


## RESEARCH ARTICLE

# Changes in early high-risk opioid prescribing practices after policy interventions in Washington State

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## Abstract

**Objective:** To test associations between several opioid prescribing policy interventions and changes in early (acute/subacute) high-risk opioid prescribing practices.

**Data Sources:** Population-based workers' compensation pharmacy billing and claims data, Washington State Department of Labor and Industries (January 2008-June 2015).

**Study Design:** We used interrupted time series analysis to test associations between three policy intervention timepoints and monthly proportions of population-based measures of high-risk, low-risk, and any workers' compensation-related opioid prescribing. We also tested associations between the policy intervention timepoints and five high-risk opioid prescribing indicators among workers prescribed any opioids within 3 months after injury: (a) >7 cumulative (not necessarily consecutive) days' supply of opioids during the acute phase, (b) high-dose opioids, (c) concurrent sedatives, (d) chronic opioids, and (e) a composite high-risk opioid prescribing indicator.

**Principal Findings:** Within 3 months after injury, 9 percent of workers were exposed to high-risk and 12 percent to low-risk workers' compensation-related opioid prescribing; 79 percent filled no workers' compensation-related opioid prescription. Among workers prescribed any early (acute/subacute) opioids, the indicator for >7 days' supply of opioids during the acute phase was present for 30 percent, high-dose opioids for 18 percent, concurrent sedatives for 3 percent, and chronic opioids for 2 percent. Beyond a general shift toward more infrequent and lower-risk workers' compensation-related opioid prescribing, each policy intervention timepoint was significantly associated with reductions in specific acute/subacute high-risk opioid prescribing indicators; each of the four specific high-risk opioid prescribing indicators had significant reductions associated with at least one policy.

**Conclusions:** Several state-level opioid prescribing policies were significantly associated with safer workers' compensation-related opioid prescribing practices during the first 3 months after injury (acute/subacute phase), which should in turn reduce transition to chronic opioids and associated negative health outcomes.

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## KEYWORDS

analgesics, drug prescriptions, inappropriate prescribing, interrupted time series analysis, opioid, policy, workers' compensation

## 1 | INTRODUCTION

Over the past two decades, high-risk opioid prescribing practices have contributed to a national epidemic of opioid overdose deaths.<sup>1-4</sup> High-risk opioid prescribing practices include excessive initial days' supply, high doses, concurrent prescribing of opioids and sedatives, and long-term prescribing. Accumulating evidence suggests that even limited opioid use during the first 6 weeks after injury is associated with longer-term opioid use, as well as long-term work disability.<sup>5-14</sup> There is also increasingly compelling evidence of an association between higher opioid doses and opioid-related morbidity/mortality.<sup>15-19</sup> A population-based study in a large health plan demonstrated a 9-fold increase in overdose risk at doses  $\geq 100$  milligram (mg) morphine equivalent daily dose (MEDD) relative to  $< 20$  mg.<sup>16</sup> According to the CDC, the 20 percent of patients prescribed high-dose opioids ( $\geq 100$ mg MEDD) account for 80 percent of opioid overdoses.<sup>2</sup> Concurrent prescribing of opioids and sedatives has also been associated with increased risk of fatal and nonfatal opioid overdoses.<sup>20,21</sup>

Systematic evaluation of state-level opioid prescribing policies is in its infancy, and it is unclear which specific policies are most effective. A systematic review by CDC researchers lamented the paucity of rigorous research on this topic.<sup>22</sup> However, several studies have found promising associations between opioid prescribing policy interventions and prescribing practices. Evaluations of the 2007 opioid prescribing guideline implemented in Washington State—the first state to implement an opioid guideline specifying a high-dose threshold (120 mg MEDD) and related clinical guidance—found associated reductions in high-dose prescribing using both workers' compensation (WC) pharmacy data<sup>23</sup> and Medicaid data.<sup>24</sup> A sequential and progressive opioid dose reduction strategy involving both prior authorization and high-dose thresholds was successful in decreasing the average daily opioid dose among Massachusetts Medicaid members.<sup>25</sup> At the national level, a study that included 38 intervention and comparison states found that mandated prescription monitoring program (PMP) review and pain clinic laws were associated with reductions in opioid prescribing rates.<sup>26</sup> Using time series analyses, researchers found that several opioid prescribing practices were decreasing before release of the 2016 CDC Guideline for Prescribing Opioids for Chronic Pain, but that guideline release was associated with an even greater decline.<sup>27</sup>

Identifying which specific opioid prescribing policies are most effective can pose major challenges, as they are often implemented population-wide and close together in time.<sup>22,28-30</sup> The aim of this study was to assess associations between implementation of a series of opioid prescribing policies in Washington State and changes in opioid prescribing practices during the acute (0-6 weeks) and subacute (6 weeks to 3 months) phases of pain after injury. We used WC data

### What is Known on this Topic

- There is mounting evidence that even limited opioid use during the acute phase (first 6 weeks) of a pain episode may increase the risk of chronic opioid use, severe dependence and addiction, and overdose.
- The impact of policy interventions on opioid prescribing practices during the acute/subacute phase of pain (first 3 months) has been under-researched relative to impact on longer-term prescribing practices, yet the acute/subacute phase provides the most critical window of opportunity for prevention of opioid-related morbidity and mortality.

