

# Massachusetts' opioid limit law associated with a reduction in postoperative opioid duration among orthopedic patients

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## Abstract

Postoperative orthopedic patients are a high-risk group for receiving long-duration, large-dosage opioid prescriptions. Rigorous evaluation of state opioid duration limit laws, enacted throughout the country in response to the opioid overdose epidemic, is lacking among this high-risk group. We took advantage of Massachusetts' early implementation of a 2016 7-day-limit law that occurred before other statewide or plan-wide policies took effect and used commercial insurance claims from 2014–2017 to study its association with postoperative opioid prescriptions greater than 7 days' duration among Massachusetts orthopedic patients relative to a New Hampshire control group. Our sample included 14 097 commercially insured, opioid-naïve adults aged 18 years and older undergoing elective orthopedic procedures. We found that the Massachusetts 7-day limit was associated with an immediate 4.23 percentage point absolute reduction (95% CI, 8.12 to 0.33 percentage points) and a 33.27% relative reduction (95% CI, 55.36% to 11.19%) in the percentage of initial fills greater than 7 days in the Massachusetts relative to the control group. Seven-day-limit laws may be an important state-level tool to mitigate longer duration prescribing to high-risk postoperative populations.

**Key words:** orthopedic surgery; opioid prescribing limit law; post-operative opioid prescribing; interrupted times series; pharmacoepidemiology.

## Introduction

Nearly half of orthopedic surgeons prescribed opioids in 2019, the highest rate among surgeons.<sup>1–5</sup> Despite declining opioid prescription durations across surgical specialties, postoperative orthopedic patients have the highest likelihood of receiving prescriptions exceeding high-dosage thresholds, with nearly 6% filling opioid prescriptions at 6 months.<sup>3,6–8</sup> Orthopedic surgeries are painful due to their invasiveness and direct impact on postoperative mobility, a key part of postoperative recovery.<sup>9,10</sup> This patient population is therefore at short- and long-term risk of opioid overdose due to long prescription duration, high dosage, and unconsumed opioid pills.<sup>7,11–14</sup>

Concerns over the opioid overdose epidemic prompted a wave of state policies regulating opioid prescribing. Since 2016, 39 states have implemented duration or dosage laws, with 7-day limits being the most common.<sup>15,16</sup> The intended target of these policies are opioid-naïve patients with acute pain conditions, including postoperative pain. Massachusetts was the first state to implement a 7-day limit in March 2016 applicable to first-time opioids prescribed in the outpatient setting.<sup>17</sup> The law does not restrict dosage or pill count and

gives prescribers a professional judgment exception to prescribe longer durations if medically indicated.

Rigorous evaluation of these state laws' impact on postoperative orthopedic patients has been lacking. One analysis of the Massachusetts 7-day limit found a modest decrease in initial fills great than 7 days' duration among patients undergoing common surgeries.<sup>18</sup> However, only 2 of the 24 procedures were orthopedic, limiting the insight into its impact on postoperative orthopedic patients. In the absence of a control group, these findings are susceptible to bias from concurrent interventions and time-varying confounders.<sup>19,20</sup> Understanding the impact of duration limits on postoperative orthopedic patients, a high-risk group known for receiving long-duration opioid prescriptions, is especially important for state lawmakers looking for “balanced” policies that mitigate excessive prescribing to high-risk populations, given the Centers for Disease Control and Prevention's (CDC's) 2022 guidance that encourages a shift away from rigid opioid prescribing limits.<sup>21</sup>

By taking advantage of Massachusetts' early implementation, our study offers an invaluable policy evaluation opportunity that is less confounded by subsequent state- or plan-wide policies. This stands in comparison to other multi-state evaluations during the brief period of 2017–2019 when

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**Table 1.** Pre- and post-policy study group characteristics among opioid-naïve adults undergoing elective procedures.

