



Original article

Prescription opioid use by injured workers in Tennessee: a descriptive study using linked statewide databases



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ABSTRACT

Purpose: This is the first study in Tennessee to measure opioid use in injured workers and among the first nationally to use a prescription drug monitoring program to do so. We conducted a retrospective cohort study to evaluate the prevalence of opioid use after injury and associated characteristics among workers reporting one injury to Tennessee Workers' Compensation.

Methods: Injured workers identified in Workers' Compensation records 2013–2015 were linked to their prescription history in Tennessee's prescription drug monitoring database.

Results: Among 172,256 injured workers, the prevalence of receiving an opioid after injury was 22.8% in 1 week, 29.7% in 1 month, and 33.3% in 6 months. Receiving an opioid was associated with having a fracture (odds ratio, 4.9; 95% confidence interval, 4.64–5.11 vs. other injuries). Hydrocodone short-acting was the most commonly received opioid (69.5% of injured workers), and the mean of each worker's maximum dose was 42.8 morphine milligram equivalents (SD 39.26). Ten percent of injured workers who received opioids also received a benzodiazepine.

Conclusions: Injured workers have a high prevalence of opioid use after injury, but prescribing patterns generally tend to follow Tennessee prescribing guidelines.

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Introduction

Tennessee is among the hardest-hit states in the current prescription opioid epidemic and has the third highest prescribing rate (107.5 prescriptions per 100 persons in 2016) of opioids in the United States [1,2]. Tennessee passed legislation in 2013 limiting opioid prescribing to 30 days' supply per prescription fill [3] and implemented prescribing guidelines in 2014 that caution against prescribing daily doses of more than 120 morphine milligram equivalents (MMEs) in most cases [4]. Injured workers are a special population with regard to opioid use because of the need to balance pain relief with rehabilitation [5,6]; but no studies have reported on opioid use by this population in Tennessee.

The most common causes of workplace injuries are overexertion, contact with objects and equipment, and slips, trips, and falls. The most highly affected industries are service, transportation, and manufacturing [7]. One nationally representative study of 2004–2012 National Health Interview Study data found that 78 workers per 10,000 reported experiencing a work-related injury in the previous 3 months [8]. The United States Department of Labor reported that nearly one-third of reported workplace injuries and illnesses were serious enough to result in lost work days in 2016 [9]; but that fatal work injuries were rare with 5190 deaths reported in the same year [10]. Although reporting of injuries is mandatory for workplaces participating in Workers' Compensation (WC), injuries requiring only first aid to treat are exempt and others perceived to be minor, especially strains and sprains, may go unreported [11].

In the United States, research on the prevalence of opioid use by claimants using WC records has yielded lowest estimates in Illinois (6.6%), intermediate levels in Ohio (19.2%) and Michigan (27%), and

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highest in Washington State (42%) and Louisiana (46.4%) [12–16]. In prior studies in the work-related literature, middle age, daily tobacco use, fractures and dislocation injuries, and back pain were associated with receiving an opioid, whereas associations with sex were mixed [17–20]. Other studies have presented data from prescription drug monitoring programs and other government registries that are stratified by payment source, including WC, but to our knowledge, no study has used a prescription drug monitoring program to measure opioid use in injured workers accounting for all payment types [21].

In other states, opioids may be prescribed to injured workers for longer and at higher doses than is recommended [22]. Opioid use in injured workers, especially in doses over 100 daily MMEs, is associated with increased medical and WC claim costs, delayed return to work, absenteeism, lost productivity, progression to long-term disability, and overdose [14,23,24]. Many of these adverse outcomes are more likely when opioids are received early after injury, in the presence of benzodiazepines, in long-acting formulas, and in high doses [13,14,22]. Long-acting formulas and high doses increase the length of time or the amount of opioid that is present in the body. Benzodiazepines are a type of anti-anxiety drugs that may depress breathing to dangerously low levels when used in combination with opioids, increasing the risk of overdose [25]. Visiting multiple prescribers and dispensers (doctor shopping) has also recently arisen as a key indicator for opioid misuse, but few studies have evaluated doctor shopping as an adverse outcome in injured workers [26].

Tennessee is notable in being both among the hardest-hit states in the opioid epidemic [27] and, to our knowledge, the first to link WC records to a prescription drug monitoring program. We conducted a retrospective cohort study among workers with one injury reported to the Tennessee Bureau of WC in 2013–2015 to evaluate (1) the prevalence of filling an opioid prescription after injury; (2) demographics and injury characteristics associated with opioid use in the first 6 months after injury selected based on previous literature [13,17,18,20]; and (3) characteristics of opioid use after injury. Characteristics of opioid use after injury included the high-risk opioid prescribing patterns of high dose (>100 daily MMEs), receiving a long-acting opioid, receiving an opioid with a benzodiazepine, and visiting multiple providers and dispensers for an opioid analgesic (i.e., potential doctor and pharmacy shopping, a known measure of opioid misuse) [28]. To provide a clear understanding of the relationship between injury type and opioid prescription use, the study was restricted to injured workers who reported only one injury during the study period. An additional analysis of maximum received daily MMEs and day's supply was conducted to evaluate adherence to prescribing guidelines.