### What This Study Adds

- We found that three policy interventions were each associated with reductions in certain high-risk workers' compensation-related opioid prescribing practices, consistent with features of the specific policy; in particular, after implementation of a requirement for prior authorization after 6 weeks, the prevalence of receiving 60 days' supply of opioids within the acute/subacute phase fell abruptly to almost nil.
- This study demonstrates that a public payer, collaborating with other state agencies, can successfully implement policies that may prevent unsafe opioid prescribing practices.

to investigate this aim because injured workers—like the general population—have been exposed to dramatic temporal changes in opioid prescribing practices,<sup>31-33</sup> and because Washington State WC data are population-based and thus suitable for state-level policy evaluations.<sup>34</sup> Also, this is a population in which the prevalence of chronic opioid use is low (1.9 percent of injured workers during the 3 months *before* injury, based on 2012-2015 Washington PMP data<sup>35</sup>); hence, the 3 months after injury primarily reflects new-onset opioid prescribing and can be used to assess acute/subacute WC-related prescribing practices. This study extends the limited existing opioid policy evaluation literature by assessing the impact of several policy interventions on reducing high-risk opioid prescribing practices during the acute/subacute phase after injury. The acute/subacute phase has been under-researched relative to the chronic phase, while providing the most critical window of opportunity for preventing transition to chronic opioid use, severe dependence and addiction, and overdose.

**TABLE 1** Summary of opioid prescribing policy features

Policy feature	Updated AMDG Interagency Guideline on Opioid Dosing for Chronic Non-cancer Pain	Professional rules for opioid prescribing	Prescription Monitoring Program	L&I Guideline for Prescribing Opioids to Treat Pain in Injured Workers, and related payment rules
Month/year implemented	June 2010	July 2011: osteopathic physicians and physician assistants, podiatrists, dentists, advanced registered nurse practitioners January 2012: allopathic physicians and physician assistants	January 2012: health care provider access began	July 2013
Highlights	High-dose threshold (120mg MEDD) Clinically meaningful improvement in function Avoid combining opioids with sedatives Validated online tools to screen and monitor for risks Detailed urine drug testing guidance	Mandatory pain specialist consultation for opioids >120 mg MEDD Screen for risks before initiating chronic opioid therapy and monitor during ongoing chronic opioid therapy Screen and monitor more frequently for opioids >40 mg MEDD Caution regarding concomitant benzodiazepines	Ability to check PMP before prescribing opioids	Expanded to address acute/subacute phase in addition to chronic phase ≤14 d supply recommended in acute phase Prior authorization needed beyond 6 wk Check PMP before prescribing opioids Use of specified tools for risk screening Clinically meaningful improvement in function Discontinue/taper concurrent sedatives
Pain phase	Chronic	Chronic	All phases	All phases
Enforceability	Voluntary	Enforceable via professional rules	Voluntary	Enforceable via payment policies

Abbreviations: AMDG, Agency Medical Directors' Group; L&I, Washington State Department of Labor and Industries; MEDD, morphine equivalent daily dose; PMP, Prescription Monitoring Program.

## 2 | METHODS

### 2.1 | Study population

Washington State has a single payer WC system (State Fund) that covers approximately 70 percent of workers covered by Washington's Industrial Insurance Act.<sup>36</sup> Self-insured employers account for the remaining 30 percent. WC pharmacy billing and claims data for all accepted State Fund claims (N = 676 118) were obtained from the Washington State Department of Labor and Industries (L&I) for work-related injuries/illnesses occurring from January 1, 2008, through June 30, 2015, excluding workers younger than 18. Self-insured claims were excluded due to unavailable pharmacy billing data. WC pharmacy billing data include opioid records related to the WC injury/illness, but do not include opioids prescribed for non-WC conditions, billed to primary health insurance, or paid out-of-pocket.

### 2.2 | Opioid prescribing guidelines

Several guidelines and rules related to opioid prescribing practices were implemented in Washington during the study timeframe (Table 1). Some policy interventions were implemented concurrently or nearly so, which posed a challenge for determining their individual effects (see Section 2.5).

The Agency Medical Directors' Group (AMDG) is a statutorily authorized collaboration of medical directors and senior policy makers from all Washington State agencies that manage or regulate publicly funded health insurance plans. In June 2010, the AMDG published an updated Interagency Guideline on Opioid Dosing for Chronic Non-cancer Pain, including publicly available online tools for monitoring safe and effective use of opioids.<sup>37</sup> These tools included validated instruments for tracking pain, pain interference with function, and substance abuse and depression screening, and guidance on urine drug testing. The guideline recommended avoiding doses above 120 mg MEDD for patients who did not have clinically meaningful improvement in pain and function, without first obtaining a pain specialist consultation. It also recommended against combining opioids with sedatives for chronic non-cancer pain without a specific medical and/or psychiatric indication. An earlier version of this guideline was implemented as a limited educational pilot in March 2007; however, dissemination activities (eg, presentations to provider groups, free Web-based training) were paused through 2009 due to a legal challenge.

Washington passed legislation in 2010 mandating that new administrative opioid prescribing rules be developed for the professions that prescribe opioids<sup>38</sup>; administrative rules consistent with the legislative mandate were adopted by five professional boards and commissions in July 2011 and January 2012.<sup>39</sup> These rules specified mandatory consultation for opioid doses at or above 120 mg MEDD, and the use of validated tools for risk screening and monitoring.

In January 2012, Washington became one of 49 states with operational PMPs.<sup>39</sup> Licensed pharmacies and practitioners are required to electronically report to the PMP all dispensed non-inpatient prescriptions for more than a 24-hour supply of Schedule II, III, IV, and V controlled substances.<sup>40</sup>

In July 2013, L&I implemented the Guideline for Prescribing Opioids to Treat Pain in Injured Workers,<sup>41</sup> which was intended to prevent unnecessary or inappropriate acute/subacute WC-related opioid prescribing and to curtail the transition to chronic opioid use.<sup>39</sup> This guideline specified that WC coverage for opioids would be terminated after 6 weeks unless there was documentation of: PMP access to ensure that controlled substance history was consistent with the prescribing record and worker report; achievement of clinically meaningful improvement in function and pain; use of specified screens for depression, substance use disorders, and opioid risk; and consideration of discontinuation or taper of concurrent sedatives.

