Observations	1,118	1,118	1,118	1,118	1,118
Mean of outcome variable	167.48	0.161	0.460	1,069.003	2.849
C. Effect of limits on initial opioid Rx by year of implementation					
Must-access PDMP				-124.4286**	-0.1503***
				(48.3440)	(0.0363)
Limits on initial opioid Rx implemented in 2016				-410.8691***	-0.1446**
				(137.8188)	(0.0657)
Limits on initial opioid Rx implemented in 2017–2018				-91.1106*	-0.0075
				(47.7725)	(0.0643)
Observations				1,118	1,118
Mean of outcome variable				1,069.00	2.85

Notes: Estimates from state-level regressions for claims at 12 months of maturity, for injuries occurring October 2009–March 2018. Samples include all claims or claims with opioids (as indicated) aggregated to quarter of injury and state. Each observation is weighted by the number of claims represented. Controls are included for industry composition, average county-level unemployment rate, average county-level median household income, average county-level percentage disabled, and average county-level percentage without health insurance. We also control for state and quarter fixed effects. *, **, *** Statistically significant at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are clustered by state. To account for partial exposure for injuries for which the policy changed during the 12 months the data capture, we define the variable denoting the policy change as 1 if it was in effect for all 12 months of the postinjury exposure, 0.75 if it was in effect for 3 of the 4 quarters of postinjury exposure, 0.5 if it was in effect for 2 of the 4 quarters of postinjury exposure, and 0.25 if it was in effect for the last quarter of the 4 quarters of postinjury exposure.
Key: MME: morphine milligram equivalent amount of opioids; PDMP: must-access prescription drug monitoring program; Rx: prescription.

Table A.6 Specifications with Additional Controls for Preferred Specifications in Table 4

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome	**Longer-Term Opioid Prescribing**	**More Than 90 Days of Opioids Prescribed**	**Daily Dose Greater Than 120 mg**	**Longer-Term Opioid Prescribing**	**More Than 90 Days of Opioids Prescribed**	**Daily Dose Greater Than 120 mg**
Sample	**All Claims**	**All Claims**	**All Claims**	**Claims with Opioids**	**Claims with Opioids**	**Claims with Opioids**
A. Specifications with controls for other policies						
Must-access PDMP	-0.0002	-0.0003	-0.0002	-0.0070***	-0.0048	-0.0010
	(0.0007)	(0.0009)	(0.0002)	(0.0020)	(0.0043)	(0.0012)
Limits on initial opioid Rx				-0.0006	0.0007	-0.0004
				(0.0043)	(0.0071)	(0.0011)
Opioid treatment guidelines	0.0009	0.0006	-0.0002	-0.0021	-0.0000	-0.0020
	(0.0011)	(0.0014)	(0.0002)	(0.0045)	(0.0088)	(0.0022)
Treatment guidelines	-0.0003	-0.0013	0.0003	0.0019	0.0020	0.0054***
	(0.0009)	(0.0011)	(0.0003)	(0.0032)	(0.0062)	(0.0019)
Drug formulary	-0.0018	-0.0033***	-0.0023***	-0.0029*	0.0012	-0.0066***
	(0.0014)	(0.0011)	(0.0006)	(0.0015)	(0.0022)	(0.0014)
Observations	1,118	1,118	1,118	1,118	1,118	1,118
Mean of outcome variable	0.010	0.011	0.002	0.060	0.101	0.016
B. Effects of must-access PDMPs by year of implementation						
Must-access PDMPs implemented in 2012–2013	-0.0019***	-0.0038***	-0.0002	-0.0132***	-0.0213***	0.0001
	(0.0007)	(0.0008)	(0.0004)	(0.0045)	(0.0068)	(0.0027)
Must-access PDMPs implemented in 2014–2015	0.0003	0.0013	-0.0001	-0.0033	0.0070*	-0.0005
	(0.0007)	(0.0008)	(0.0003)	(0.0029)	(0.0038)	(0.0015)
Must-access PDMPs implemented in 2016–2018	0.0016	0.0018	-0.0003	-0.0009	0.0080	-0.0027
	(0.0014)	(0.0013)	(0.0003)	(0.0048)	(0.0087)	(0.0020)
Limits on initial opioid Rx				-0.0020	-0.0030	-0.0006
				(0.0049)	(0.0075)	(0.0014)
Observations	1,118	1,118	1,118	1,118	1,118	1,118
Mean of outcome variable	0.010	0.011	0.002	0.060	0.101	0.016
C. Effect of limits on initial opioid Rx by year of implementation						
Must-access PDMP				-0.0067***	-0.0041	-0.0006
				(0.0021)	(0.0046)	(0.0013)
Limits on initial opioid Rx implemented in 2016				-0.0118**	-0.0135	-0.0022
				(0.0052)	(0.0096)	(0.0021)
Limits on initial opioid Rx implemented in 2017–2018				0.0050	0.0080	0.0004
				(0.0044)	(0.0079)	(0.0015)
Observations				1,118	1,118	1,118
Mean of outcome variable				0.060	0.101	0.016

