



sites, making it accessible throughout the state. A later study by Wickizer et al<sup>18</sup> identified that COHE participation led to a 30% reduction in the risk of experiencing long-term work disability. COHE participation may impact the disability outcomes under study, via reinforcing provider adherence to opioid prescribing policies and promoting other occupational health best practices.

The aim of this study was to assess the impact of early high-risk opioid prescribing practices (during the first 90 days following injury) on several disability-related outcomes, including duration of time loss benefits for time missed from work, receipt of total permanent disability (workers' compensation pension), and a surrogate measure for receipt of Social Security disability benefits. Additionally, we assessed whether COHE participation modified the association between early high-risk opioid prescribing practices and disability-related outcomes. Finally, we took several steps to address concerns regarding confounding by indication, where the reason for receiving a medication is related to the outcome of interest, by adding key measures and including sensitivity analyses to control for injury severity. The study adds to the literature by including a measure for receipt of Social Security benefits and by including over 10 years of workers' compensation data.

## METHODS

### Study Design

We used a retrospective cohort design and logistic regression models to test the association between early high-risk opioid prescribing patterns and work-related disability outcomes. We obtained administrative data from the Washington State Department of Labor and Industries (DLI) for injured workers. The DLI State Fund insures two-thirds of the non-federal workers in Washington State (one-third are employed by firms that self-insure).<sup>19</sup> By law, all firms that do not self-insure are required to purchase workers' compensation insurance through the State Fund.

### Study Population

The study population included injured workers with accepted DLI State Fund workers' compensation claims for incident injuries from July 1, 2002 through August 30, 2013. In recent years, the State Fund has paid claims for approximately 85,000 injured workers per year. Follow-up time for each injured worker was restricted to exactly 5 years for each of the outcomes. We included in-state residents aged 18 to 56 years who filled at least one opioid prescription within the first 6 weeks of the date of injury. Workers were included if their first attending provider was in a profession authorized to prescribe opioids (ie, medical or osteopathic physician, physician assistant, or nurse practitioner) but excluded if their first attending provider was either not authorized to prescribe opioids or had an identified specialty outside primary care (primary care was defined to include general practice, family practice, pediatrics, internal medicine, public health, occupational medicine, or geriatrics). In Washington State, providers are legally required to file an accident report within 5 days of identifying a work-related injury or illness, and the provider that files the accident report is identified as the first attending provider. The restriction to include only workers with a first attending primary care provider was intended to enhance homogeneity of the sample, as well as to exclude more severe cases, such as those for whom a surgeon was initially and primarily responsible, in addition to reducing threats of confounding by indication. Opioid prescribing guidelines differ for cancer-related pain; therefore, injured workers with cancer were excluded. Injured workers with a diagnosis of cancer other than nonmelanoma skin cancers were excluded using International Classification of Diseases, Ninth Revision, Clinical Modification, and Tenth Revision, Clinical Modification (ICD-9-CM and ICD-10-CM) codes, using hospital and medical records from within the first 120 days of injury. Nonmelanoma skin cancers were not included

in our cancer definition because such cancers typically do not involve chronic pain requiring opioids. Finally, workers who died within the 5 years of follow-up time were excluded.

There were 1,171,699 incident State Fund workers' compensation claims by injured workers from July 1, 2002 through August 30, 2013. Restricting to those with a first attending primary care provider resulted in 567,054 claims by injured workers, and further restriction to having at least one filled opioid prescription within the first 6 weeks of injury resulted in 93,987 eligible claims by injured workers. After step-wise exclusions for age ( $n=7236$ ), cancer ( $n=28$ ), out of state residency ( $n=3330$ ), and those who died within 5 years of follow-up ( $n=243$ ), the final study population consisted of 83,150 claims by injured workers with a first attending primary care provider and an opioid prescription filled within the first 6 weeks of injury. The study was approved by the University of Washington Institutional Review Board.

### Opioid Prescribing Indicators

We constructed five high-risk opioid prescribing indicators as follows: (1) more than 7 days of opioids in the acute phase of injury (first 6 weeks); and during the first 90 days after injury, measures of: (2) high-dose opioid prescribing, (3) chronic opioid prescribing, (4) concurrent opioid and sedative prescribing, and (5) a composite high-risk opioid prescribing indicator. To calculate opioid prescription date ranges and prescription overlap for the various indicators, we used fill date (start date) in conjunction with days' supply. High-dose opioid prescribing was defined as having a mean MEDD of over 50 mg, averaged over the number of days with any opioids supplied within the first 90 days of injury. If there were multiple opioid prescriptions with overlapping date ranges (based on fill dates and days' supply), their cumulative MEDD was summed on any days of overlap. Chronic opioid prescribing was defined as having 60 or more total days' supply of opioids within the first 90 days of injury. Concurrent opioid prescribing was defined as having at least 1 day of overlap of an opioid with a sedative, prescribed within the first 90 days of injury. The first four indicators were not mutually exclusive. The composite high-risk opioid prescribing indicator was defined as the maximum of all the previous four high-risk opioid prescribing indicators. The comparison group, those exposed to only low-risk opioid prescribing, consisted of workers who had an opioid prescription but did not have any of the high-risk opioid prescribing indicators during the first 90 days of injury. The composite high-risk indicator and the low-risk indicator were mutually exclusive.