## 2.3 | Opioid prescribing indicators

We defined four high-risk WC-related opioid prescribing indicators, with all but the first covering the first 3 months after injury: (a) >7 cumulative (not necessarily consecutive) days' supply of opioids prescribed during the acute phase (0-6 weeks after injury), (b) high-dose opioid prescribing (>50 mg MEDD), (c) concurrent opioid and sedative prescribing, and (d) chronic opioid prescribing ( $\geq 60$  cumulative days' supply). The four high-risk opioid prescribing indicators selected for this study have been used in previous studies<sup>6,14</sup> and were selected based on substantial evidence for their contribution to the risk of transition to chronic opioid use, opioid-related morbidity, and/or work disability. The risk of remaining on opioids for one year goes up by 1 percent per day, starting with the third day of the initial opioid prescription.<sup>5</sup> As few as 30-90 days of opioid use are associated with likelihood of prolonged use of opioids.<sup>10</sup> After adjustment for baseline pain, function, and injury severity, the strongest predictor of longer-term opioid prescription was total dose in the first 3 months—a function of both MEDD and days' supply.<sup>11</sup> These data are consistent with the 2016 CDC opioid prescribing guideline, which recommends  $\leq 3$  days for acute pain and states that 7 days will rarely be needed.<sup>42</sup> Receipt of over 7 days of opioids in the acute phase of low back injury was associated with roughly twice the risk of work disability one year later, even after adjustment for pain level, pain interference, psychosocial barriers to recovery, and objectively-rated injury severity at baseline<sup>6</sup>; a smaller study reported similar findings.<sup>12</sup> Because many studies have focused on consecutive (vs cumulative) days' supply, we conducted sensitivity analyses using an alternate consecutive version of the >7 days' supply indicator, based on >7 days' supply for any single acute-phase opioid prescription. However, we used the cumulative measure for the primary analysis, for which findings were more conservative (see Section 3). Concurrent prescribing of opioids and sedatives is associated with increased risk of fatal and nonfatal opioid overdoses,<sup>20,21</sup> as are high-dose prescription opioids.<sup>15-17,43</sup> With respect to the

specific high-dose threshold selected, four large observational population-based studies demonstrated that doses between 50 and 99 mg MEDD increased the risk of overdose up to fourfold.<sup>15-17,43</sup> The original AMDG guideline was focused on chronic prescribing and was the first state guideline to include a high-dose threshold with specific clinical guidance. That threshold (120 mg MEDD) was high by current standards and is not often reached during the acute/subacute phase. We therefore defined the high-dose indicator in accordance with the 2016 CDC 50 mg MEDD threshold.<sup>42</sup>

Opioid prescriptions were defined as WC payment for specified opioids, excluding buprenorphine (see Tables S1A,B).<sup>44,45</sup> To calculate opioid prescription date ranges and prescription overlap for the various indicators, we used the prescription fill date in conjunction with days' supply. For the high-dose indicator, MEDD (calculated using Bree Collaborative conversion factors, page 8<sup>44</sup>) was averaged over the number of days with any opioids supplied during the first 3 months after injury. If there were multiple opioid prescriptions with overlapping date ranges (based on fill dates and days' supply), cumulative MEDD was summed on any days of overlap. Concurrent opioid prescribing was defined as at least one day of overlap of an opioid with a sedative (ie, benzodiazepines, barbiturates, carisoprodol, or non-benzodiazepine hypnotics).

These four high-risk indicators were not mutually exclusive. High-risk opioid prescribing—a composite indicator—was defined as presence of any of the four high-risk indicators.<sup>14</sup> Low-risk opioid prescribing was defined as at least one opioid prescription within 3 months after injury together with the absence of all four high-risk indicators. Thus, injured workers fell into three mutually exclusive WC-related opioid prescribing exposure categories during the acute/subacute phase—those with: (a) the composite high-risk opioid indicator, (b) the low-risk opioid indicator, and (c) no WC-related opioids prescribed within 3 months after injury.

## 2.4 | Worker and claim characteristics

L&I administrative data were used to describe the sample—overall, and by WC-related opioid prescribing risk group. Worker characteristics included age at the time of injury and gender. Nature of injury was based on Occupational Injury and Illness Classification (OIICS) 1.01 codes and categorized as (a) fractures, (b) strains/sprains/tears, (c) other traumatic injuries, and (d) other/multiple injuries/illness.<sup>46</sup> L&I classified each claim as either medical-only (only medical benefits were paid) or compensable (the claim involved compensation beyond medical benefits; eg, wage replacement for missed work days beyond the initial 3-day post-injury waiting period, or permanent disability payments). The level of missing data was negligible—under 0.1 percent for all variables.

## 2.5 | Data analysis

We tabulated the proportion of injured workers with each WC-related opioid prescribing indicator on a monthly basis from January 2008 through June 2015, and created eight separate time series. For the three population-based indicators (high-risk, low-risk, and any opioids),

the monthly denominator was the number of all eligible injured workers with an incident injury during that month. For the four specific high-risk indicators, and again for the composite high-risk indicator, the monthly denominator was further restricted to injured workers prescribed any WC-related opioids within 3 months of injury.

We assessed high-risk indicator overlap and documented the most common high-risk opioid prescribing patterns. We assessed change over time in relative proportions of high-risk, low-risk, and any WC-related opioid prescribing.