Variable	Pre-policy		Std. diff.	Post-policy		Std. diff.
	New Hampshire ( <i>n</i> = 1377)	Massachusetts ( <i>n</i> = 7671)		New Hampshire ( <i>n</i> = 1061)	Massachusetts ( <i>n</i> = 3988)	
Age, mean (SD), y	51.69 (12.74)	52.72 (14.02)	−0.08	51.92 (13.08)	53.30 (14.21)	−0.10
Age group, No. (%)						
18–34 y	146 (10.6)	956 (12.5)	−0.06	133 (12.5)	484 (12.1)	0.01
35–44 y	174 (12.6)	829 (10.8)	0.06	108 (10.2)	381 (9.6)	0.02
45–54 y	399 (29.0)	1906 (24.9)	0.09	297 (28.0)	953 (23.9)	0.09
55–64 y	500 (36.3)	2578 (33.6)	0.06	403 (38.0)	1411 (35.4)	0.05
65–74 y	133 (9.7)	1191 (15.5)	−0.18	99 (9.3)	610 (15.3)	−0.18
75+ y	25 (1.8)	211 (2.8)	−0.06	21 (2)	149 (3.7)	−0.11
Male, No. (%)	700 (50.8)	3941 (51.4)	−0.01	517 (48.7)	1957 (49.1)	−0.01
Type of surgery, No. (%)						
TKA	139 (10.1)	924 (12.1)	−0.06	133 (12.5)	491 (12.3)	0.01
THA	109 (7.9)	659 (8.6)	−0.02	113 (10.7)	431 (10.8)	−0.01
Foot	150 (10.9)	840 (11)	0.00	108 (10.2)	460 (11.5)	−0.04
Hand	320 (23.2)	1782 (23.2)	0.00	232 (21.9)	884 (22.2)	−0.01
Knee arthroscopy	433 (31.5)	2207 (28.8)	0.06	315 (29.7)	1102 (27.6)	0.05
Shoulder	223 (16.2)	1238 (16.1)	0.00	160 (15.1)	620 (15.6)	−0.01
Medical and mental health conditions, No. (%)						
Fibromyalgia	49 (3.6)	387 (5.0)	−0.07	77 (7.3)	273 (6.8)	0.02
OA/RA	407 (29.6)	2369 (30.9)	−0.03	344 (32.4)	1337 (33.5)	−0.02
Anxiety	75 (5.4)	528 (6.9)	−0.06	82 (7.7)	341 (8.6)	−0.03
Depression	98 (7.1)	621 (8.1)	−0.04	76 (7.2)	374 (9.4)	−0.08
Drug-use disorder	4 (0.3)	35 (0.5)	−0.03	5 (0.5)	22 (0.6)	−0.01
PTSD	10 (0.7)	61 (0.8)	−0.01	8 (0.8)	38 (1)	−0.02
Schizophrenia	1 (0.1)	7 (0.1)	−0.01	1 (0.1)	7 (0.2)	−0.02
Tobacco use	39 (2.8)	150 (2.0)	0.06	39 (3.7)	104 (2.6)	0.06

Source: Authors' analysis of commercial claims data from a large regional health plan, 2014–2017. Note that medical and mental health conditions are not mutually exclusive and may not add up to 100%. There were no missing covariate data in either group.

Abbreviations: OA, osteoarthritis; PTSD, posttraumatic stress disorder; RA, rheumatoid arthritis; SD, standard deviation; Std. diff, standardized difference between the Massachusetts and New Hampshire groups; THA, total hip arthroplasty; TKA, total knee arthroplasty.

35 states followed suit and enacted similar laws, making it difficult to disentangle the effect of 1 state policy from another's.<sup>16</sup> Additionally, major health plans and pharmacy benefit managers during this period implemented various plan-wide opioid dispensing limits, making it even more challenging to tease out the state policy effect, especially those analyses using large-scale commercial health plan data.<sup>22–24</sup> We fill the gap of existing literature by capitalizing on Massachusetts' "first mover" position and constructing convincing counterfactuals (eg, clean pre- and post-policy windows and comparable control group). We focus on patients undergoing orthopedic procedures using a quasi-experimental design to assess the association between the Massachusetts 7-day limit and opioid prescribing. We hypothesized that a negative association exists between the 7-day limit and receiving prescriptions greater than 7 days' duration.

We explore spillover to patients recently prescribed opioids as a potential unintended policy consequence, a population considered exempt from the law but who may still experience reductions in opioid prescribing. We also explore whether differences in opioid prescribing arise by stratifying analyses into low-to-moderately painful and very painful procedures.

## Data and methods

### Data

We used medical and pharmacy claims data from a large regional health plan that provides commercial and Medicare Advantage plans to approximately 1 million members across 5 New England states. We used a repeated cross-sectional interrupted time series with a control series design from March

2014 to June 2017. The Massachusetts 7-day limit went into immediate effect on March 14, 2016. We included 24 pre-policy months (March 2014–February 2016) and 15 post-policy months (April 2016–June 2017). We considered March 2016 to be a phase-in month and excluded these data from analyses. Our study window ended in June 2017 because there was a health plan-wide opioid prescribing restriction affecting all commercial members effective July 1, 2017.