Methods

Data sources

We used data from 2013–2015 WC records and 2013–2016 Controlled Substances Monitoring Database (CSMD). In Tennessee, it is required by law for businesses with five or more employees and all construction and coal mining businesses to carry WC insurance [29]. WC records were supplied by the Employer's First Report of Illness or Injury form, which is required for employers to submit within 15 days of illnesses/injuries occurring at their workplace, exempting injuries that require only first aid to treat [30,31]. Submission of this form is required regardless of the employee's intention to seek care or compensation. Years 2013–2015 of the WC data were provided to the Tennessee Department of Health from the Tennessee Department of Labor as part of an ongoing collaboration.

The CSMD includes data about every controlled substance that is legally dispensed in outpatient settings in Tennessee. Data entry by dispensers is mandatory in most cases (excluding inpatient settings, drugs dispensed by veterinarians with ≤ 5 days' supply, drug samples and drugs given by a facility with ≤ 48 hours' supply, drug samples for schedule IV and V substances with ≤ 72 hours' supply, and narcotic treatment programs registered with and required to keep records by the Drug Enforcement Administration) [32]. This study uses data from the last quarter of 2012 through mid-2016, including prescriptions for each injured worker from 2 months before their date of injury through 6 months after injury.

Workers who reported an injury to the Tennessee Bureau of WC from 2013 through 2015 were matched to their prescription history in the CSMD on name and date of birth. Names were cleaned to standardize formats, remove prefixes and suffixes, and separate multiple names into separate fields (maximum four). Dates were cleaned to remove improbable dates and prescriptions where the date of birth fell on or after the date that the prescription was filled. WC records and the CSMD were linked deterministically, where two records were considered a match if they had a link between any of the four first name fields, a link between any of the four last name fields, and the same date of birth. This study was approved by the Institutional Review Boards at the Tennessee Department of Health and University of Hawaii.

Study population

The main study population included Tennessee residents aged 15–99 years who reported only one injury to Tennessee WC during the study period of 2013–2015. Workers were excluded if they were missing date of birth, aged less than 15 or 100 years or more at the time of injury, missing sex, had no physical injury, or resided out of state (Fig. 1). To focus on the relationship between injury and opioid use and decrease confounding from opioid use associated with other injuries, only workers who reported a single injury during the study period were analyzed.

Inclusion criteria for opioids were schedule II–IV drugs with 180 days' supply or less. The Drug Enforcement Administration and Food and Drug Administration classify drugs into five categories based on the drug's legality and potential for abuse, with schedule V (five) opioids including low-dose cough syrups and schedule I (one) containing heroin [33]. Exclusion criteria were prescriptions from Veterans Affairs (VA) pharmacies ($n = 548$) and veterinarians ($n = 8$) and opioids indicated for medication-assisted therapy (MAT), including all buprenorphine except Butrans and Belbuca, $n = 3746$. Reporting from VA pharmacies during the early years of this study was incomplete, and the decision was made at the design phase to exclude VA pharmacy data due to missing data concerns. VA pharmacies contributed about 1% of all opioid prescriptions in the cohort. MAT is the use of specific opioids in combination with behavioral therapy to treat opioid addiction and was excluded as the focus for our study was on initiation of opioids to treat pain due to injury. Excluding MAT also enabled comparison to previous studies of opioid analgesic use among injured workers and WC claimants [34]. Prescription exclusions only applied to prescriptions: no person was excluded from the study population based on these criteria.

Demographics and injury information

Demographic and injury variables were collected from WC records and were selected based on availability, completeness of data, and previous literature identifying risk factors for opioid use

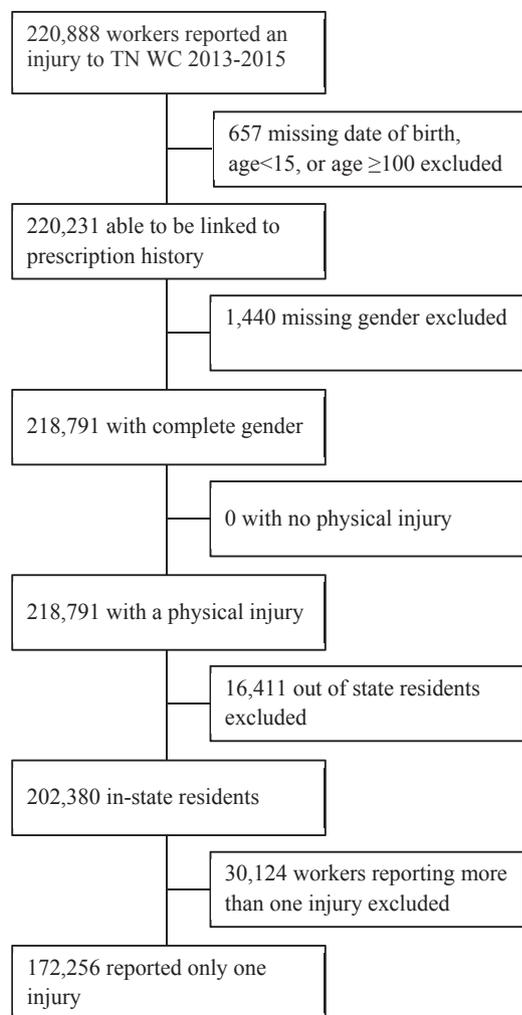


Fig. 1. Study flowchart.

including middle age, fractures and dislocation injuries, and back pain. The five most frequently occurring types of injury were selected, and others that were not in the top five were grouped into an “other” category. Estimates for three of the top five (burns, contusions, and lacerations) were not different and had overlapping confidence intervals (CIs) and so were combined with the “other” category for analysis. Geographical area of residence was classified into east, middle, and west Tennessee based on geocoded zip code and Tennessee Department of Health boundaries. Residence was also classified into urban and rural regions with urban including the counties with the six largest cities in Tennessee (urban region population density range 176.4–1243.3 people per square mile) [35].