Interrupted time series analysis (ITSA) was used to examine the impacts of opioid prescribing policies by testing for a structural break in monthly proportions (abrupt change in level or trend) at each of three opioid-related policy implementation timepoints, for each of the three population-based WC-related opioid prescribing indicators and each of the five high-risk WC-related opioid prescribing indicators.<sup>47,48</sup> Three intervention variables were constructed; these variables were set to 0 before the corresponding intervention timepoint and set to 1 at the month of intervention implementation (Table 1). The first intervention variable represented the June 2010 publication of the updated AMDG opioid prescribing guideline. The second intervention variable was set to 1 beginning January 2012, and represented a set of policy interventions that occurred too close in time to test separately: (a) adoption of professional rules

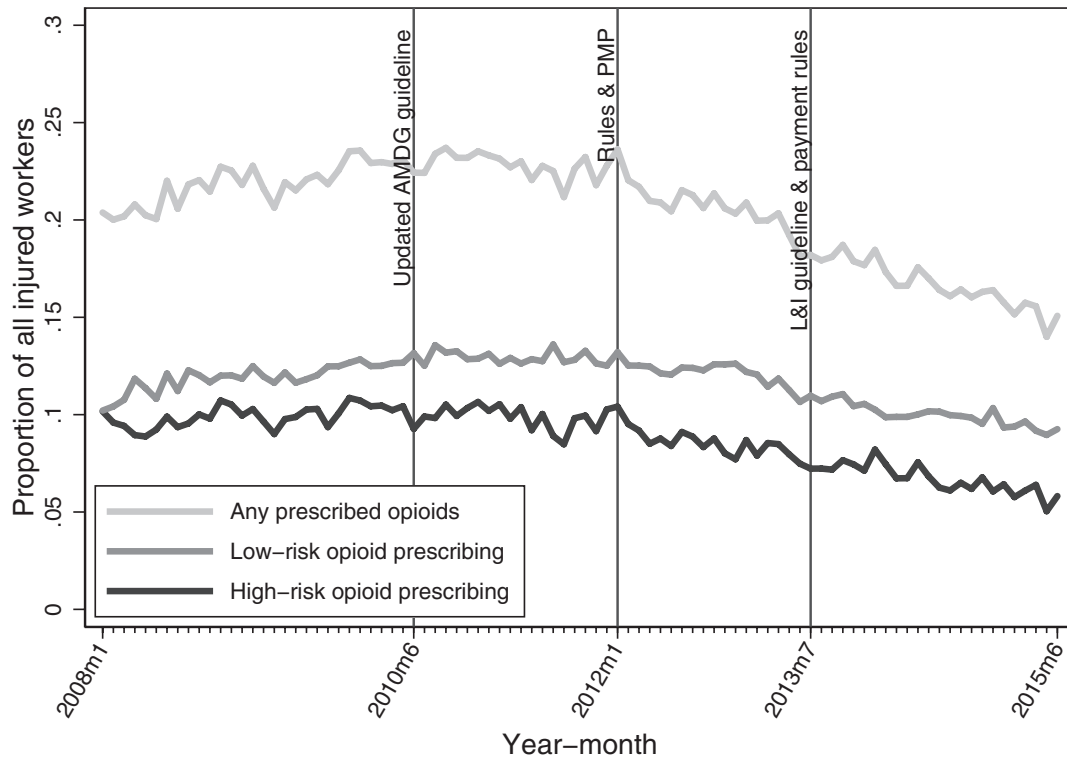
for opioid prescribing in July 2011 and January 2012; and (b) prescriber access to the PMP beginning January 2012. Injured workers whose first-listed attending provider was covered by the July 2011 rules accounted for only about 13 percent of the sample, while all injured workers were covered by the January 2012 rules and/or PMP operationalization. The third intervention variable represented the July 2013 implementation of L&I's opioid prescribing guideline and related rules. ITSA models generally require a minimum of eight observations before and after the intervention timepoint of interest; we had 90 monthly observations overall for each ITSA model, with adequate ( $\geq 19$ ) pre-post monthly observations to test each of these three intervention timepoints.<sup>48</sup>

We implemented ITSA models based on ordinary least squares regression; Newey-West standard errors were used to account for heteroscedasticity and possible autocorrelated errors up to some lag.<sup>49</sup> A set of indicators for calendar quarter were included to account for seasonal variation. The Cumby-Huizinga general specification test for autocorrelation in time series (robust form) was used to identify appropriate lag times for each opioid prescribing indicator.<sup>50</sup> In a single-group analysis for each opioid prescribing indicator, we tested parameters for level and trend changes from pre- to post-intervention time periods for each intervention variable.

**TABLE 2** Characteristics of Washington State injured workers with State Fund workers' compensation claims for injuries/illnesses occurring from January 1, 2008–June 30, 2015: Workers' compensation-related opioid prescribing exposure during the first 3 months after injury by category (N = 676 118)

Characteristic	N	Opioid prescribing exposure category			P-value <sup>†</sup>
		High-risk opioid prescribing (%)	Low-risk opioid prescribing (%)	No opioids prescribed (%)	
Overall	676 118	8.8	11.7	79.6	
Gender					
Male	452 515	9.4	12.0	78.6	<.0005
Female	223 582	7.5	11.0	81.5	
Age categories					
18-24	104 258	5.6	11.1	83.3	<.0005
25-34	176 509	8.4	12.5	79.2	
35-44	149 624	10.0	12.7	77.3	
45-54	144 842	10.5	11.6	77.9	
55-64	86 501	8.8	9.5	81.8	
65+	14 384	7.2	7.9	84.9	
Nature of injury					
Fracture	36 076	26.0	19.5	54.5	<.0005
Strain/sprain/tear	244 750	11.3	13.8	74.9	
Other traumatic injuries	332 270	5.4	10.0	84.5	
Other/multiple injuries/illness	63 020	6.8	7.3	85.9	
Claim status					
Medical only	491 203	3.9	9.8	86.3	<.0005
Compensable	184 915	21.7	16.7	61.6	

<sup>†</sup>Chi-square test of independence.



**FIGURE 1** Change over time in the population-based proportion of injured workers exposed to high-risk, low-risk, and any workers' compensation-related opioid prescribing within 3 mo after injury (1/1/2008-6/30/2015). AMDG, Agency Medical Directors' Group; L&I, Washington State Department of Labor and Industries; PMP, Prescription Monitoring Program

Analyses were conducted using STATA 15.1<sup>51</sup>; database construction was conducted using R version 3.6.0.<sup>52</sup> The University of Washington Human Subjects Division approved this study.