An opioid prescription was defined as a payment by DLI for a prescription that had the following assigned therapeutic class codes: H30, H3A, H3N, H3U, H3X, and H3Z, which include codeine, hydrocodone, morphine, oxycodone, and tramadol, among others.<sup>20,21</sup> A sedative was defined as any of the following drugs/classes: benzodiazepines, barbiturates, carisoprodol, and non-benzodiazepine hypnotics.

### Measures

When an injured worker misses more than 3 days of work due to an injury, they may receive temporary disability payments (time loss) for time missed from work. We analyzed four work disability outcome (binary) measures: (1) receiving more than 90 days of time loss following the date of injury; (2) receiving more than 1 year of time loss; (3) receipt of a DLI pension for total permanent disability (workers' compensation pension); and (4) a measure for receipt of income support from SSA, recorded by DLI in a Social Security offset (SSO) data field. Workers receiving time loss payments and who are in receipt of SSDI or supplemental security income (SSI) through the Social Security Administration (SSA) have an offset to their payments recorded in the workers' compensation database. Since these offsets are captured systematically in the DLI computerized data system, we assessed the risk of transition to receipt of Social Security income

support related to early high-risk receipt of opioids. The DLI SSO indicator could reflect retirement, SSDI, or SSI payments, and they are not distinguishable in the available data. We excluded workers who would have been older than 61 by the end of the 5-year follow-up period (ie, restricted to workers under 57 years old at injury), in order to focus primarily on disability rather than retirement payments, and because offset rules differ for injured workers ages 62 and up.

DLI administrative data provided a number of variables that were included as covariates in our logistic regression models in order to control for potential confounding. Binary variables included: (1) sex (referent: male); (2) whether the worker had any dependents (referent: no dependents); (3) marital status (referent: not married); (4) preferred language (referent: English); (5) employer size (referent: less than 50 full time employees [FTE]); (6) hospitalization within the first 7 days of injury (referent: none within first 7 days)<sup>22,23</sup>; and (7) first attending provider enrolled in COHE at the time of injury (referent: not enrolled).<sup>24</sup> Categorical variables included: (1) age (in years) at the time of injury; (2) industry sector when injured, based on North American Industry Classification System (NAICS) codes,<sup>25</sup> collapsed to nine categories (referent: construction/utilities/mining); (3) occupation when injured, based on Standard Occupational Classification 2000 codes,<sup>26</sup> collapsed to 11 categories and a category for unclassifiable/missing (referent: construction/extraction); (4) provider type, including physician, nurse practitioner, or physician assistant (referent: physician); (5) urban-rural county according to the 2013 National Center for Health Statistics (NCHS) 6-category urban-rural county classification scheme (referent: Large central metro)<sup>27</sup>; (6) body part, categorized as lower extremity, upper extremity, back/neck, other/multiple, and using Occupational Injury and Illness Classification System (OIICS) 1.01 codes (referent: lower extremity)<sup>28</sup>; and (7) nature of injury, categorized as fractures, strains/sprains/tears, other traumatic injuries, and other/multiple using OIICS 1.01 codes (referent: fractures).<sup>28</sup> We included a hazard group based on DLI-assigned employer risk class, which was developed for insurance administration purposes to classify risk of compensable injury or illness. The hazard group ranks risk classes in groups from one as the lowest risk to nine as the highest risk, and was included as a continuous variable.<sup>29</sup> Finally, the year of injury was included as an indicator variable to control for temporal effects.

Measures of early hospitalization, body part, and nature of injury, are of particular importance to further address concerns of confounding by indication. Their inclusion, in addition to our previous restrictions to those having an opioid prescribed within 6 weeks after injury, and having a first attending primary care provider, were included to help address injury severity among injured workers.

## Data Analysis

We used logistic regression models for each of the four outcomes described earlier. The exposure of interest was high-risk versus low-risk opioid prescribing. The adjusted models controlled for the covariates discussed above, with robust standard errors adjusted to account for clustering within providers using a unique provider identification number. We also tested for an interaction between high-risk prescribing and COHE participation, as we hypothesized that COHE participation might modify the association between high-risk opioid prescribing and each of the outcomes.<sup>24</sup> The interaction term was added to adjusted models for each of the outcomes.

We performed several sensitivity analyses to determine whether the estimates generated from our analyses were sensitive to certain assumptions and added measures of injury severity for two analyses to address confounding by indication concerns. The first sensitivity analysis was restricted to incident injuries occurring from July 2002 through December 2006, limiting to injuries occurring before the 2007 educational pilot of opioid prescribing guidelines.<sup>8</sup>

The 2007 educational pilot was associated with a reduction in high-risk prescribing, and the restriction helps to minimize possible temporal and policy intervention effects.<sup>30</sup>

The second sensitivity analysis assessed the impact of injury severity as a potential confounder using the Abbreviated Injury Scale (AIS). We ran adjusted models after restricting to workers with traumatic injuries for which an AIS severity score could be calculated. AIS was calculated from diagnosis codes in medical/hospital billing data for the first 7 days after injury, using crosswalks obtained from the Association for the Advancement of Automotive Medicine (AAAM).<sup>31,32</sup> The maximum AIS score across body regions for each worker was added to the adjusted model and was categorized as a score of 1 to 2 versus 3 to 6, based upon an ordinal scale of 1 = minor to 6 = maximal (referent: AIS 1–2). We categorized the AIS score because of the relatively small number of injured workers with higher scores. A maximum AIS of three and above roughly corresponds to injuries likely to require hospitalization.