The health plan operates in Connecticut, Maine, Massachusetts, New Hampshire, and Rhode Island. We included New Hampshire as a control state to account for health plan and nationwide secular trends. New Hampshire had an adequate sample size, no concurrent opioid prescribing limit law affecting postoperative patients during this study period, and had similar patient demographics and surgeries performed (Table 1). Additionally, the health plan had a similar market share among employer-sponsored plans across both states.<sup>25,26</sup> Although Connecticut (7-day limit effective July 1, 2016), Maine (7-day limit effective January 1, 2017), and Rhode Island (30 morphine milligram equivalents [MME] daily dosage limit effective March 22, 2017) enacted opioid prescribing limit laws later in our study period, we did not include these given the small sample sizes and limited post-policy windows.<sup>16</sup> We identified opioid fills from pharmacy claims, which capture health plan-reimbursed prescription fills. We used National Drug Codes obtained from First Databank NDC database to identify Food and Drug Administration–approved opioid formulations for pain management.<sup>27</sup> We excluded opioids used for cough, headache, and the treatment of opioid use disorder. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting

guideline for cross-sectional studies. The study was approved by the Institutional Review Board of Harvard Pilgrim Health Care.

### Study population

We developed a rolling cohort of adults from Massachusetts and New Hampshire (a control state) aged 18 years and older undergoing orthopedic procedures during the study period. Patients were required to have an elective orthopedic procedure identified using Current Procedural Terminology (CPT) codes from medical claims, which capture health plan–reimbursed outpatient and inpatient encounters. We analyzed patients' first procedures only. We exclusively studied elective procedures to reduce heterogeneity of surgical indication and postoperative pain needs. [Appendix A1](#) and [Appendix A2](#) provide our procedure classification strategy and CPT procedure codes, respectively. Traumatic injuries or spine surgeries, for example, may require a high dosage and long duration of opioids that may be less sensitive to the 7-day-limit policy. Because the policy was intended for “first time” opioid prescriptions, we included only patients who were opioid-naive at the time of surgery, defined as having not filled an opioid from –180 days to –7 days before surgery. The beginning of the patient-level follow-up period was the date of surgery if the patient was not admitted to a hospital or the discharge date if the patient was admitted to a hospital. We included patients with at least 6 months of continuous preoperative enrollment to identify baseline covariates. We excluded those with procedures within 6 months after surgery to avoid misclassifying prescriptions intended for subsequent surgeries and with conditions either exempt from the Massachusetts 7-day limit or associated with long-term opioid use, including hospice/palliative care, sickle cell disease, or non-skin cancer diagnosis. [Appendix A1](#) and [Appendix A3](#) provide our exclusionary CPT procedure codes and exclusionary International Classification of Diseases, Ninth Revision (ICD-9), and International Classification of Diseases, Tenth Revision (ICD-10) codes, respectively. [To access the Appendix, click on the Details tab of the article online.]

### Measures

#### Outcomes

Our primary outcomes included the initial fill's days' supply and receipt of an initial fill greater than 7 days' duration. We defined the “initial” fill as the first opioid fill within 7 days of the follow-up period. If 2 or more prescriptions were eligible, we randomly selected 1 prescription as the initial fill. Our secondary outcomes to assess for changes in opioid prescribing included the receipt of any opioid prescription within the first 7 follow-up days, total MME for the initial fill, and daily MME for the initial fill. We calculated MME by multiplying the prescription's total dosage by a standard conversion factor.<sup>21</sup>

#### Key variables of interest

We created a binary indicator for study group and assigned a value of 1 for Massachusetts patients and 0 for New Hampshire patients. We created a binary indicator for level change, which we assigned a value of 1 for the post-policy period after March 2016 for both Massachusetts and New Hampshire patients and of 0 otherwise. We created a trend change variable that counts continuously from 0 beginning

in the first post-policy period month for Massachusetts and New Hampshire patients and assigned a value of 0 for April 2016, 1 for May 2016, 2 for June 2016, and so forth.

### Covariates

We identified patient age and sex. We used ICD-9 and ICD-10 codes used in previous studies assessing postoperative opioid prescribing to identify mental health conditions as well as chronic conditions that may be associated with pain or opioid use, including fibromyalgia, osteoarthritis/rheumatoid arthritis, tobacco use, and substance use disorder.<sup>18,28</sup> [Appendix A3](#) provides our covariate ICD-9 and ICD-10 codes. [To access the Appendix, click on the Details tab of the article online.]