Sex, date of birth (used to calculate age), type of injury, part of body injured, and residence had less than 2% missing values and were included in all analyses. Marital status had greater than 40% missing values and was included in descriptive analyses but excluded from multivariable analyses.

Prescription outcome measures

The primary outcome was filling a prescription for an opioid (hereafter, we referred to as receiving an opioid) within 6 months of injury. Secondary outcomes were receiving an opioid within 1 week of injury, receiving an opioid within 1 month of injury, type

of payment, dose in daily MMEs, days' supply, and type of opioid. Four high-risk opioid patterns were additionally analyzed: (1) receiving more than 100 daily MMEs, (2) receiving a long-acting opioid at any point within 6 months of injury, (3) receiving an opioid within 30 days of a benzodiazepine, and (4) having a multiple provider episode (visiting ≥ 3 prescribers and ≥ 3 dispensers in the 180 days after injury) [36,37]. Prior opioid use, defined as receipt of an opioid within the 60 days before injury, was included as a covariate.

Statistical analysis

Frequencies, proportions, means, and SD were used to describe the population. Means, SD, and proportions were used to describe the distribution of measures of opioid use in the 6 months after injury and other demographic and clinical characteristics within the study sample.

To identify associations between demographics and injury characteristics with receiving an opioid within 6 months of injury, logistic regression was used to compute unadjusted and adjusted odds ratios (ORs) with 95% CIs for receiving an opioid. The covariates used for adjusted models were determined a priori and were age, sex, type of injury, part of body injured, region of residence, and opioid use before injury. Following reports that younger men and older women are groups of concern for opioid use in the overall U.S. population [38,39]; two-factor interactions were tested for between age and sex, age and prior opioid use, and sex and prior opioid use. Sensitivity analyses additionally adjusting for marital status and excluding workers with severe injury types (crushing, amputation, rupture, myocardial infarction, severance, AIDS, cancer, and black lung) that could reasonably be expected to require heavy use of pain medications in treatment [40] along with Hepatitis C, a condition associated with heroin use [41]; were conducted. The full list of reportable injuries is available on the national Workers Compensation Insurance Organizations website [42]. Respondents with missing or unknown values for the selected variables were excluded from the multivariable analysis.

Prescribing patterns were described with mean, SD, and sample percentages. Trends by year were tested for with the Cochran-Armitage test. Although our analysis focuses on opioid analgesic use, the proportion of workers given opioids for MAT and benzodiazepines, and the types of benzodiazepines that were prescribed, were also reported. All statistical tests were two-sided with a statistical significance level of $P < .05$ and were conducted using SAS v 9.4 (SAS Institute, Cary, NC).

Results

Demographics and receipt of an opioid after injury

Of 220,888 workers who reported injuries to Tennessee WC 2013–2015, 172,256 (85.1%) met inclusion criteria and were included in this study (Fig. 1). The study population was predominantly middle aged, male, from rural areas of residence, and from middle Tennessee (Table 1). The top five injuries were strains, sprains, and tears (35.4%), contusions (15.7%), lacerations (14.1%), fractures (4.5%), and burns (2.4%). Together, contusions, lacerations, and burns made up 53.4% of the “Other” injury group. In 2015, 31.8% of injured workers received an opioid within 6 months of injury (Fig. 2), of which 80% ($n = 14,544$) were opioid-free at the time of injury (Supplemental Table S2).

Compared with injured workers who did not receive opioids within 6 months of injury, those who received opioids were older and more likely to be from a rural region. Women had slightly less

Table 1
 Characteristics of injured workers who reported one injury compared with those who reported two or more injuries to Tennessee Workers' Compensation 2013–2015 ($n = 202,380$)

Characteristic	Injured workers with one injury ($n = 172,256$)	Injured workers with two or more injuries ($n = 30,124$)
	n (%)	n (%)
Age, mean (SD)	40.3 (13.74)	40.7 (13.00)
Age, y		
15–34	66,430 (38.6)	10,857 (36.0)
35–54	74,871 (43.5)	14,160 (47.0)
55–99	30,955 (18.0)	5107 (17.0)
Sex		
Female	76,994 (44.7)	12,716 (42.2)
Male	95,262 (55.3)	17,408 (57.8)
Marital status		
Single	3719 (2.2)	599 (2.0)
Married	45,424 (26.4)	8157 (27.1)
Widowed, separated, or divorced	42,232 (24.5)	7318 (24.3)
Unknown or missing	80,881 (47.0)	14,050 (46.6)
Region of residence		
Rural	106,185 (61.6)	18,634 (61.9)
Urban	66,071 (38.4)	11,490 (38.1)
Geographical area		
East	61,964 (36.0)	10,098 (33.5)
Middle	73,289 (42.6)	13,812 (45.9)
West	37,003 (21.5)	6214 20.6

opioid use than men. Workers of middle age groups had overlapping OR and CIs of receiving an opioid (data not shown), so age categories were collapsed (Table 2).