The third sensitivity analysis restricted our sample to those with low back conditions, excluding those with fractures. We created a severity indicator with three levels as defined by Krause et al,<sup>33</sup> based upon the most severe low back condition within the first 90 days after injury, using ICD-9-CM diagnosis codes from medical and hospital billing data. The low back conditions were identified using the “definite” ICD-9-CM codes identified in Cherkin et al.<sup>34</sup> Low severity was defined as having probable degenerative changes or non-specific backache.<sup>33</sup> Medium severity was defined as having sciatica, possible instability, or herniated lumbar disc without myelopathy.<sup>33</sup> High severity was defined as having postlaminectomy syndrome, spinal stenosis, or herniated lumbar disc with myelopathy.<sup>33</sup> The severity measure was added to the main model as a set of indicator variables.

The fourth sensitivity analysis was restricted to those injured workers who did not have an opioid prescription filled during the 90 days prior to injury, based upon Washington State Prescription Monitoring Program (PMP) data.<sup>35</sup> We implemented this restriction to minimize confounding due to having opioids prescribed prior to being injured, since those already on opioids may be more likely to have been prescribed higher doses, or have more days’ supply, independent of opioid indication. The PMP became operational in January 2012. To allow a full 90 days of complete PMP data, we further restricted these data to injuries occurring on or after April 1, 2012. All analyses were conducted using Stata 15.1,<sup>36</sup> and variable and data frame construction was conducted using R version 3.6.0.<sup>37</sup>

## RESULTS

Injured workers had a mean age of 36.9 years and were mostly men (69%). Most did not indicate preference of a language other than English (91.1%), were not currently married (55.6%), and did not have dependents (71.5%). Further descriptive statistics of the study population are shown in Table 1.

A total of 12,792 (15.4%) injured workers were off work and on disability (time loss) for more than 90 days following injury, 6250 (7.5%) injured workers were off work and on disability for more than 1 year following injury, 330 (0.4%) injured workers received a pension for total permanent disability, and 568 (0.7%) had an SSO at some point during the follow-up period (Table 2). Of the injured workers, 36.8% were exposed to more than 7 days of opioids within the acute phase of injury, 14.1% were exposed to high-dose prescribing, 3.3% were exposed to chronic prescribing, and 3.8% were exposed to concurrent prescribing. Composite high-risk opioid prescribing was identified in almost half of the study population (46.5%). Among workers exposed to high-risk opioid prescribing, 23.8% had more than 90 days of time loss compared to 8.1% for those exposed to low-risk prescribing, 11.8% had more than 1 year of time loss days compared with 3.8% for low-risk, 0.7%

**TABLE 1.** Characteristics of the Study Population Among Those Prescribed At least One Opioid Within the First 6 Weeks of Injury

	Total		Composite High-Risk Indicator		Composite Low-Risk Indicator	
	N	%	N	%	N	%
	83,150		38,680		44,470	
Age at injury						
18–25 years	14,384	(17.3)	5,394	(13.9)	8,990	(20.2)
26–33 years	19,321	(23.2)	8,505	(22.0)	10,816	(24.3)
34–41 years	18,734	(22.5)	9,038	(23.4)	9,696	(21.8)
42–49 years	18,994	(22.8)	9,629	(24.9)	9,365	(21.1)
50–56 years	11,717	(14.1)	6,114	(15.8)	5,603	(12.6)
Sex						
Male	57,291	(68.9)	26,671	(69.0)	30,620	(68.9)
Female	25,857	(31.1)	12,008	(31.0)	13,849	(31.1)
Missing	2	(0.0)	1	(0.0)	1	(0.0)
Preferred language						
English	75,722	(91.1)	35,620	(92.1)	40,102	(90.2)
Other	7,428	(8.9)	3,060	(7.9)	4,368	(9.8)
Currently married						
No	46,231	(55.6)	20,874	(54.0)	25,357	(57.0)
Yes	36,656	(44.1)	17,727	(45.8)	18,929	(42.6)
Missing	263	(0.3)	79	(0.2)	184	(0.4)
Any dependents						
No	59,480	(71.5)	26,138	(67.6)	33,342	(75.0)
Yes	23,670	(28.5)	12,542	(32.4)	11,128	(25.0)
Industry*						
Construction	15,496	(18.6)	7,375	(19.1)	8,121	(18.3)
Agriculture	4,650	(5.6)	2,024	(5.2)	2,626	(5.9)
Arts	6,989	(8.4)	2,890	(7.5)	4,099	(9.2)
Education	10,733	(12.9)	5,268	(13.6)	5,465	(12.3)
Information	4,559	(5.5)	2,006	(5.2)	2,553	(5.7)
Manufacturing	10,383	(12.5)	4,714	(12.2)	5,669	(12.7)
Retail/wholesale trade	14,125	(17.0)	6,614	(17.1)	7,511	(16.9)
Services	12,387	(14.9)	5,838	(15.1)	6,549	(14.7)
Transportation	3,809	(4.6)	1,939	(5.0)	1,870	(4.2)
Missing	19	(0.0)	12	(0.0)	7	(0.0)
Occupation†						
Construction	13,006	(15.6)	6,125	(15.8)	6,881	(15.5)
Building	5,060	(6.1)	2,394	(6.2)	2,666	(6.0)
Business	4,914	(5.9)	2,375	(6.1)	2,539	(5.7)
Farming	3,411	(4.1)	1,464	(3.8)	1,947	(4.4)
Food prep	5,292	(6.4)	2,087	(5.4)	3,205	(7.2)
Health care	5,616	(6.8)	2,648	(6.8)	2,968	(6.7)
Installation	7,155	(8.6)	3,207	(8.3)	3,948	(8.9)
Personal care	2,376	(2.9)	1,124	(2.9)	1,252	(2.8)
Production	9,591	(11.5)	4,330	(11.2)	5,261	(11.8)
Sales	7,044	(8.5)	3,389	(8.8)	3,655	(8.2)
Transportation	12,014	(14.4)	5,941	(15.4)	6,073	(13.7)
Unclassifiable	7,671	(9.2)	3,596	(9.3)	4,075	(9.2)
Employer size						
<50 FTE	39,336	(47.3)	18,113	(46.8)	21,223	(47.7)
≥50 FTE	43,629	(52.5)	20,449	(52.9)	23,180	(52.1)
Missing	185	(0.2)	118	(0.3)	67	(0.2)
Hazard group						
Presented as mean and std. dev.	4.4	(2.5)	4.5	(2.5)	4.4	(2.5)
Provider type						
Physician (MD&DO)	56,764	(68.3)	27,558	(71.2)	29,206	(65.7)
Physician assistant	18,665	(22.4)	7,858	(20.3)	10,807	(24.3)
Nurse practitioner	7,721	(9.3)	3,264	(8.4)	4,457	(10.0)
COHE participation						
No	61,064	(73.4)	28,923	(74.8)	32,141	(72.3)
Yes	22,086	(26.6)	9,757	(25.2)	12,329	(27.7)
Urban-rural						
Large central metro	15,461	(18.6)	6,554	(16.9)	8,907	(20.0)
Large fringe metro	27,550	(33.1)	13,345	(34.5)	14,205	(31.9)
Medium metro	17,099	(20.6)	8,035	(20.8)	9,064	(20.4)
Small metro	12,909	(15.5)	5,436	(14.1)	7,473	(16.8)
Metropolitan	7,392	(8.9)	3,906	(10.1)	3,486	(7.8)