### Statistical analysis

To identify covariate balance, we generated standardized differences to compare pre- and post-policy characteristics between groups and considered values between –0.2 and 0.2 to indicate well-balanced groups.<sup>29,30</sup> We generated time series of unadjusted mean monthly values to visualize outcome level and trend changes. We generated segmented multivariable regression models using generalized estimating equations (GEEs) with a Gaussian distribution and identity link for continuous outcomes, binomial distribution and identity link for binary outcomes, and robust variance estimates to test for post-policy level or trend changes among the Massachusetts group relative to the New Hampshire group.<sup>31,32</sup> Control group adjustment in time-series analyses can control for time-varying confounders and adjust for secular trends, such as the CDC Guideline for Prescribing Opioids for Chronic Pain released nationally in March of 2016.<sup>19,20</sup> Unlike difference-in-differences, comparative interrupted time series does not make assumptions about pre-policy parallel trends.<sup>19</sup> The interaction between study group and level change indicators estimates the immediate level change in the Massachusetts group relative to the New Hampshire group in the month after the policy compared with the month before. The interaction between study group and trend change estimates slope change from the pre- to post-policy period in the Massachusetts group relative to the New Hampshire group. Models were adjusted for key predictors of postoperative pain needs, including age, sex, history of arthritis, and total hip or knee arthroplasty.<sup>18,28</sup> We used a nonlinear combination of estimators (NLCOM) to calculate relative level changes in the month after the policy compared with the month before. We used NLCOM to calculate absolute and relative changes at the final post-policy month among the Massachusetts group relative to the Massachusetts group had there been no 7-day limit (the counterfactual).<sup>33,34</sup> [Appendix A4](#) provides details about our analytic approach and model specification. [To access the Appendix, click on the Details tab of the article online.]

We conducted secondary analyses among non-opioid-naive patients undergoing elective procedures to assess for a spillover effect. Although the law is intended for first-time opioid prescriptions in the outpatient setting, opioid prescribing to the non-opioid-naive patient may be affected by shifts in health system prescribing patterns or misinterpretation of the law.

We also conducted a secondary analysis among opioid-naive adults undergoing low-to-moderately painful orthopedic procedures to determine whether the 7-day limit was associated with a reduction in opioid prescribing. [Appendix A5](#)

provides definitions for these procedures. [To access the Appendix, click on the Details tab of the article online.]

We conducted sensitivity analyses on a broadened orthopedic sample to test the consistency and generalizability of our results among patients undergoing any orthopedic procedure, including elective, nonelective, and spine surgeries. For instance, patients with chronic pain from knee arthritis are more likely to report persistent pain following an elective knee replacement compared with those without chronic knee pain. Testing across this broadened cohort can assess if our findings are driven by characteristics of those undergoing elective procedures or prescribing practices of orthopedists performing elective procedures. Due to limited sample size and heterogeneity within the nonelective and spine cohorts, separate analyses were not possible, and these cohorts were combined with the elective cohort. Procedure type indicators were added to account for this.

We also conducted sensitivity analyses of our secondary analyses to assess for spillover effect among non-opioid-naive patients in the broadened cohort of patients undergoing elective, nonelective, and spine surgeries. Finally, we conducted a sensitivity analysis among opioid-naive adults undergoing highly painful orthopedic procedures (see [Appendix A5](#)). [To access the Appendix, click on the Details tab of the article online.] Clinicians performing more painful orthopedic procedures may be more likely to cite the 7-day-limit professional judgement exception allowing prescriptions longer than 7 days' duration. All analyses were performed using SAS version 9.4 (SAS Institute) and Stata 15.1 (StataCorp).

## Limitations

This study has several limitations. First, we cannot estimate a causal policy effect using observational data and can only identify associations with changes in postoperative opioid prescribing. However, we utilize a strong quasi-experimental design, demonstrate well-balanced groups across the pre- and post-policy periods, and control for important patient-level covariates. Second, although our study is limited to a single health plan covering commercial and Medicare Advantage patients across 2 states, our sample's age and sex closely resemble those of samples identified in a previous study using Medicaid data from 4 states and a study using national all-payer data.<sup>35,36</sup> Third, although we do assess spillover effects into patients previously prescribed opioids, we are underpowered to assess spillover effects among patients on long-term opioid therapy. Future analyses could evaluate postoperative prescribing among a subset of patients on chronic, long-term opioids. Fourth, unintended effects may occur through other mechanisms: a study identified opioid prescriptions filled by patients' spouses on the patient's day of surgery.<sup>37</sup> We cannot identify prescriptions filled by other family members, nor can we identify prescriptions that were covered by other forms of payment. Fifth, our findings are not applicable to states with different opioid prescribing limit features, such as those with dosage limitations or with limitations that extend beyond the initial opioid prescription. Analyzing opioid prescribing in states with such policies might provide insight into whether these features affect prescribing patterns in postoperative patients. Finally, we do not have data on publicly insured patients. Although 1 study identified reduced opioid prescribing among patients insured by Medicaid, future studies might focus on the publicly insured, postoperative orthopedic population to determine if these changes persist.<sup>38</sup>