### 3 | RESULTS

This study included a total of 676 118 injured workers with Washington State Fund WC claims. During the first 3 months after injury, 9 percent were exposed to high-risk WC-related opioid prescribing practices, 12 percent were exposed to low-risk WC-related prescribing practices, and about 79 percent did not fill any opioid prescription covered by WC (Table 2). Injured workers with fractures were more likely to have any WC-related opioids filled, and more likely to be exposed to high-risk WC-related prescribing practices, than were workers with other injury types. Workers with compensable claims were more likely to have any WC-related opioids filled, and more likely to be exposed to high-risk WC-related prescribing practices, than were workers with medical-only claims.

Among workers prescribed any WC-related opioids during the first 3 months after injury ( $N = 138\ 124$ ), 30 percent had the  $>7$  days' supply indicator, 18 percent had the high-dose indicator, 3 percent had the concurrent indicator, and 2 percent had the chronic indicator (not mutually exclusive categories). The most common high-risk WC-related prescribing pattern during the first 3 months after

injury was  $>7$  days' supply of opioids with no other high-risk indicators present, accounting for 22 percent of injured workers with any opioids prescribed and 50 percent of those with the composite high-risk opioid prescribing indicator (a detailed tabulation of these indicator patterns is provided in the Table S2). High-dose prescribing with no other indicators present accounted for 12 percent of injured workers with any opioids prescribed and 28 percent of those with the composite high-risk opioid prescribing indicator. The presence of those two indicators together (without the concurrent and chronic indicators) accounted for 5 percent of injured workers with any opioids prescribed during those 3 months and 11 percent of those with the composite high-risk opioid prescribing indicator. All other patterns were relatively uncommon, accounting for 1 percent or less of injured workers with any WC-related opioids prescribed during the 3 months after injury.

Figure 1 depicts change over time in the monthly proportions of injured workers exposed to high-risk, low-risk, and any WC-related opioid prescribing within 3 months after injury, from January 2008 through June 2015. Very generally, acute/subacute opioid prescribing trends increased through 2009, plateaued, and were decreasing by about 2012. The percentage of all injured workers exposed to early high-risk opioid prescribing (the composite indicator) decreased from 10 percent in January 2008 to 6 percent in June 2015. The same was true for early low-risk opioid prescribing (declining from 10 percent in January 2008 to 9 percent in June 2015), as all opioid prescribing during the 3 months after injury generally

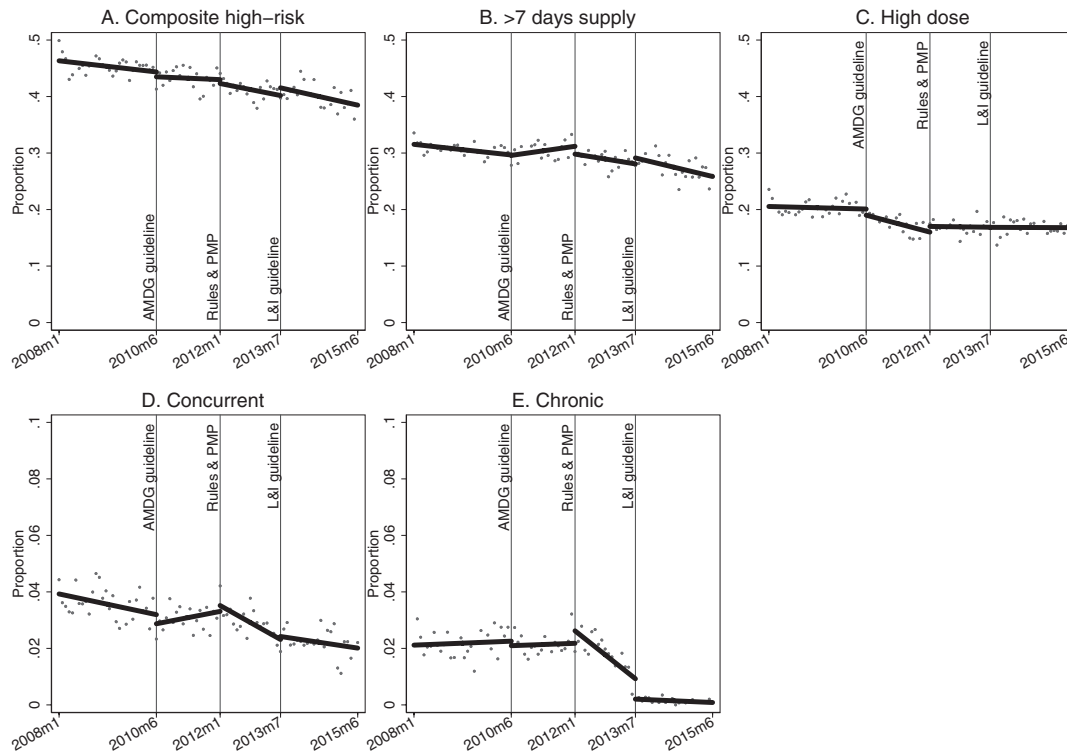
**TABLE 3** Interrupted time series analysis (ITSA) regression results: Associations of each policy intervention with changes in level or trend for each of three population-based workers' compensation-related opioid prescribing indicators and five high-risk workers' compensation-related opioid prescribing indicators (N = 90 observation months)