TABLE 1. (Continued)

	Total		Composite High-Risk Indicator		Composite Low-Risk Indicator	
	N	%	N	%	N	%
Noncore	2,081	(2.5)	1,097	(2.8)	984	(2.2)
Missing	658	(0.8)	307	(0.8)	351	(0.8)
Body part						
Lower extremity	14,196	(17.1)	6,578	(17.0)	7,618	(17.1)
Upper extremity	26,623	(32.0)	10,965	(28.3)	15,658	(35.2)
Back/neck	24,746	(29.8)	12,912	(33.4)	11,834	(26.6)
Other/multiple	17,552	(21.1)	8,204	(21.2)	9,348	(21.0)
Missing	33	(0.0)	21	(0.1)	12	(0.0)
Nature of injury						
Fracture	6,343	(7.6)	3,288	(8.5)	3,055	(6.9)
Strain/sprain/tear	43,495	(52.3)	22,293	(57.6)	21,202	(47.7)
Other traumatic injuries	27,004	(32.5)	9,680	(25.0)	17,324	(39.0)
Other/multiple	6,285	(7.6)	3,404	(8.8)	2,881	(6.5)
Missing	23	(0.0)	15	(0.0)	8	(0.0)
Hospitalized within 7 days						
No	82,671	(99.4)	38,282	(99.0)	44,389	(99.8)
Yes	479	(0.6)	398	(1.0)	81	(0.2)
Year						
2002	2,689	(3.2)	1,379	(3.6)	1,310	(2.9)
2003	5,765	(6.9)	2,946	(7.6)	2,819	(6.3)
2004	6,485	(7.8)	3,171	(8.2)	3,314	(7.5)
2005	6,781	(8.2)	3,394	(8.8)	3,387	(7.6)
2006	6,968	(8.4)	3,503	(9.1)	3,465	(7.8)
2007	6,476	(7.8)	3,268	(8.4)	3,208	(7.2)
2008	8,752	(10.5)	4,055	(10.5)	4,697	(10.6)
2009	8,315	(10.0)	3,819	(9.9)	4,496	(10.1)
2010	8,846	(10.6)	3,915	(10.1)	4,931	(11.1)
2011	8,530	(10.3)	3,728	(9.6)	4,802	(10.8)
2012	8,385	(10.1)	3,432	(8.9)	4,953	(11.1)
2013	5,158	(6.2)	2,070	(5.4)	3,088	(6.9)

\*Industry categories: (1) Construction, utilities, mining; (2) Agriculture, forestry, fishing, hunting; (3) Arts, entertainment, hospitality; (4) Education, health care, social services; (5) Information, finance, real estate, professional, technology; (6) Manufacturing; (7) Retail/wholesale trade; (8) Services: administrative, support, waste, other (9) Transportation, warehousing.

<sup>†</sup>Occupation categories: (1) Construction, extraction; (2) Building/grounds, maintenance, protective; (3) Business, science, social services, education, arts, entertainment; (4) Farming, fishing, forestry; (5) Food preparation and service; (6) Health care; (7) Installation, maintenance, repair; (8) Personal care and service; (9) Production; (10) Sales, office, administrative support; (11) Transportation; (12) Unclassifiable.

had received total permanent disability compared with 0.2% for low-risk, and 1.1% had an SSO compared with 0.3% for low-risk.