## Results

### Descriptive statistics

Our final sample included 11 659 Massachusetts and 2438 New Hampshire opioid-naive patients. [Appendix A6](#) provides our study sample flow diagram. [To access the Appendix, click on the Details tab of the article online.] The Massachusetts and New Hampshire mean pre-policy ages were 52.72 and 51.69 years, and post-policy ages were 53.30 and 51.92 years, respectively ([Table 1](#)). Knee arthroscopies accounted for 28.8% and 27.6% of procedures in the Massachusetts pre- and post-policy periods and 31.5% and 29.7% in the New Hampshire pre- and post-policy periods, respectively. During the study period, 72.0% of patients filled an opioid prescription within 7 days, while 9.2% received an initial fill greater than 7 days. Mean durations of initial opioid prescriptions in Massachusetts before and after the policy were 3.75 and 3.36 days, respectively, and 3.71 and 3.57 days in New Hampshire, respectively.

### Policy association with opioid prescription outcomes

[Figure 1](#) shows plots of our primary outcomes and initial total MME generated from unadjusted segmented regression models. In the month following the Massachusetts 7-day limit, there was an immediate 4.23 percentage point absolute reduction (95% CI,  $-8.12$  to  $-0.33$  percentage points;  $P = .03$ ) and a 33.27% relative reduction (95% CI,  $-55.36\%$  to  $-11.19\%$ ;  $P = .003$ ) in the percentage of initial fills greater than 7 days in the Massachusetts relative to the New Hampshire group when adjusting for age, sex, and hip or knee total arthroplasty ([Table 2](#), row 2, columns 3 and 4). There were no absolute or relative changes in the percentage of initial fills greater than 7 days between the Massachusetts and the counterfactual group at the final post-policy month. [Appendix A7](#) describes these changes in row 2, columns 2 and 3, and [Appendix A8](#) describes regression results. [To access the Appendix, click on the Details tab of the article online.]

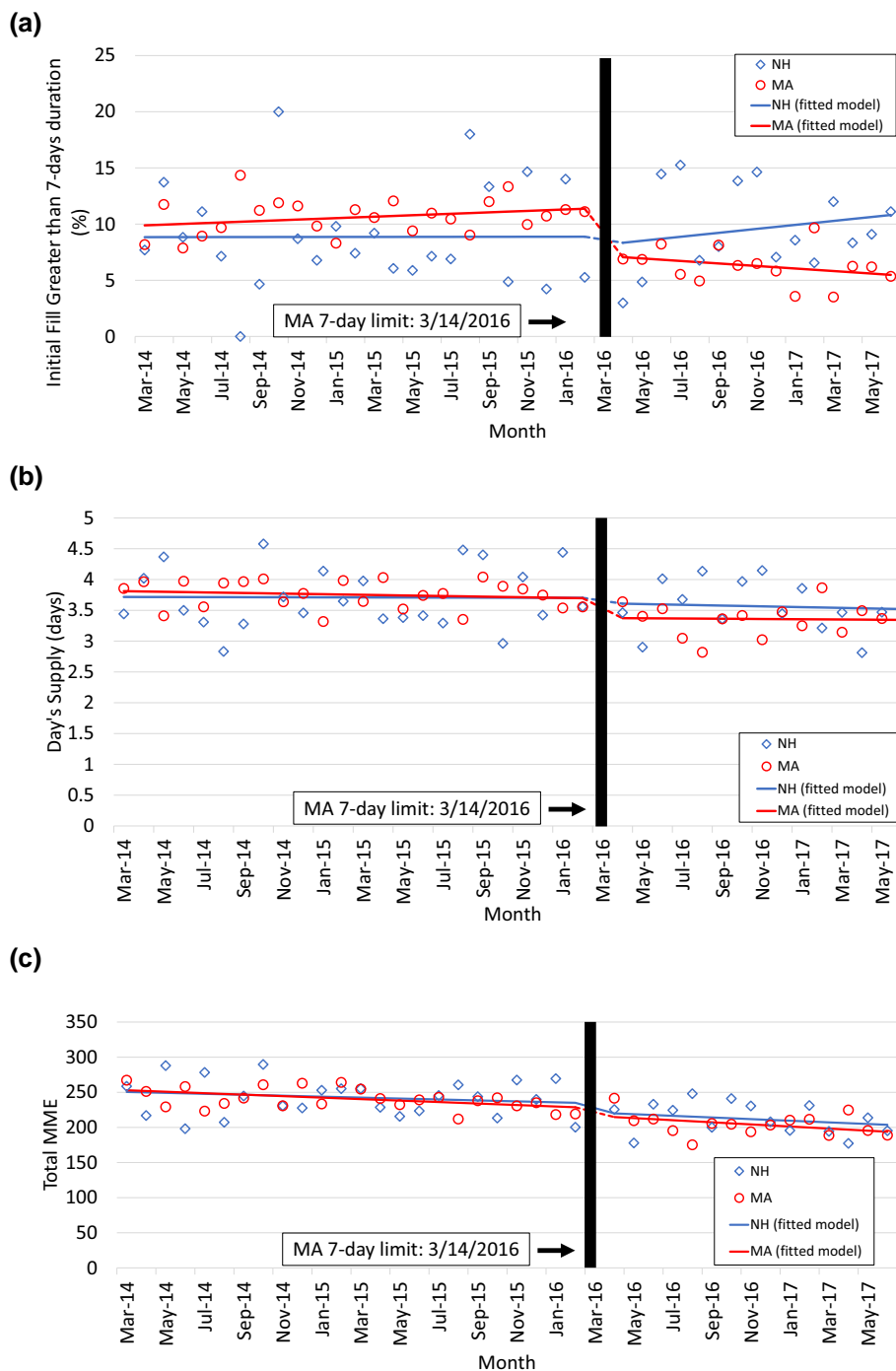
There were no statistically significant post-policy changes in level or trend of our secondary outcomes, including the percentage filling an initial prescription, total MME, or daily MME. For our primary and secondary outcomes, we describe trend, level, and relative changes after implementation of the Massachusetts 7-day limit in [Table 2](#) and relative and absolute changes at the final post-policy month, which can be found in [Appendix A6](#). [Appendix A9](#) and [Appendix A10](#) provide plots of our secondary outcomes. [To access the Appendix, click on the Details tab of the article online.]