Policy intervention parameters	Opioid prescribing indicators (denominator for proportions included only injured workers with any opioid prescribed within 3 months after injury)					High-risk opioid prescribing indicators (denominator for proportions included only injured workers with any opioid prescribed within 3 months after injury)										
	High-risk	Low-risk	Any opioids	Composite	>7 days' supply	High dose	Concurrent	Chronic	High-risk	Low-risk	Any opioids	Composite	>7 days' supply	High dose	Concurrent	Chronic
Baseline level	0.09664* (0.09369, 0.09958)	0.10924* (0.10513, 0.11335)	0.20587* (0.20119, 0.21056)	0.46989* (0.45919, 0.48059)	0.31959* (0.31177, 0.32741)	0.20879* (0.19745, 0.22013)	0.03966* (0.03595, 0.04338)	0.02121* (0.01769, 0.02473)	0.09664* (0.09369, 0.09958)	0.10924* (0.10513, 0.11335)	0.20587* (0.20119, 0.21056)	0.46989* (0.45919, 0.48059)	0.31959* (0.31177, 0.32741)	0.20879* (0.19745, 0.22013)	0.03966* (0.03595, 0.04338)	0.02121* (0.01769, 0.02473)
Baseline trend	0.00037* (0.00022, 0.00053)	0.00064* (0.00048, 0.00080)	0.00101* (0.00081, 0.00122)	-0.00042 (-0.00092, 0.00008)	-0.00049* (-0.00090, -0.00008)	-0.00004 (-0.00061, 0.00052)	-0.00019 (-0.00040, 0.00002)	0.00006 (-0.00015, 0.00028)	0.00037* (0.00022, 0.00053)	0.00064* (0.00048, 0.00080)	0.00101* (0.00081, 0.00122)	-0.00042 (-0.00092, 0.00008)	-0.00049* (-0.00090, -0.00008)	-0.00004 (-0.00061, 0.00052)	-0.00019 (-0.00040, 0.00002)	0.00006 (-0.00015, 0.00028)
AMDG guideline: Change in level	-0.00291 (-0.00803, 0.00222)	0.00221 (-0.00068, 0.00510)	-0.00069 (-0.00639, 0.00500)	-0.01008 (-0.02287, 0.00272)	-0.00230 (-0.01721, 0.01260)	-0.01084 (-0.02201, 0.00034)	-0.00318 (-0.00821, 0.00185)	-0.00231 (-0.00755, 0.00293)	-0.00291 (-0.00803, 0.00222)	0.00221 (-0.00068, 0.00510)	-0.00069 (-0.00639, 0.00500)	-0.01008 (-0.02287, 0.00272)	-0.00230 (-0.01721, 0.01260)	-0.01084 (-0.02201, 0.00034)	-0.00318 (-0.00821, 0.00185)	-0.00231 (-0.00755, 0.00293)
AMDG guideline: Change in trend	-0.00071* (-0.00120, -0.00022)	-0.00085* (-0.00108, -0.00062)	-0.00157* (-0.00198, -0.00115)	-0.00003 (-0.00114, 0.00109)	0.00138 (-0.00006, 0.00282)	-0.00177* (-0.00282, -0.00072)	0.00023 (-0.00016, 0.00062)	0.00004 (-0.00042, 0.00049)	-0.00071* (-0.00120, -0.00022)	-0.00085* (-0.00108, -0.00062)	-0.00157* (-0.00198, -0.00115)	-0.00003 (-0.00114, 0.00109)	0.00138 (-0.00006, 0.00282)	-0.00177* (-0.00282, -0.00072)	0.00023 (-0.00016, 0.00062)	0.00004 (-0.00042, 0.00049)
Rules and PMP: Change in level	-0.00165 (-0.00881, 0.00551)	0.00237 (-0.00045, 0.00520)	0.00072 (-0.00652, 0.00796)	-0.00930 (-0.02345, 0.00485)	-0.01759 (-0.03617, 0.00100)	0.01126 (-0.00386, 0.02637)	0.00392 (-0.00161, 0.00944)	0.00286 (-0.00347, 0.00920)	-0.00165 (-0.00881, 0.00551)	0.00237 (-0.00045, 0.00520)	0.00072 (-0.00652, 0.00796)	-0.00930 (-0.02345, 0.00485)	-0.01759 (-0.03617, 0.00100)	0.01126 (-0.00386, 0.02637)	0.00392 (-0.00161, 0.00944)	0.00286 (-0.00347, 0.00920)
Rules and PMP: Change in trend	-0.00060 (-0.00122, 0.00002)	-0.00061* (-0.00098, -0.00024)	-0.00121* (-0.00186, -0.00056)	-0.00048 (-0.00204, 0.00108)	-0.00171* (-0.00339, -0.00004)	0.00186* (0.00058, 0.00314)	-0.00059* (-0.00104, -0.00013)	-0.00087* (-0.00146, -0.00028)	-0.00060 (-0.00122, 0.00002)	-0.00061* (-0.00098, -0.00024)	-0.00121* (-0.00186, -0.00056)	-0.00048 (-0.00204, 0.00108)	-0.00171* (-0.00339, -0.00004)	0.00186* (0.00058, 0.00314)	-0.00059* (-0.00104, -0.00013)	-0.00087* (-0.00146, -0.00028)
L&I guideline: Change in level	-0.00002 (-0.00553, 0.00549)	-0.00683* (-0.01083, -0.00284)	-0.00685* (-0.01237, -0.00134)	0.01498 (-0.00834, 0.03830)	0.01231 (-0.00388, 0.02850)	-0.00094 (-0.01863, 0.01676)	-0.00065 (-0.00489, 0.00359)	-0.00970* (-0.01406, -0.00535)	-0.00002 (-0.00553, 0.00549)	-0.00683* (-0.01083, -0.00284)	-0.00685* (-0.01237, -0.00134)	0.01498 (-0.00834, 0.03830)	0.01231 (-0.00388, 0.02850)	-0.00094 (-0.01863, 0.01676)	-0.00065 (-0.00489, 0.00359)	-0.00970* (-0.01406, -0.00535)
L&I guideline: Change in trend	0.00008 (-0.00040, 0.00056)	0.00018 (-0.00012, 0.00047)	0.00026 (-0.00034, 0.00085)	-0.00064 (-0.00163, 0.00036)	-0.00079 (-0.00203, 0.00045)	-0.00008 (-0.00132, 0.00116)	0.00040 (-0.00001, 0.00081)	0.00076 (0.00032, 0.00119)	0.00008 (-0.00040, 0.00056)	0.00018 (-0.00012, 0.00047)	0.00026 (-0.00034, 0.00085)	-0.00064 (-0.00163, 0.00036)	-0.00079 (-0.00203, 0.00045)	-0.00008 (-0.00132, 0.00116)	0.00040 (-0.00001, 0.00081)	0.00076 (0.00032, 0.00119)
Lag	0	10	2	6	0	0	0	0	0	0	0	0	0	0	0	0