Having a fracture and having a record for opioid use before injury were most strongly associated with receiving an opioid in the 6 months after injury. Having a strain, sprain, or tear was also associated with receiving an opioid in the 6 months after injury, but associations differed by part of body with lower back strains, sprains, or tears being associated with more opioid use than strains, sprains, and tears in other parts of the body. Fractures were more likely to receive an opioid if they had a finger fracture and less likely if they had a wrist fracture (Supplement Table S3).

Sensitivity analyses adjusted for marital status (where data not missing) and excluded people with extreme injuries including crushing ($n = 1819$), amputation ($n = 382$), rupture ($n = 190$), myocardial infarction ($n = 144$), severance ($n = 109$), AIDS ($n = 33$), cancer ($n = 18$), hepatitis C ($n = 12$), and black lung ($n = 2$) that would be expected to receive heavy pain medication during treatment or be associated with injection drug use. After adjustment and exclusion, finger injuries and residence in Middle Tennessee were no longer associated with opioid use, but other associations were similar. No interactions were found among sex, age, and prior opioid use. There was a small but significant decrease in the percentage of injured workers receiving opioids by year (Supplement Table 3), but controlling for year in the multivariable model did not alter other associations.

Patterns of opioid use

Only 5.0% ($n = 2866$) received a prescription for more than 100 daily MMEs. The numbers of prescribers and dispensers visited were also low, with 80.2% of injured workers ($n = 38,346$) visiting only one prescriber and one dispenser. Two percent ($n = 1185$) visited three or more prescribers and three or more dispensers and qualified as having a multiple provider episode. Most workers received Hydrocodone short-acting (SA; 69.5%), Oxycodone SA (23.0%), and/or Tramadol SA (23.8%; nonexclusive categories). The prevalence of receiving a long-acting opioid was 2.5% and receiving an opioid within 30 days of receiving a benzodiazepine was 9.5% (Table 3).

Changes in high-risk patterns by year were tested for, and significant decreases were found for receiving more than 100 mean daily MME (5.6% in 2013 vs. 5.0% in 2015, $P < .01$), receiving a long-acting opioid (2.8% in 2013 vs. 2.3% in 2015, $P < .01$), and having a multiple provider episode (2.4% in 2013 vs. 1.9% in 2015, $P < .01$).

Most workers used a private, commercial insurance to pay for opioids (65.1%; Table 3). Five percent ($n = 3064$) used both commercial insurance and WC, 1.9% ($n = 1106$) used both cash and WC, and 0.5% ($n = 272$) used both Medicaid and WC to pay for opioids. Very few prescriptions ($n = 867$, 1.5%) had unspecified payment type.

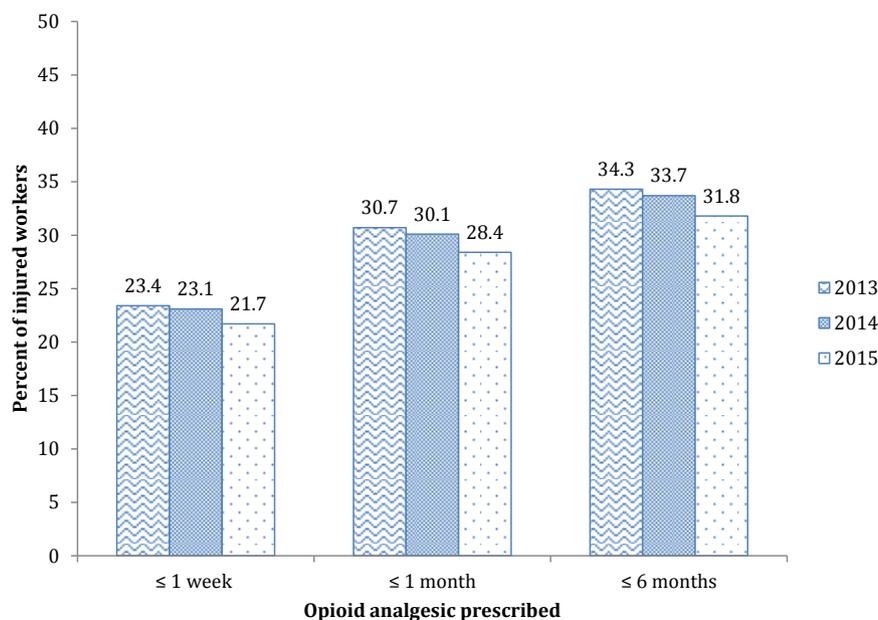


Fig. 2. Receipt of an opioid analgesic after injury in workers who reported one injury to Tennessee Workers' Compensation 2013–2015 ($n = 172,256$).