### Secondary analyses

Among non-opioid-naive patients undergoing elective procedures, level or trend difference in percentage of initial fills greater than 7 days in the Massachusetts relative to the New Hampshire group was not significant but had a magnitude similar to our main results (full results are shown in [Appendix A11](#) and a plot of the percentage of initial fills greater than 7 days' outcome is shown in [Appendix A12](#)). [To access the Appendix, click on the Details tab of the article online.]

Among patients undergoing low-to-moderately-painful orthopedic surgeries, we found an immediate 4.39 percentage point absolute reduction (95% CI,  $-8.54\%$  to  $-2.43$  percentage points;  $P = .038$ ) in the percentage of initial fills greater than 7 days in the Massachusetts relative to the New





**Figure 1.** (A) The graph shows initial opioid prescriptions with greater than a 7-day duration among Massachusetts (MA) and New Hampshire (NH) patients undergoing elective orthopedic procedures before and after the Massachusetts 7-day limit became effective on March 14, 2016. Linear trends are fit across the unadjusted monthly percentages in each state before and after the 7-day limit, with a dashed line connecting each state trend from the pre- to post-policy period. (B) The graph shows the initial opioid prescription's days' supply among MA and NH patients undergoing elective orthopedic procedures before and after the Massachusetts 7-day limit became effective on March 14, 2016. Linear trends are fit across the unadjusted monthly mean days' supply in each state before and after the 7-day limit, with a dashed line connecting each state trend from the pre- to post-policy period. (C) The graph shows the initial opioid prescription's MME among MA and NH patients undergoing elective orthopedic procedures before and after the Massachusetts 7-day limit became effective on March 14, 2016. Total MME were calculated as the total amount of opioid in milligrams multiplied by a standard conversion factor. Linear trends are fit across the unadjusted monthly MME per day in each state before and after the 7-day limit, with a dashed line connecting each state trend from the pre- to post-policy period. Source: Authors' analysis of commercial claims data from a large regional health plan, 2014–2017. Abbreviation: MME, morphine milligram equivalents.

Hampshire group (full results are shown in [Appendix A13](#) and a plot of the percentage of initial fills greater than 7 days' outcome is shown in [Appendix A14](#)). [To access the Appendix, click on the Details tab of the article online.]