Note: Estimates reflect monthly proportions. Annual percentage change can be calculated via multiplying a coefficient by 12 months and then by 100%. To account for seasonal variation, each ITSA model included a set of indicators for calendar quarter.

Abbreviations: AMDG, Agency Medical Directors' Group; CI, confidence interval; ITSA, interrupted time series analysis; L&I, Washington State Department of Labor and Industries; PMP, Prescription Monitoring Program.

\* Statistically significant at  $P < .05$  (the null hypothesis for baseline tests was that the level/trend estimate was = 0; the null hypothesis for subsequent policy-specific tests was that the level/trend estimate had not changed since the previous corresponding estimate).



**FIGURE 2** Interrupted time series analysis (ITSA) approach with fitted trend lines between policy intervention timepoints. AMDG, Agency Medical Directors' Group; L&I, Washington State Department of Labor and Industries; PMP, Prescription Monitoring Program. Proportions were calculated as the proportion of injured workers with the specified high-risk prescribing indicator, among injured workers prescribed any workers' compensation-related opioids within three months after injury

became less prevalent. However, among injured workers with any WC-related opioids prescribed during the 3 months after injury, the share exposed to low-risk (versus high-risk) opioid prescribing gradually increased from 50 percent in January 2008 to 61 percent in June 2015 (Figure S1).

Interrupted time series analysis regression estimates for the eight time series are presented in Table 3. The three population-based time series had level and/or trend decreases associated with all three policy interventions; trends in both low-risk and high-risk WC-related opioid prescribing were entangled with the overall decrease in any WC-related opioid prescribing over this timeframe (Figure 1).<sup>33</sup> Fitted trend lines between policy intervention timepoints for each of the five high-risk prescribing indicators are depicted in (Figure 2; Figure S2 and Table S3 for corresponding comparisons of the two versions of the >7 days' supply indicator; although the alternate consecutive indicator was less prevalent than the cumulative indicator, post-policy trend changes were substantially similar, and the cumulative indicator provided more conservative confidence intervals.) At baseline, among those prescribed any opioids, the concurrent and chronic high-risk prescribing indicators were the least prevalent—at 4 percent and 2 percent, respectively—compared with 32 percent for the >7 days' supply indicator, and 21 percent for the high-dose indicator (Table 3). After the first policy intervention in June 2010 (AMDG guideline with high-dose threshold), there

was a significant decrease in trend for only the high-dose indicator. The second policy intervention timepoint in January 2012 (professional opioid prescribing rules and operational PMP) was significantly associated with decreases in trend for three indicators: >7 days' supply, concurrent, and chronic. The third policy intervention in July 2013 (L&I guideline requiring prior authorization beyond 6 weeks) was associated with a significant drop in level for the chronic indicator. Counterintuitively, the second and third policy interventions were associated with trend increases for the high-dose and chronic indicators, respectively. However, the increases were relative to decreasing trends during the prior time period; both were statistically flat when compared to zero, and did not indicate upward trends.

## 4 | DISCUSSION

It is clear from long-term trends that early (acute/subacute) WC-related opioid prescribing practices are improving over time in Washington State, with regard to both frequency of any opioid prescribing, and safer prescribing practices when opioids are needed. In addition, each of the three policy intervention timepoints was significantly associated with reductions in specific high-risk prescribing indicators; all four indicators had significant reductions associated with at least one policy. Washington State



has been a national leader in promoting safer opioid prescribing practices and transforming WC-related health care delivery.<sup>39,53,54</sup> These efforts appear to be paying off, both with respect to WC-related opioid prescribing practices, and with respect to reducing the consequent burden of opioid overdose.<sup>30</sup> Early high-risk opioid prescribing practices are associated with long-term use.<sup>5,9,13,55</sup> Safer acute/subacute opioid prescribing practices should in turn reduce transition to chronic opioid use and associated negative health outcomes, including long-term dependence, opioid use disorder, opioid overdose, and mortality, as well as negative work-related outcomes, including time lost from work and work injuries.<sup>5-13,15-19,43,53,56</sup>

During the first 3 months after injury (acute/subacute phase), 9 percent of injured workers were exposed to high-risk opioid prescribing practices, with the >7 days' supply and high-dose indicators being most prevalent. This information may be useful in guiding development of policy interventions focused on decreasing duration and dose during the acute/subacute phase; these more prevalent patterns may also have the most leeway for potential reductions. Prevalence of the concurrent and chronic indicators, though known to be associated with negative outcomes, was quite low in the acute/subacute phase under study.

Specific policy interventions were significantly associated with certain level and trend decreases in various subsets of the high-risk prescribing indicators. There was a significant association between the first policy intervention timepoint, which represented June 2010 implementation of the updated AMDG guideline, and a decrease in trend for the high-dose indicator. This voluntary guideline was focused on chronic noncancer pain, but included a high-dose threshold with associated clinical guidance as a centerpiece. Interestingly, the high-dose threshold was set at 120 mg MEDD in the guideline, but apparently had some impact even at the 50 mg MEDD high-dose level that we monitored for this study (doses as high as 120 mg MEDD were unusual during the acute/subacute phase).