Notes: Estimates from state-level regressions for claims at 12 months of maturity, for injuries occurring October 2009–March 2018. Samples include all claims or claims with opioids (as indicated) aggregated to quarter of injury and state. Each observation is weighted by the number of claims represented. Longer-term opioid prescriptions are defined as having prescriptions within the first three months after an injury and three or more filled opioid prescriptions between the 7th and 12th months after an injury. Controls are included for industry composition, average county-level unemployment rate, average county-level median household income, average county-level percentage disabled, and average county-level percentage without health insurance. We also control for state and quarter fixed effects. *, **, *** Statistically significant at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are clustered by state. To account for partial exposure for injuries for which the policy changed during the 12 months the data capture, we define the variable denoting the policy change as 1 if it was in effect for all 12 months of the postinjury exposure, 0.75 if it was in effect for 3 of the 4 quarters of postinjury exposure, 0.5 if it was in effect for 2 of the 4 quarters of postinjury exposure, and 0.25 if it was in effect for the last quarter of the 4 quarters of postinjury exposure.

Key: PDMP: must-access prescription drug monitoring program; Rx: prescription.

Table A.7 Specifications with Additional Controls for Preferred Specifications in Table 7

	(1)	(2)	(3)
Outcome	**Weeks of Temporary Disability Payments**	**Weeks of Temporary Disability Payments**	**Claims with More Than 7 Days of Lost Work Time**
Sample	**Claims with More Than 7 Days of Lost Work Time**	**All Claims**	**All Claims**
A. Specifications with controls for other policies			
Must-access PDMP	0.1351	0.0498	0.0004
	(0.1502)	(0.0519)	(0.0023)
Opioid treatment guidelines	0.0784	0.1791***	0.0114***
	(0.1382)	(0.0634)	(0.0028)
Treatment guidelines	-0.1330	-0.2518***	-0.0147***
	(0.1121)	(0.0533)	(0.0035)
Drug formulary	-0.3457	-0.3008***	-0.0166***
	(0.3543)	(0.0679)	(0.0029)
Observations	1,118	1,118	1,118
Mean of outcome variable	13.34	2.83	0.21
B. Effects of must-access PDMPs by year of implementation			
Must-access PDMPs implemented in 2012–2013	0.1223	0.0534	0.0018
	(0.2048)	(0.0847)	(0.0052)
Must access PDMPs implemented in 2014–2015	0.0769	-0.0025	-0.0024
	(0.2551)	(0.0745)	(0.0032)
Must-access PDMPs implemented in 2016–2018	0.2836	0.2010	0.0079
	(0.1959)	(0.1187)	(0.0063)
Observations	1,118	1,118	1,118
Mean of outcome variable	13.34	2.830	0.212

Notes: Estimates from state-level regressions for claims at 12 months of maturity, for injuries occurring October 2009–March 2018. Samples include all claims or claims with more than seven days of lost work time (as indicated) aggregated to quarter of injury and state. Each observation is weighted by the number of claims represented. Controls are included for industry composition, average county-level unemployment rate, average county-level median household income, average county-level percentage disabled, and average county-level percentage without health insurance. We also control for state and quarter fixed effects. *, **, *** Statistically significant at the 10 percent, 5 percent, and 1 percent level, respectively. Standard errors are clustered by state. To account for partial exposure for injuries for which the policy changed during the 12 months the data capture, we define the variable denoting the policy change as 1 if it was in effect for all 12 months of the postinjury exposure, 0.75 if it was in effect for 3 of the 4 quarters of postinjury exposure, 0.5 if it was in effect for 2 of the 4 quarters of postinjury exposure, and 0.25 if it was in effect for the last quarter of the 4 quarters of postinjury exposure.
Key: PDMP: must-access prescription drug monitoring program.