### Sensitivity analyses

Our sample for our sensitivity analysis broadened our cohort undergoing elective procedures to also include those undergoing nonelective and spine procedures. This sample included

**Table 2.** Segmented regression model results showing trend change, level change, and relative changes after the Massachusetts 7-day limit among opioid-naive adults undergoing elective procedures.

Variable	Trend change (pre-post change in slope) <sup>a</sup> (95% CI)	Level change (absolute change from month before to after policy) <sup>b</sup> (95% CI)	Relative change from month before to month after policy (percentage) <sup>c</sup> (95% CI)
Initial opioid prescription greater than 7 days' duration (percentage point)	−0.01 (−0.37, 0.35)	−4.23 (−8.12, −0.33) <sup>d</sup>	−33.27 (−55.36, −11.19) <sup>e</sup>
Mean initial days' supply (days)	0.01 (−0.04, 0.07)	−0.06 (−0.61, 0.48)	−1.67 (−16.04, 12.71)
Receipt of postoperative opioid prescription (percentage point)	0.58 (−0.16, 1.31)	−1.44 (−8.39, 5.52)	−1.85 (−10.66, 6.97)
Mean total MME, initial fill	0.50 (−2.62, 3.63)	16.37 (−13.86, 46.61)	8.45 (−8.33, 25.22)
Mean daily MME, initial fill	0.26 (−0.43, 0.92)	2.31 (−4.17, 8.79)	5.18 (−10.03, 20.39)

Source: Authors' analysis of commercial claims data from a large regional health plan, 2014–2017. Parameter estimates and 95% CIs for trend, level, and relative changes in outcomes immediately after the 7-day limit are shown.

Abbreviation: MME, morphine milligram equivalents.

<sup>a</sup>Estimates are taken directly from the generalized estimating equation model's parameter estimates. Trend change corresponds to the relative change in slope (example, mean days' supply per month) from before to after the policy among the Massachusetts relative to the New Hampshire group.

<sup>b</sup>Refers to the immediate absolute change in the Massachusetts group relative to the absolute change in the New Hampshire group in the month after the policy change compared to the month before.

<sup>c</sup>Refers to the relative change in the Massachusetts group relative to the New Hampshire group at month 1. All values in column 4 are percentage (%) changes.

<sup>d</sup> $P < .05$ .

<sup>e</sup> $P < .01$ .

14 344 Massachusetts and 3077 New Hampshire opioid-naive patients. Appendix A15 provides descriptive statistics for these groups. [To access the Appendix, click on the Details tab of the article online.] The results of our main sensitivity analysis were largely consistent with the findings from our main analyses. We describe trend, level, and relative changes after implementation of the Massachusetts 7-day limit in Appendix A16 and relative and absolute changes at the final post-policy month in Appendix A17. [To access the Appendix, click on the Details tab of the article online.] By June 2017 (the final post-policy month), the absolute difference point estimates in the percentage of initial fills greater than 7 days in the Massachusetts relative to the counterfactual group were similar between our elective and broadened cohorts: while the elective group had a nonsignificant 4.43 percentage point absolute reduction (−10.04 to 1.18 percentage points;  $P = .12$ ) and 33.58% relative reduction (95% CI, −70.82% to 3.66%;  $P = .08$ ), the broadened cohort had a significant 6.33 percentage point absolute reduction (95% CI, −11.49 to −1.17 percentage points;  $P = .02$ ) and 49.16% relative reduction (95% CI, −84.19% to −14.12%;  $P = .006$ ).

Among non-opioid-naive adults undergoing elective, non-elective, and spine procedures, we found an immediate 3.81 percentage point absolute reduction (95% CI, −7.59 to −0.05 percentage points;  $P = .047$ ) in the percentage of initial fills greater than 7 days in the Massachusetts relative to the New Hampshire group (see Appendix A11). Finally, among opioid-naive adults undergoing highly painful orthopedic procedures, we did not identify significant level or trend changes in the percentage of initial fills greater than 7 days in the Massachusetts relative to the New Hampshire group (see Appendix A13). [To access the Appendix, click on the Details tab of the article online.]

## Discussion

The Massachusetts 7-day limit was associated with a 33% relative reduction in the percentage of elective orthopedic surgery patients receiving an initial opioid prescription greater than 7 days' duration. Although we found a nonsignificant

reduction in initial fills greater than 7 days' duration at the final post-policy month, it was significant when we included elective, nonelective, and spine procedures in our analysis. We anticipate a sustained effect among a larger sample of elective-procedure patients. We found a similar spillover into non-opioid-naive patient population. Significant reductions in initial fills greater than 7 days were driven by patients undergoing low-to-moderately-painful compared with highly painful procedures. Our results did not indicate any change in initial opioid fills after surgery or MME, suggesting that the duration limits may decrease lengthy opioid prescriptions without affecting opioid initiation or dose.