The second policy intervention timepoint represented adoption of enforceable opioid prescribing rules for various professions and operationalization of the PMP as a voluntary resource for clinicians. This second timepoint was significantly associated with decreased trends in three high-risk indicators: 7 days' supply, concurrent, and chronic. The new professional rules were focused on chronic noncancer pain, but did contain elements addressing more frequent monitoring at doses >40 mg MEDD, mandatory pain specialist consultation at doses >120 mg MEDD, and caution regarding concomitant use of benzodiazepines. We were unable to disaggregate the individual impact of the enforceable professional rules versus the PMP due to simultaneous implementation. It is possible that the ability to check for other prescriptions would be particularly important for the concurrent indicator, while the professional rules related to chronic noncancer pain management might be particularly important for the chronic indicator, but we cannot be certain.

The third policy intervention timepoint, representing adoption of the 2013 L&I guideline and associated WC payment rules, was significantly associated with an abrupt drop in level for the chronic

indicator. This result was expected, since the policy newly required prior authorization for opioids prescribed for longer than 6 weeks, as well as for opioids prescribed beyond 12 weeks after injury or surgery. This result also aligns with the marked mid-2013 drop in opioid prescribing during the subacute phase that was reported in an earlier Washington WC study.<sup>53</sup> There was no significant impact on other indicators, despite the guideline's new and expanded focus on the acute/subacute phase (in addition to the chronic phase); this may be related to the fact that the enforceable payment rules were focused only on the subacute phase. Nevertheless, high-risk WC-related prescribing had been decreasing for some time when this guideline was implemented, and those downward trends generally continued.

In summary, although some indicators had significant level and/or trend reductions that were associated with the policy elements one might expect, other changes did not have a clear mechanism of effect. There did appear to be a general shift toward more infrequent opioid prescribing, as well as lower-risk opioid prescribing, over the timeframe of this study. Whether opioid prescribing policies and guidelines serve to reinforce emerging change in practice patterns and standards of care, or whether they serve as a primary driver of such change, is less clear and likely varies by setting and by provider.

The existing literature does not provide strong evidence that the mere presence of a PMP serves to improve prescribing practices.<sup>57,58</sup> Although mandatory PMP use laws may increase PMP utilization by prescribers, it is less clear whether such use directly translates to improvement in prescribing practices.<sup>59</sup> There is also mixed evidence as to whether PMP design features are effective in increasing use or improving prescribing practices.<sup>60,61</sup> In a study comparing PMP registrants with non-registrants, factors other than the PMP itself appeared to have greater influence on prescribing trends.<sup>62</sup> The literature provides some evidence that specifically targeted, monitored, or enforceable opioid policies and guidelines can have measurable impact. For example, state-level implementation of opioid dosing guidelines in Washington, Colorado, and Utah was significantly associated with reductions in opioid overdose hospitalization trends relative to comparator states.<sup>30</sup> Other studies have demonstrated that prior authorization programs, formularies, and automated electronic record alerts can be associated with improved prescribing practices.<sup>63-67</sup> However, these programs may not improve prescribing practices beyond their specific target.<sup>68,69</sup>

Identifying which policy components are most effective can be challenging.<sup>22,28,29</sup> The major strength of this study was the use of long-term population-based data, allowing us to disaggregate several different policy interventions using ITSA techniques. However, we were unable to disaggregate professional opioid prescribing rules and PMP operationalization, due to simultaneous implementation. Qualitative research focused on opioid prescribers and pharmacy staff might shed more light on the most important drivers of changes in high-risk prescribing patterns after multiple contemporaneous policy interventions. A major limitation was the lack of an external comparison group. By restricting high-risk prescribing denominators to injured workers prescribed any WC-related opioids, we partially

controlled for the overall decline in WC-related opioid prescribing; this also would exclude any effects of each policy on overall opioid prescribing prevalence. This study did not attempt to assess potential unintended consequences of opioid prescribing policies, such as inadequate pain management, substitution of non-prescribed opioids, or provider reluctance to prescribe opioids or accept new pain patients. Although chronic pain treatment was the primary focus of some guidelines, this study focused on acute/subacute prescribing practices and did not assess policy impact on chronic prescribing practices.

One challenge for this study was balancing the use of monthly versus quarterly data summaries; quarterly data summaries offered larger, more stable numerators, but at the cost of too few pre-post observations to adequately test all three policy intervention timepoints. Use of monthly summaries may have contributed to a lack of statistical significance for some parameters, due to increased variance. Our opioid prescribing indicators were based on what was filled and covered by WC. It is possible that workers received WC-related opioid prescriptions that they never filled, or were prescribed opioids that were for non-WC conditions, billed to other insurance or paid out-of-pocket; these scenarios would not be evident from WC pharmacy billing data and could result in under-ascertainment of high-risk opioid prescribing. In addition, both MEDD calculations and the date ranges used for detecting overlapping prescriptions were based on the pharmacy estimate of days' supply, which may differ from prescriber-intended days' supply.

## 5 | CONCLUSION

Washington State has been a national leader in promoting safer opioid prescribing practices. This study demonstrates that a public payer, collaborating with other state agencies, can successfully implement policies that may prevent unsafe opioid prescribing practices. One important reason for this is that L&I acts as a single payer for WC, thus avoiding the fragmentation that often plagues delivery systems. Beyond a general shift toward more infrequent and lower-risk WC-related opioid prescribing, this study demonstrated that several state-level opioid prescribing policy interventions were significantly associated with reductions in specific high-risk WC-related opioid prescribing practices during the acute/subacute phase after injury. In turn, safer acute/subacute opioid prescribing practices should reduce transition to chronic opioid use and associated negative health outcomes such as long-term dependence, disability, opioid use disorder, opioid overdose, and mortality.

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### SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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