Table 2

Association of demographic characteristics and type of injury with receiving an opioid analgesic within 6 mo of injury in workers who reported one injury to Tennessee Workers' Compensation 2013–2015 ($n = 172,256$)

Characteristic	Opioid prescription filled within 6 mo of injury		Unadjusted OR (95% CI)
	No	Yes	
	($n = 114,974$) n (%)	($n = 57,282$) n (%)	
Age, mean (SD)	39.5 (13.84)	42.1 (13.39)	—
Age, y			
15–34	47,892 (41.7)	18,538 (32.4)	1.0 (ref)
35–54	47,652 (41.4)	27,219 (47.5)	1.5 (1.44–1.51)
55–99	19,430 (16.9)	11,525 (20.1)	1.5 (1.49–1.58)
Sex			
Female	52,070 (45.3)	24,924 (43.5)	1.0 (ref)
Male	62,904 (54.7)	32,358 (56.5)	1.1 (1.05–1.10)
Type of injury			
Other	73,383 (63.8)	30,109 (52.6)	1.0 (ref)
Strain, sprain, or tear	38,996 (33.9)	21,988 (38.4)	1.4 (1.35–1.40)
Fracture	2595 (2.3)	5185 (9.0)	4.9 (4.64–5.11)
Part of body			
Other	67,374 (58.6)	32,180 (56.2)	1.0 (ref)
Finger(s)	12,773 (11.1)	5498 (9.6)	0.9 (0.87–0.93)
Lower back	10,660 (9.3)	7005 (12.2)	1.4 (1.33–1.42)
Multiple body parts	7847 (6.8)	4680 (8.2)	1.2 (1.20–1.30)
Hand	8705 (7.6)	3466 (6.0)	0.8 (0.80–0.87)
Knee	7615 (6.6)	4453 (7.8)	1.2 (1.18–1.27)
Region			
Rural	69,827 (60.7)	36,358 (63.5)	1.0 (ref)
Urban	45,147 (39.3)	20,924 (36.5)	0.9 (0.87–0.91)
Geographical area			
East	41,538 (36.1)	20,426 (35.7)	1.0 (ref)
Middle	49,784 (43.3)	23,505 (41.0)	0.96 (0.94–0.98)
West	23,652 (20.6)	13,351 (23.3)	1.1 (1.12–1.18)
Prior opioid use	5568 (4.8)	12,052 (21.0)	5.2 (5.06–5.42)

Few ($n = 759$, 0.4%) injured workers in this study population received buprenorphine for MAT. All 759 had a record for receiving MAT before injury with no new courses of MAT started within the 6 months after injury. Among injured workers who received MAT, 198 (26.1%) also received an opioid analgesic after injury. Because of a short follow-up time, later trends in MAT use could not be ascertained.

Benzodiazepine use was more widespread, with 5.6% ($n = 9575$) of the total sample, and 10.1% ($n = 5785$) of workers who received opioids filling a prescription for this class of drug. All 5785 opioid users that received a benzodiazepine after injury also had a record for filling a benzodiazepine before injury, and all received an opioid within 30 days of a benzodiazepine. Benzodiazepine use did not show a significant trend in changing over time and was not described further due to small sample size.

Discussion

This population-based study of injured workers in Tennessee found widespread opioid use that generally fell within recommended guidelines. Almost one-fifth of people who reported only one injury from 2013 to 2015 received an opioid within a week of injury, one-fourth received an opioid within 1 month of injury, and one-third received an opioid within 6 months of injury.

Among people who received opioids, mean dose and days' supply were within prescribing guidelines. The Tennessee Chronic Pain Guidelines set an upper threshold of 120 daily MME as the maximum dose that should be prescribed without referral to a pain specialist [4]; and 95% of injured workers in this study had their maximum dose fall below this threshold. Similarly, 85% of injured workers received no prescription over the maximum 30 days'

Table 3

Description of opioid analgesic use in the 6 mo after injury by workers who reported one injury to Tennessee Workers' Compensation 2013–2015 ($n = 57,282$)^a

	Mean (SD)	Median (IQR)
Maximum received daily MME	42.8 (39.26)	31.3 (21.43–50.00)
Maximum received d' supply	9.4 (9.81)	5.0 (3.00–10.00)
Number of prescribers visited	1.4 (0.76)	1 (1.00–2.00)
Number of dispensers visited	1.2 (0.52)	1 (1.00–1.00)
Most frequently received types of opioid ^b	n (%)	
Hydrocodone SA	39,813 (69.5)	
Oxycodone SA	13,171 (23.0)	
Tramadol SA	13,647 (23.8)	
Codeine	2084 (3.6)	
Morphine LA	472 (0.8)	
Type of payment ^c		
Commercial Insurance	37,283 (65.1)	
Workers' Compensation	11,567 (20.2)	
Cash	10,599 (18.5)	
Medicaid	3966 (6.9)	
Medicare	1152 (2.0)	
Military	10 (0.02)	
Indian Nations	1 (0.0)	
High-risk opioid prescribing pattern experienced		
Opioid received within 30 d of a benzodiazepine	5451 (9.5)	
>100 mean daily MMEs	2866 (5.0)	
Long-acting opioid	1437 (2.5)	
Multiple provider episode ^d	1185 (2.1)	
Received a benzodiazepine in the 6 mo after injury	5785 (10.1)	
Most frequently received types of benzodiazepine ^e		
Alprazolam	2683 (4.7)	
Diazepam	1415 (2.5)	
Clonazepam	1025 (1.8)	
Lorazepam	652 (1.1)	
Temazepam	221 (0.4)	

IQR = interquartile range; MME = morphine milligram equivalents; SA = short-acting.

^a Table is limited to injured workers who received an opioid within 6 mo of injury.

^b Categories are nonexclusive, injured workers may appear in more than one category.

^c Visiting three or more prescribers and three or more providers in the 6 mo after injury.

supply allowed by Tennessee state law for schedule II and III controlled substances [3]. The numbers of prescribers and dispensers visited were low (80.2% visited only one prescriber and only one dispenser), as were the prevalence of high-risk opioid use patterns such as receiving a long-acting opioid and having an opioid within 30 days of a benzodiazepine. A low proportion of the total sample received benzodiazepines. This proportion was doubled in people who received opioids, demonstrating a potential area for intervention.