For each of the outcomes of interest, exposure to high-risk opioid prescribing was associated with more than a two times higher odds of a work-related disability, when compared with workers exposed to low-risk opioid prescribing. In adjusted models, exposure to high-risk opioid prescribing was associated with a 3.12 times

higher odds (95% CI: 2.97, 3.27) of more than 90 days of time loss, a 2.88 times higher odds (95% CI: 2.71, 3.06) of more than 1 year of time loss, a 3.11 times higher odds (95% CI: 2.39, 4.05) of total permanent disability, and a 2.76 times higher odds (95% CI: 2.26, 3.38) of SSO, on average, when compared with low-risk opioid prescribing exposure (Table 3). Missing data resulted in 1601 cases being excluded from the adjusted logistic regression analyses.

TABLE 2. Work-Related Disability Outcomes by Opioid Prescribing Indicator

	Overall	TL >90 days		TL >1 year		TPD		SSO	
	n	n	%	n	%	n	%	n	%
Low-risk indicator	83,150	12,792	15.4%	6,250	7.5%	330	0.4%	568	0.7%
Composite high-risk indicator	44,470	3,592	8.1%	1,693	3.8%	74	0.2%	140	0.3%
Specific high-risk indicators	38,680	9,200	23.8%	4,557	11.8%	256	0.7%	428	1.1%
>7 days in acute phase	30,614	7,951	26.0%	6,250	20.4%	223	0.7%	382	1.2%
High-dose	11,754	2,881	24.5%	1,370	11.7%	77	0.7%	129	1.1%
Chronic	2,754	1,167	42.4%	641	23.3%	48	1.7%	65	2.4%
Concurrent with sedatives	3,149	1,359	43.2%	766	24.3%	142	4.5%	130	4.1%

SSO, Social Security offset; TL, time loss; TPD, total permanent disability.

**TABLE 3.** Associations of High-Risk Opioid Prescribing in Relation to Work Disability Outcomes Among those Prescribed At Least One Opioid Within the First 6 Weeks of Injury

Logistic Regression	TL >90 days		TL >1 year		TPD		SSO	
	81,549 OR	95% CI	81,549 OR	95% CI	81,549 OR	95% CI	81,549 OR	95% CI
Observations								
Opioid prescribing								
Low-risk indicator	Ref		Ref		Ref		Ref	
Composite high-risk indicator	3.12	2.97, 3.27	2.88	2.71, 3.06	3.11	2.39, 4.05	2.76	2.26, 3.38
Age at injury								
18–25	0.37	0.34, 0.40	0.27	0.24, 0.31	0.01	0.00, 0.05	0.04	0.02, 0.07
26–33	0.49	0.46, 0.53	0.48	0.44, 0.52	0.06	0.03, 0.10	0.06	0.04, 0.10
34–41	0.60	0.56, 0.64	0.63	0.58, 0.69	0.14	0.10, 0.21	0.21	0.16, 0.27
42–49	0.85	0.80, 0.91	0.86	0.80, 0.93	0.45	0.35, 0.57	0.45	0.37, 0.55
50–56	Ref		Ref		Ref		Ref	
Sex								
Male	Ref		Ref		Ref		Ref	
Female	1.39	1.31, 1.47	1.47	1.36, 1.59	0.91	0.66, 1.27	1.09	0.86, 1.39
Preferred language								
English	Ref		Ref		Ref		Ref	
Other	1.79	1.64, 1.94	2.05	1.83, 2.29	3.41	2.35, 4.95	1.01	0.68, 1.51
Marital status								
No	Ref		Ref		Ref		Ref	
Yes	0.91	0.87, 0.95	0.96	0.91, 1.02	1.32	1.05, 1.67	1.14	0.95, 1.36
Dependents								
No	Ref		Ref		Ref		Ref	
Yes	1.82	1.73, 1.90	1.35	1.26, 1.44	0.30	0.21, 0.44	0.61	0.48, 0.77
Industry*								
Construction	Ref		Ref		Ref		Ref	
Agriculture	0.90	0.77, 1.05	0.76	0.62, 0.92	0.80	0.44, 1.49	0.98	0.52, 1.82
Arts	1.17	1.02, 1.34	1.01	0.85, 1.21	1.02	0.48, 2.19	1.14	0.65, 2.03
Education	1.12	0.99, 1.26	0.95	0.81, 1.10	1.05	0.56, 1.96	1.15	0.74, 1.79
Information	0.97	0.87, 1.10	0.93	0.80, 1.08	0.75	0.39, 1.44	1.63	1.06, 2.50
Manufacturing	0.81	0.73, 0.91	0.87	0.76, 1.00	1.00	0.63, 1.59	1.28	0.89, 1.84
Retail/Wholesale trade	0.99	0.90, 1.10	0.91	0.81, 1.02	0.64	0.38, 1.06	0.73	0.49, 1.08
Services	1.14	1.04, 1.25	0.93	0.83, 1.05	0.73	0.47, 1.13	0.92	0.65, 1.31
Transportation	1.20	1.06, 1.35	1.10	0.95, 1.28	0.92	0.52, 1.60	1.31	0.84, 2.03
Occupation†								
Construction	Ref		Ref		Ref		Ref	
Maintenance	1.10	0.99, 1.23	0.99	0.86, 1.15	1.71	0.99, 2.98	0.85	0.55, 1.32
Business	0.65	0.58, 0.74	0.66	0.56, 0.78	0.95	0.52, 1.72	0.52	0.33, 0.83
Farming	0.99	0.84, 1.17	0.90	0.73, 1.12	1.27	0.65, 2.50	0.56	0.28, 1.15
Food prep	0.86	0.74, 0.99	0.97	0.80, 1.18	0.61	0.21, 1.72	0.87	0.45, 1.68
Health care	0.96	0.84, 1.10	0.94	0.79, 1.13	1.26	0.62, 2.54	0.69	0.42, 1.12
Installation	0.82	0.74, 0.90	0.86	0.75, 0.98	0.88	0.53, 1.46	0.71	0.48, 1.04
Personal care	1.05	0.90, 1.22	1.06	0.88, 1.29	1.03	0.41, 2.61	0.79	0.44, 1.41
Production	0.85	0.76, 0.94	0.83	0.73, 0.95	1.36	0.86, 2.15	0.70	0.48, 1.02
Sales	0.85	0.76, 0.95	0.83	0.71, 0.97	0.90	0.47, 1.75	0.73	0.47, 1.13
Transportation	1.00	0.91, 1.10	0.92	0.81, 1.04	1.58	0.99, 2.53	0.82	0.57, 1.17
Unclassifiable	0.86	0.78, 0.95	0.81	0.71, 0.92	1.09	0.65, 1.81	0.60	0.40, 0.90
Employer size								
<50 FTE	Ref		Ref		Ref		Ref	
≥50 FTE	0.78	0.74, 0.81	0.73	0.69, 0.77	0.79	0.63, 0.99	0.98	0.82, 1.17
Hazard group	1.08	1.07, 1.10	1.10	1.08, 1.12	1.13	1.06, 1.21	1.04	0.99, 1.10
Provider type								
Physician (MD&DO)	Ref		Ref		Ref		Ref	
Physician assistant	0.94	0.88, 1.02	0.90	0.82, 0.98	1.04	0.76, 1.43	0.90	0.71, 1.14
Nurse practitioner	1.08	0.99, 1.18	1.02	0.92, 1.14	1.36	0.93, 1.99	0.82	0.61, 1.11
COHE participation								
No	Ref		Ref		Ref		Ref	
Yes	0.90	0.84, 0.96	0.86	0.79, 0.93	0.87	0.65, 1.17	0.91	0.74, 1.13
Urban-rural								
Large central metro	Ref		Ref		Ref		Ref	
Large fringe metro	1.20	1.11, 1.30	1.35	1.22, 1.48	1.36	0.89, 2.07	1.29	0.95, 1.76
Medium metro	1.25	1.15, 1.36	1.49	1.34, 1.66	2.14	1.40, 3.27	2.04	1.49, 2.80
Small metro	1.15	1.05, 1.27	1.40	1.26, 1.57	2.36	1.53, 3.65	2.58	1.85, 3.58
Micropolitan	1.31	1.17, 1.47	1.68	1.47, 1.93	2.77	1.71, 4.47	2.08	1.43, 3.02
Noncore	1.42	1.20, 1.67	1.58	1.30, 1.92	3.73	2.06, 6.75	3.35	2.13, 5.26
Body part								
Lower extremity	Ref		Ref		Ref		Ref	
Upper extremity	0.93	0.88, 0.99	1.03	0.94, 1.13	0.92	0.62, 1.36	0.77	0.56, 1.07