Our findings have similarities to other opioid prescription duration limit studies while providing new insights. Schmid et al<sup>39</sup> used a multistate, difference-in-differences approach to estimate the impact of opioid prescribing limits among patients undergoing common surgical procedures and found small negative associations in the percentage of prescription sizes greater than 3, 5, or 7 days. Agarwal et al<sup>18</sup> used interrupted time series without a control group and found the Massachusetts 7-day limit was associated with a 5.9% absolute level reduction in prescriptions longer than 7 days and significant reduction in MME level and trend among commercially insured adults undergoing common surgical procedures. Our finding of a significant reduction in prescriptions greater than 7 days are robust to controlling for a New Hampshire cohort. These findings remained significant in our sensitivity analysis across all orthopedic procedures, providing further evidence of a strong association between the Massachusetts 7-day limit and reductions in prescriptions greater than 7 days' duration. Unlike Agarwal et al, we did not identify a significant MME reduction when controlling for New Hampshire, suggesting that declines in MME across the study period were not unique to Massachusetts. While we found a small but significant spillover into non-opioid-naive patients undergoing any orthopedic procedure, these findings should be interpreted cautiously as these patients had received 1 or more opioid prescriptions in the 6-month preoperative period and may not be considered to have chronic, long-term opioid use.

State opioid limit law evaluations using robust analytic approaches have focused on common surgeries that vary by

postoperative pain needs. We found that the Massachusetts 7-day limit was associated with reductions in initial fills greater than 7 days' duration among those undergoing low-to-moderately-painful but not very painful orthopedic procedures. Reasons for this include the professional judgment exception in the Massachusetts law, where clinicians may choose to continue to prescribe longer duration of opioids for very painful procedures anticipating significant postoperative pain. Conversely, there is likely less heterogeneity in response to the law among clinicians performing low-to-moderately-painful surgeries, given a desire to comply with the law while knowing that such surgeries demand shorter opioid prescriptions.

Our findings are important for clinicians, particularly orthopedic surgeons, faced with limiting opioid prescribing while ensuring adequate pain control. Multiple studies of postoperative orthopedic patients found that 60% of prescribed opioids went unused.<sup>40,41</sup> We found reductions in prescriptions longer than 7 days among opioid-naïve patients without increases in MME, suggesting that state 7-day duration limits might curb longer duration prescribing for acute postoperative pain while maintaining pain control. Our findings are further supported by a recent trial of patients undergoing arthroscopic procedures, which found no difference in pain scores among an opioid-sparing group compared with usual care.<sup>42</sup>

Our findings are also important for policy makers who are considering their state strategies for opioid prescribing in light of the 2022 CDC guidelines, which emphasized individualizing a patient's pain control needs for acute, subacute, and chronic pain while de-emphasizing rigid limitations, including tapering patients off long-term opioid therapy.<sup>21</sup> For example, Minnesota and Arizona recently enacted legislation to safeguard opioid prescribing for patients experiencing intractable pain.<sup>43,44</sup> Colorado and Oklahoma are considering similar legislation, whereas the Deputy Secretary for Health in Florida reaffirmed their commitment to stringent opioid prescribing regulations.<sup>45-47</sup> Policy makers might be reassured that a 7-day limit was not associated with unintended consequences identified at the pharmacy claims level for opioid-naïve patients with acute postoperative pain. Our findings may assist in crafting "balanced" policies that seek to mitigate longer duration prescribing to high-risk populations in the acute postoperative setting without adversely affecting patients requiring long-term opioids for chronic pain management. Further research is needed to evaluate potential unintended consequences of duration limits, such as inadequate pain management measured by opioid refills or readmissions for pain management, or prescription of alternative pain medications with high-risk side effects. Future research might track legislative movement and evaluate how refinement and relaxing of opioid prescribing laws further impact different patient populations.

## Conclusion

We found an association between the Massachusetts 7-day limit and reductions in initial opioid prescriptions greater than 7 days among Massachusetts opioid-naïve patients undergoing elective orthopedic procedures. Seven-day limits may be 1 aspect of a balanced state policy approach for addressing opioid overprescribing that accompany protections for those on long-term opioids.

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## Supplementary material

Supplementary material is available at *Health Affairs Scholar* online.

## Conflicts of interest

Please see ICMJE form(s) for author conflicts of interest. These have been provided as [supplementary materials](#).

## Notes

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