The prevalence of opioid use observed in this study is consistent with a previous review of worldwide WC claimants from 2000 to 2010 that found an opioid use prevalence of 31.8% [12]. Compared with other states, the prevalence of opioid use after injury in Tennessee appears to be higher than Ohio (19.2% of WC claimants receive an opioid during their claim) and may be similar to the 42% prevalence observed in Washington or 46.4% prevalence observed in Louisiana if this study had the same 1-year follow-up time as these studies [12–14]. However, these studies in other states are likely underestimates due to their confinement to a single payer source, and the estimates presented in this article may be more accurate due to measuring opioids received through all payer sources.

Our study found similar associations between demographic and injury variables and opioid use as prior studies. Middle and older age groups in U.S. WC claimants were more likely than younger age groups to receive an opioid after injury (OR, 2.6; 95% CI, 1.81–3.87

for age >55 vs. <26 years) [20]. Similar to our results, a previous study in Alberta WC claimants found that fractures and dislocations had higher odds (OR, 2.5, 95% CI, 2.14–2.36) of receiving an opioid in a year after injury compared with back sprains [17].

The prevalence of high-risk opioid patterns observed in this study is consistent with previous literature. In Ohio between 2008 and 2009, mean MME during a WC claim was 57.5, and 10% of injured workers received 120 or more daily MMEs, and in Tennessee, 75% of injured workers, 2013–2015, received no more than 50 MMEs on all prescriptions, a decrease that may reflect a nationwide trend in decreasing MMEs for opioid analgesics over this period [12,43]. In Ottawa, WC claimants undergoing shoulder, knee, back, or carpal tunnel surgery received a comparatively lower mean dose of 11.25 daily MMEs [21]. In a nationwide study of WC claimants with low back pain, 9.4% received a long-acting opioid within 2 years of injury [22]. We did not find any research measuring multiple provider episodes in WC claimants or injured workers, and our results indicate that it may not be a substantial problem. In the overall Tennessee population in 2016, the rate of visiting five or more prescribers and five or more dispensers in 6 months was 49.96 per 100,000 persons [44]. Using the same metric in this population of workers who reported only one injury, the rate was 22.64 per 100,000 persons.

This study casts light on benzodiazepine use by injured workers. Of the 9575 people who received a benzodiazepine in the 2 months before injury in the total sample, 60.4% ($n = 5785$) received an opioid after injury while continuing their benzodiazepine use, and 39.6% did not receive an opioid. This is a higher proportion than what was observed in a study of WC claims in Louisiana 1999–2002 (4.9%) and may reflect an increased use of benzodiazepines in recent years or in Tennessee. In Louisiana, claimants with benzodiazepine use demonstrated benzodiazepine dose escalation over 3 years postinjury, and claims with benzodiazepines and SA opioids cost triple those of SA opioids alone [14].

In conclusion, opioid use by injured workers in Tennessee is widespread but generally within prescribing guidelines. This study is the first in Tennessee to describe opioid use by injured workers and is to our knowledge the first nationally to use a prescription drug monitoring program linked to WC records for this purpose. However, more research is needed to understand health trajectories after opioids are initiated in injured workers. We plan to build on this work by evaluating long-term opioid use and clinical events related to drug use after injury.

Limitations

This study controlled for type of injury reported to WC but could not account for other injuries, comorbidities, and socioeconomic factors that may influence opioid use. Particularly, this study could not control for mental health conditions that are frequently associated with higher prevalence of both prescription opioid use and adverse effects from opioids [36,45–47]. Because data on claim outcomes were not available, this study could not evaluate work-time loss, disability, and other potential work outcomes of opioid use.

This study likely underestimates the total burden of opioid use in injured workers as we did not include workers with more than one injury. Workers with more injuries may have more contacts with medical care and residual pain or prescriptions from previous injuries resulting in more overall opioid use [36]. However, if injuries are not reported because of their lack of severity, then opioid use would not be expected. There is also evidence that, although reporting of workplace injuries is mandated by state law, many workplace injuries go unreported [48]. This study could not identify the reason that opioids were given, and prescriptions were

associated with injuries temporally in the absence of clinical data. To limit confounding by opioids received for other injuries, the study population was restricted to injured workers who reported only one injury during the study period. Results are limited in generalizability to injured workers who had only one injury and the timeframe under study.

Drug diversion is a well-known phenomenon for controlled substances that may bias estimates of use that are based on legally obtained drugs. This study only has data on prescription opioids purchased from dispensers and measures filled prescriptions, not consumption. Practice setting was not available for all prescribers. Some underestimation of the burden of opioid use may have occurred due to the exclusion of VA pharmacies; however, VA pharmacies contributed only about 1% of total opioid prescriptions, and the impact on associations is expected to be small. Data availability based on the years of the study may limit our assessment of the role of prior opioid use on use of prescribed opioids for pain after injury.

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This study was approved by the Institutional Review Boards at the Tennessee Department of Health and University of Hawaii.

Supplementary Data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.annepidem.2019.02.001>.