TABLE 3. (Continued)

Logistic Regression	TL >90 days		TL >1 year		TPD		SSO	
Back/neck	0.96	0.90, 1.02	1.33	1.22, 1.46	1.89	1.32, 2.69	1.63	1.22, 2.18
Other/multiple	0.92	0.86, 0.98	1.22	1.11, 1.33	1.23	0.84, 1.82	1.61	1.20, 2.15
Nature of injury								
Fracture	Ref		Ref		Ref		Ref	
Strain/sprain/tear	1.31	1.21, 1.43	1.79	1.58, 2.02	1.86	1.08, 3.19	1.99	1.29, 3.06
Other traumatic injuries	0.70	0.64, 0.77	0.99	0.87, 1.13	1.34	0.77, 2.33	1.32	0.86, 2.02
Other/multiple	1.42	1.28, 1.57	1.83	1.58, 2.12	1.65	0.90, 3.01	2.03	1.26, 3.27
Hospitalized within 7 days								
No	Ref		Ref		Ref		Ref	
Yes	3.61	2.98, 4.37	3.07	2.44, 3.87	3.86	1.89, 7.90	2.74	1.42, 5.26
Year								
2002	Ref		Ref		Ref		Ref	
2003	0.98	0.85, 1.12	0.91	0.76, 1.10	1.06	0.55, 2.06	0.83	0.49, 1.39
2004	1.01	0.88, 1.16	0.95	0.79, 1.14	1.05	0.54, 2.03	0.59	0.34, 1.03
2005	0.96	0.83, 1.11	0.89	0.74, 1.07	0.93	0.48, 1.82	0.74	0.43, 1.26
2006	1.00	0.86, 1.15	0.98	0.81, 1.18	0.93	0.47, 1.85	0.97	0.57, 1.64
2007	1.02	0.88, 1.17	1.09	0.90, 1.32	0.81	0.40, 1.64	1.04	0.61, 1.76
2008	0.97	0.84, 1.11	1.12	0.94, 1.34	0.95	0.49, 1.83	0.85	0.51, 1.42
2009	1.03	0.89, 1.19	1.09	0.90, 1.32	0.72	0.37, 1.43	0.89	0.53, 1.49
2010	1.00	0.87, 1.15	1.03	0.85, 1.24	0.52	0.25, 1.08	0.96	0.58, 1.60
2011	0.96	0.83, 1.11	0.97	0.80, 1.18	0.58	0.28, 1.21	1.01	0.60, 1.69
2012	1.05	0.91, 1.21	0.99	0.82, 1.20	0.67	0.34, 1.32	1.03	0.62, 1.73
2013	0.99	0.85, 1.16	0.94	0.76, 1.15	0.58	0.27, 1.25	0.71	0.39, 1.29

FTE, full time employees; SSO, Social Security offset; TL, time loss; TPD, total permanent disability.