References

- [1] Centers for Disease Control, Prevention. Opioid painkiller prescribing infographic. <http://www.cdc.gov/vitalsigns/opioid-prescribing/infographic.html>. [Accessed 11 January 2018].
- [2] Centers for Disease Control, Prevention. Annual surveillance report of drug-related risks and outcomes - United States, 2017. In: Centers for Disease Control and Prevention USDoHaHS. In: Surveillance Special Report. 1; 2017. Retrieved from, <https://www.cdc.gov/drugoverdose/pdf/pubs/2017-cdc-drug-surveillance-report.pdf>. [Accessed 5 November 2018].
- [3] Prescription Requirements. TCA § 53-11-308. 2013. Tennessee.
- [4] Tennessee Department of Health. Chronic pain guidelines: Clinical practice guidelines for outpatient management of chronic non-malignant pain. 2014. Retrieved from, <https://www.tn.gov/content/dam/tn/health/healthprofboards/pain-management-clinic/ChronicPainGuidelines.pdf>. [Accessed 5 November 2018].
- [5] Harris I, Mulford J, Solomon M, van Gelder JM, Young J. Association between compensation status and outcome after surgery: a meta-analysis. *JAMA* 2005;293:1644–52.
- [6] Newton-John TR, McDonald AJ. Pain management in the context of workers compensation: a case study. *Transl Behav Med* 2012;2:38–46.
- [7] National Safety Council. Workplace injuries by the numbers. <https://www.nsc.org/work-safety/tools-resources/infographics/workplace-injuries>. [Accessed 24 February 2018].
- [8] Gu JK, Charles LE, Andrew ME, Ma CC, Hartley TA, Violanti JM, et al. Prevalence of work-site injuries and relationship between obesity and injury among U.S. workers: NHIS 2004-2012. *J Safety Res* 2016;58:21–30.
- [9] United States Department of Labor Bureau of Labor Statistics. Employer-reported workplace injury and illnesses, 2016. 2017. Retrieved from, https://www.bls.gov/news.release/archives/osh_11092017.pdf. [Accessed 5 November 2018].
- [10] United States Department of Labor Bureau of Labor Statistics. Census of fatal occupational injuries summary, 2016. 2017. https://www.bls.gov/news.release/archives/cfoi_12192017.pdf. [Accessed 5 November 2018].
- [11] Wuellner SE, Adams DA, Bonauto DK. Workers' compensation claims not reported in the Survey of Occupational Injuries and Illnesses: injury and claim characteristics. *Am J Ind Med* 2017;60:264–75.
- [12] Dembe A, Wickizer T, Sieck C, Partridge J, Balchick R. Opioid use and dosing in the workers' compensation setting: a comparative review and new data from Ohio. *Am J Ind Med* 2012;55:313–24.