\*Industry categories: (1) Construction, utilities, mining; (2) Agriculture, forestry, fishing, hunting; (3) Arts, entertainment, hospitality; (4) Education, health care, social services; (5) Information, finance, real estate, professional, technology; (6) Manufacturing; (7) Retail/wholesale trade; (8) Services: administrative, support, waste, other (9) transportation, warehousing.

<sup>†</sup>Occupation categories: (1) Construction, extraction; (2) Building/grounds, maintenance, protective; (3) Business, science, social services, education, arts, entertainment; (4) Farming, fishing, forestry; (5) Food preparation and service; (6) Health care; (7) Installation, maintenance, repair; (8) Personal care and service; (9) Production; (10) Sales, office, administrative support; (11) Transportation; (12) Unclassifiable.

There was no strong evidence that COHE participation modified the association between high-risk opioid prescribing and work-related outcomes. The odds ratio for the multiplicative interaction term was 0.96 (95% CI: 0.86, 1.07) for having 90 days of time loss, 1.03 (95% CI: 0.89, 1.19) for having more than 1 year of time loss, 0.63 (95% CI: 0.36, 1.11) for having total permanent disability, and 1.01 (95% CI: 0.64, 1.58) for having an SSO.

While the odds ratios of interest varied slightly for the first three sensitivity analyses, they remained statistically significant, with injured workers exposed to high-risk prescribing having an odds ratio at least two times higher than injured workers exposed to low-risk opioid prescribing, on average, while holding all other covariates constant. In particular, the TPD outcome had a markedly higher odds ratio prior to policy interventions based upon results from the first sensitivity analysis. The fourth sensitivity analysis, restricting to those without opioid prescriptions in the 90 days before injury, had a similar direction of the effect for all outcomes, however, the results only remained statistically significant for the time loss outcomes. Table 4 provides a summary of the adjusted odds ratios for the main analysis and the sensitivity analyses.

## DISCUSSION

This paper adds to the growing understanding of the effect of opioid prescribing on work-related disability outcomes by (1) including receipt of Social Security disability benefits as an important outcome, (2) including over 10 years of workers' compensation data, and (3) restricting the study population to include only injured workers who were prescribed early opioids, in order to focus the comparisons on differences in opioid prescribing patterns rather

than on need for opioids. Injured workers who were exposed to high-risk versus low-risk opioid prescribing had a two to three times higher odds of experiencing an adverse work-related disability outcome. Those exposed to high-risk versus low-risk opioid prescribing had a 3.11 times higher odds of receiving a pension for permanent total disability and a 2.76 times higher odds of receiving income support through the Social Security Administration, on average.

There were notable differences between workers' sex and workers' employer size in relation to having a work-related disability outcome. Female workers were more at risk of having more than 90 days (OR 1.39) or 1 year of time loss (OR 1.47), on average, when compared with males in adjusted models. However, there was no strong evidence of sex differences for total permanent disability or receipt of a Social Security offset. Injured workers employed at larger workplaces (50 or more FTE) were less likely to have 90 days of time loss (OR 0.78), 1 year of time loss (0.73), and receipt of total disability (0.79), on average, when compared with injured workers employed at smaller workplaces. There was no evidence of a protective effect for workplace size in relation to having a Social Security offset, however. These findings are similar to a previous study of Washington workers, which found that women were 15% less likely to return to work earlier, and those with an employer size of 50 or more were 8% more likely to return to work earlier.<sup>22</sup>

Musculoskeletal conditions typically seen in workers' compensation systems account for three of the top five categories of years lived with disability in the United States.<sup>38</sup> In a separate study, even modest efforts at improving opioid prescribing practices in Washington State were associated with a reduction in the transition

**TABLE 4.** A Summary of the Adjusted Associations of High-Risk Opioid Prescribing in Relation to Work Disability Outcomes Among Those Prescribed At Least One Opioid Within the First 6 Weeks of Injury

Model	TL >90 days		TL >1 year		TPD		SSO	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Main model* (n = 81,549)								
Low-risk indicator	Ref		Ref		Ref		Ref	
Composite high-risk indicator	3.12	2.97, 3.27	2.88	2.71, 3.06	3.11	2.39, 4.05	2.76	2.26, 3.38
Restricted to time period before policy interventions <sup>†</sup> (n = 28,146)								
Low-risk indicator	Ref		Ref		Ref		Ref	
Composite high-risk indicator	2.99	2.76, 3.23	2.67	2.40, 2.97	5.60	3.36, 9.33	3.17	2.20, 4.58
Traumatic injury subset; added control for severity <sup>‡</sup> (n = 59,982)								
Low-risk indicator	Ref		Ref		Ref		Ref	
Composite high-risk indicator	3.58	3.38, 3.80	3.29	3.05, 3.56	3.22	2.32, 4.49	3.16	2.44, 4.09
Restricted to low back conditions; added control for severity <sup>§</sup> (n = 19,068)								
Low-risk indicator	Ref		Ref		Ref		Ref	
Composite high-risk indicator	2.22	2.04, 2.42	2.19	1.96, 2.45	3.06	1.92, 4.88	2.43	1.69, 3.49
Restricted to subset with no opioid prescriptions during 90 days before injury <sup>¶</sup> (n = 9,705)								
Low-risk indicator	Ref		Ref		Ref		Ref	
Composite high-risk indicator	2.93	2.55, 3.37	2.51	2.08, 3.04	1.52	0.72, 3.19	1.65	0.98, 2.80

SSO, Social Security offset; TL, time loss; TPD, total permanent disability.