- [13] Franklin GM, Rahman EA, Turner JA, Daniell WE, Fulton-Kehoe D. Opioid use for chronic low back pain: a prospective, population-based study among injured workers in Washington state, 2002–2005. *Clin J Pain* 2009;25:743–51.
- [14] Lavin RA, Tao XG, Yuspeh L, Bernacki EJ. Impact of the combined use of benzodiazepines and opioids on workers' compensation claim cost. *J Occup Environ Med* 2014;56:973–8.
- [15] White JA, Tao X, Artuso RD, Bilinski C, Rademacher J, Bernacki EJ. Effect of physician-dispensed medication on workers' compensation claim outcomes in the state of Illinois. *J Occup Environ Med* 2014;56:459–64.
- [16] White JA, Tao X, Talreja M, Tower J, Bernacki E. The effect of opioid use on workers' compensation claim cost in the State of Michigan. *J Occup Environ Med* 2012;54:948–53.
- [17] Gross DP, Stephens B, Bhambhani Y, Haykowsky M, Bostick GP, Rashid S. Opioid prescriptions in Canadian workers' compensation claimants: prescription trends and associations between early prescription and future recovery. *Spine (Phila Pa 1976)* 2009;34:525–31.
- [18] Berecki-Gisolf J, Collie A, McClure RJ. Prescription opioids for occupational injury: results from workers' compensation claims records. *Pain Med* 2014;15:1549–57.
- [19] Stover BD, Turner JA, Franklin G, Gluck JV, Fulton-Kehoe D, Sheppard L, et al. Factors associated with early opioid prescription among workers with low back injuries. *J Pain* 2006;7:718–25.
- [20] Pensa MA, Galusha DH, Cantley LF. Patterns of opioid prescribing and predictors of chronic opioid use in an industrial cohort, 2003 to 2013. *J Occup Environ Med* 2017;60:457–61.
- [21] Kraut A, Raymond CB, Ekuma O, Shafer LA. A comparison of opioid use between WCB recipients and other Manitobans for knee, shoulder, back and carpal tunnel release procedures. *Am J Ind Med* 2016;59:257–63.
- [22] Cifuentes M, Webster B, Genevay S, Pransky G. The course of opioid prescribing for a new episode of disabling low back pain: opioid features and dose escalation. *Pain* 2010;151:22–9.
- [23] Rice JB, Kirson NY, Shei A, Cummings AK, Bodnar K, Birnbaum HG, et al. Estimating the costs of opioid abuse and dependence from an employer perspective: a retrospective analysis using administrative claims data. *Appl Health Econ Health Policy* 2014;12:435–46.
- [24] Kidner CL, Mayer TG, Gatchel RJ. Higher opioid doses predict poorer functional outcome in patients with chronic disabling occupational musculoskeletal disorders. *J Bone Joint Surg Am* 2009;91:919–27.
- [25] National Institute on Drug Abuse. Benzodiazepines and opioids. 2018. Available at: <https://www.drugabuse.gov/drugs-abuse/opioids/benzodiazepines-opioids>. [Accessed 5 November 2018].
- [26] Baumblatt JA, Wiedeman C, Dunn JR, Schaffner W, Paulozzi LJ, Jones TF. High-risk use by patients prescribed opioids for pain and its role in overdose deaths. *JAMA Intern Med* 2014;174:796–801.
- [27] Centers for Disease Control, Prevention. Prescription drug overdose: understanding the epidemic: data overview: prescribing data. <http://www.cdc.gov/drugoverdose/data/prescribing.html>. [Accessed 10 January 2018].
- [28] Secora AM, Dormitzer CM, Staffa JA, Dal Pan GJ. Measures to quantify the abuse of prescription opioids: a review of data sources and metrics. *Pharmacoepidemiol Drug Saf* 2014;23:1227–37.
- [29] T.C.A. § 50-6-101 et seq. Workers' Compensation Act. 2010.
- [30] Tennessee Bureau of Workers' Compensation. A beginner's guide to Tennessee Workers' Compensation. https://www.tn.gov/assets/entities/labor/attachments/BeginnersGuide_AFTERJuly1_14_English.pdf. [Accessed 16 February 2018].
- [31] Occupational Safety, Health Administration. OSHA injury and illness record-keeping and reporting requirements. <https://www.osha.gov/recordkeeping/index.html>. [Accessed 16 February 2018].
- [32] Prescription Safety Act of 2012. TCA § 53-10-304. 2012. TN.
- [33] United States Drug Enforcement Administration. Drug scheduling. <https://www.dea.gov/drug-scheduling>. [Accessed 5 November 2018].
- [34] Substance Abuse, Mental Health Services Administration. Medication assisted treatment (MAT). <https://www.samhsa.gov/medication-assisted-treatment>. [Accessed 5 November 2018].
- [35] Tennessee Department of Health. Local and regional health departments. <https://www.tn.gov/health/topic/localdepartments>. [Accessed 4 April 2018].
- [36] Kowalski-McGraw M, Green-McKenzie J, Pandalai SP, Schulte PA. Characterizing the interrelationships of prescription opioid and benzodiazepine drugs with worker health and workplace hazards. *J Occup Environ Med* 2017;59:1114–26.
- [37] Dowell D, Haegerich TM, Chou R. CDC guidelines for prescribing opioids for chronic pain – United States, 2016. *MMWR Recomm Rep* 2016;65:1–49.
- [38] Substance Abuse, Mental Health Services Administration. Opioid use in the older adult population. 2017. Available at: <https://www.samhsa.gov/capt/sites/default/files/resources/resources-opioid-use-older-adult-pop.pdf>. [Accessed 5 November 2018].
- [39] Krueger A. Where have all the workers gone? An inquiry into the decline of the U.S. labor force participation rate. https://www.brookings.edu/wp-content/uploads/2017/09/1_krueger.pdf. [Accessed 5 November 2018].
- [40] Bruera E, Paice JA. Cancer pain management: safe and effective use of opioids. *Am Soc Clin Oncol Educ Book* 2015:e593–9.
- [41] Strada L, Schulte B, Schmidt CS, Verthein U, Cremer-Schaeffer P, Kruckeberg S, et al. Epidemiology of hepatitis C virus infection among people receiving opioid substitution therapy (ECHO): study protocol. *BMC Infect Dis* 2015;15:563.
- [42] Workers Compensation Insurance Organizations. Injury description codes, nature of injury. https://www.wcio.org/Active%20PNC/WCIO_Nature_Table.pdf. [Accessed 20 February 2018].
- [43] Guy Jr GP, Zhang K, Bohm MK, Losby J, Lewis B, Young R, et al. Vital signs: changes in opioid prescribing in the United States, 2006–2015. *MMWR Morb Mortal Wkly Rep* 2017;66:697–704.
- [44] Prescription Drug Overdose Program 2018 Report: understanding and responding to the opioid epidemic in TN using morbidity, mortality, and prescription data. In: Office of Informatics and Analytics. Nashville, TN: Tennessee Department of Health; 2018.
- [45] Hah JM, Sturgeon JA, Zocca J, Sharifzadeh Y, Mackey SC. Factors associated with prescription opioid misuse in a cross-sectional cohort of patients with chronic non-cancer pain. *J Pain Res* 2017;10:979–87.
- [46] Inacio MC, Hansen C, Pratt NL, Graves SE, Roughead EE. Risk factors for persistent and new chronic opioid use in patients undergoing total hip arthroplasty: a retrospective cohort study. *BMJ Open* 2016;6:e010664.
- [47] Schoenfeld AJ, Nwosu K, Jiang W, Yau AL, Chaudhary MA, Scully RE, et al. Risk factors for prolonged opioid use following spine surgery, and the association with surgical intensity, among opioid-naïve patients. *J Bone Joint Surg Am* 2017;99:1247–52.
- [48] Committee on Education, Labor US House of Representatives. Hidden tragedy: underreporting of workplace injuries and illnesses. <http://www.bls.gov/iif/laborcommreport061908.pdf>. [Accessed 11 January 2018].