\*Adjusted for age, sex, preferred language, marital status, dependents, industry, occupation, employer size, hazard group, provider type, COHE participation, urban-rural, body part, nature of injury, hospitalization within 7 days, and year of injury.

<sup>†</sup>Restricted to workers with incident injuries from 2002 through 2006. Adjusted with main model covariates.

<sup>‡</sup>Restricted to workers with traumatic injuries for which an Abbreviated Injury Scale score could be calculated. Adjusted with main model covariates and AIS severity score.

<sup>§</sup>Restricted to injured workers with low back conditions, excluding fractures. Adjusted with main model covariates (except for nature of injury) and severity of lower back condition.

<sup>¶</sup>Restricted to injured workers with an incident injury on or after April 1, 2012, who did not have an opioid prescription 90 days prior to injury based upon Washington statewide Prescription Monitoring Program data. Adjusted with main model covariates.

from acute to chronic opioid prescribing.<sup>30</sup> In 2007, approximately 7.5% of injured workers who received an early opioid prescription transitioned to chronic opioids, and by 2010, the incidence of transition was reduced to approximately 5%. After promulgation of new rules that specifically targeted reducing transition from acute to chronic opioid prescribing in 2013, the rate of transition was reduced to less than 1%.<sup>39</sup>

A previous study that explored the association between COHE participation and longer-term disability outcomes showed a 30% reduction in risk of experiencing long-term work disability.<sup>18</sup> Although we observed a protective effect of COHE participation for the time loss outcomes, there was no evidence of a protective effect for the total permanent disability and SSO outcomes. Additionally, there was no evidence supporting a multiplicative interaction between COHE and high-risk opioid prescribing in our study, meaning that the association between high-risk opioid prescribing and measures of disability outcomes did not differ by COHE participation. The methods and study populations differed in multiple ways, however, and these differences may explain the varied findings between the current study and prior COHE studies.

## Strengths and Limitations

The study's strengths included (1) being population-based, (2) having access to a surrogate measure of receipt of Social Security disability benefits, and (3) linkage of prescription drug data to detailed disability payment records. The study has several limitations. First, confounding by indication, where the reason for receiving a medication is related to the outcome of interest, is a concern for analyses of work disability outcomes and opioid prescribing.<sup>40</sup> Injured workers who were prescribed opioids, and in particular injured workers who were prescribed high-risk opioids, may have had a more severe injury resulting in worse work-related disability outcomes. In an effort to address

confounding by indication, we compared workers with various high-risk opioid prescribing indicators to those with a low-risk opioid prescribing indicator, ensuring all participants were prescribed at least some amount of opioids following their work-related injury.<sup>40</sup> With this restriction, workers who may have had less severe injuries and consequently not prescribed opioids were not included. Furthermore, we included an indicator of early hospitalization to help control for injury severity, which has been used successfully in previous WC research to identify more severe injuries.<sup>22,23</sup> Measures of body part and nature of injury were also included. Finally, we conducted two sensitivity analyses with further control for injury severity, restricting analyses to (1) those with traumatic injuries and (2) those with low back conditions. Notably, the traumatic injuries sensitivity analysis had a consistently higher odds ratio than our main analysis. While our use of administrative data limits our ability to fully control for injury severity across all workers, both of our sensitivity analyses focused on adjusting for injury severity produced estimates consistent with our main analyses, lessening concerns regarding confounding by indication.

Second, with the available administrative data, we were unable to adjust for self-reported measures of pain and mental health, which are associated with both opioid prescribing and long-term disability outcomes.<sup>41–43</sup> In one study that captured those measures, the association between opioid prescribing and long-term disability was attenuated after adjusting for those measures, but remained statistically significant.<sup>10</sup> Similarly, we would expect attenuation of our findings if we had those measures available for our study. Measures of socioeconomic status were also unavailable for this study. Third, the estimates of opioid prescribing may be underestimates because our billing data only captured prescriptions covered by DLI. Finally, we were unable to access data from self-insured employers, which represented the remaining one-third of Washington workers. Consequently, our results may not be



representative of all workers in Washington State. We mitigated many of these limitations by controlling for characteristics of the worker, provider, employer, injury type, injury severity, and conducting a series of sensitivity analyses. Notably, our findings were robust to changes in time period, injury severity, and exposure to opioid prescriptions prior to the injury, and the estimates were strikingly similar across the four disability-related outcomes measured.

## CONCLUSIONS

Exposure to high-risk opioid prescribing practices during the acute and subacute phase (up to 90 days after injury) was significantly and substantially associated with long-term temporary and permanent disability. The magnitude of the impact of early high-risk opioid prescribing practices may be underappreciated in both state and federal workers' compensation systems.

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