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RESEARCH ARTICLE

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Predictors of long-term opioid use and opioid use disorder among construction workers: Analysis of claims data

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Abstract

Background: Construction workers have high rates of work-related musculoskeletal disorders, which lead to frequent opioid use and opioid use disorder (OUD). This paper quantified the incidence of opioid use and OUD among construction workers with and without musculoskeletal disorders.

Methods: We conducted a retrospective study using union health claims from January 2015 to June 2018 from 19,909 construction workers. Claims for diagnoses of chronic musculoskeletal disorders, acute musculoskeletal injuries, musculoskeletal surgery, and other conditions were linked to new opioid prescriptions. We examined the effects of high doses (≥50 morphine mg equivalents per day), large supply (more than 7 days per fill), long-term opioid use (60 or more days supplied within a calendar quarter), and musculoskeletal disorders, on the odds of a future OUD.

Results: There were high rates (42.8% per year) of chronic musculoskeletal disorders among workers, of whom 24.1% received new opioid prescriptions and 6.3% received long-term opioid prescriptions per year. Workers receiving opioids for chronic musculoskeletal disorders had the highest odds of future OUD: 4.71 (95% confidence interval 3.09–7.37); workers prescribed long-term opioids in any calendar quarter had a nearly 10-fold odds of developing an OUD.

Conclusions: Among construction workers, opioids initiated for musculoskeletal pain were strongly associated with incident long-term opioid use and OUD. Musculoskeletal pain from physically demanding work is likely one driver of the opioid epidemic in occupations like construction. Prevention of work injuries and alternative pain management are needed for workers at risk for musculoskeletal injuries.

KEYWORDS
blue collar worker, musculoskeletal disorders, opioid prescriptions, pain treatment

1 | INTRODUCTION

Alleviation of pain is one of the most common reasons why patients visit healthcare providers. Forty-one percent of insured Americans who start an opioid for acute musculoskeletal pain receive at least one refill.[1] In fact, musculoskeletal pain is the most frequent diagnosis leading to an opioid refill.[1] Although most patients stop their opioids once their acute pain resolves, 1%–12% of patients continue opioid use beyond 6 months.[2] Furthermore, this risk of long-term opioid use is greater among working-age men, especially those who have recurrent acute musculoskeletal pain and/or chronic pain.[3,4] In addition to musculoskeletal conditions, opioids are

prescribed for many other conditions, including cancer, dental procedures, migraines, abdominal conditions, and kidney stones.[5]

Recent studies show a trade-off between pain relief and risks of OUD.[3,4] Many patients (35%) with long-term opioid therapy use disorder are subsequently diagnosed with opioid use disorder (OUD), a "problematic pattern of opioid use leading to clinically significant impairment or distress."[6,7] There are substantial risks of adverse events from long-term opioid use: overdose, suicide, drug-craving, opioid withdrawal, and side effects (e.g., depression, hyperalgesia syndrome, and constipation).[8] How much recurrent acute musculoskeletal pain or chronic musculoskeletal pain increases the risk of long-term opioid use and OUD is unclear, especially because opioids prescribed for any condition, even transient pain, can lead to long-term opioid use.[9] This long-term use is even more distressing given that long-term opioids do not relieve chronic pain.[10] However, many patients resist stopping their opioids, and alternative pain treatments may not be available, accessible, or affordable.[11-13]

Construction workers have high rates of opioid use and overdose related to opioids.[12,14] Among all occupations in the United States, construction workers had the highest mortality rate from opioids.[15,16] A study of death certificates in Massachusetts from 2011 to 2015 found that construction workers accounted for 24% of all opioid-related deaths among the working population—a rate of fatal overdose five times higher than the rate for all workers.[16] A national sample from 2011 to 2017 showed that 10.4% of construction workers were prescribed opioid analgesics. Construction workers have several factors that may contribute to their high rates of opioid use and misuse.[14] They have among the highest rates of work injury,[17] and chronic or recurrent pain related to their physically demanding work and frequent musculoskeletal injuries.[18]

Construction workers have higher rates of musculoskeletal disorders than the general working population[19] and thus more opportunities to be prescribed opioids. These workers also possess characteristics typical of those at high risk for OUD: predominantly male, with high rates of alcohol and other substance use, and financial insecurity.[20-26] Little is known about the course of progression to OUD among these workers.

The purpose of this study was to quantify the risks from musculoskeletal disorders and new opioid prescriptions on incident long-term opioid use and OUD among construction workers. We examined two hypotheses: (1) among construction workers presenting to healthcare providers, those with acute or chronic musculoskeletal disorders will be more likely to initiate an opioid than those presenting with other diagnoses; and (2) among workers initiated on opioids, those with chronic musculoskeletal disorder diagnoses will be more likely to develop OUD than opioid users without chronic musculoskeletal disorders.

2 | MATERIALS AND METHODS

2.1 | Study population

We obtained deidentified pharmacy and health claims from the Saint Louis-Kansas City Carpenters Regional Benefit Plan, which manages the health coverage for workers and their dependents covering Missouri, Kansas, and southern Illinois. Health coverage eligibility requires active union membership status and an initial accrual of 500 work hours in a 6-month period, with an additional accrual of 300 work hours per quarter or 1,200 h per year for ongoing eligibility. The Plan created dataset consisting of all outpatient health claims (dates of service, ICD-9/ICD-10 codes, procedure code, service provider), and pharmacy data (dates of fill, National Drug Code [NDC] code, drug names, fill number, quantity dispensed, days' supply per prescription, and pharmacy identifier), and demographics (age, gender). These data covered all visits and services in the period from January 2015 to June 2018. The deidentified claims dataset was restricted to active union workers ($n = 20,824$) who were 18 years of age or older. Spouses and dependents were not included in the dataset received from the Health Plan. We excluded females ($N = 915$; 4.4% of workers) from the database, leaving 19,909 active union male construction workers in the study sample. Institutional review and ethics approval was obtained from the Human Subjects Office at Washington University in St. Louis, Missouri, USA. There was a waiver of consent as this was a secondary data analysis and the data were deidentified.

2.2 | Measures

2.2.1 | Outpatient health claims

The international classification diagnostic (ICD) system changed to ICD-10 codes on October 1, 2015, using ICD-9 codes before that date. First, we selected the codes from each system. For claims beginning in October 2015, we identified diagnoses from relevant ICD-10 codes: acute musculoskeletal injuries (ICD10:S00-T14), chronic musculoskeletal disorders (ICD10:M.x [x = any number], G54-G57), dental procedures, and painful conditions of the abdominal region (ICD-10: kidney stones [N20] and abdominal or pelvic pain [R10]). All other diagnostic conditions were assigned to "other." For the claims up to the end of September 2015, we used ICD-9 codes to identify comorbid conditions; we generated relevant ICD-9 codes by converting the ICD-10 codes using the general equivalence mapping tool.[27] For all data, we identified musculoskeletal surgery using Current Procedural Terminology (CPT) codes (CPT: 20005-21010; 21500-22900; 62263-63746; 64400-64999). Finally, we classified musculoskeletal diagnoses by one of three body regions: back/torso, upper extremity, lower extremity. We assigned body region to acute musculoskeletal injuries based on the first 2-digits of the ICD-10 S.x codes. ICD-10 chronic musculoskeletal disorder codes (ICD-10: M.x and G.x) were assigned to a body region by consensus of two authors (Ann Marie Dale and Brian F. Gage).

2.2.2 | Pharmacy data

In the pharmacy claims, we identified prescribed opioids and benzodiazepines from the drug name and the corresponding NDC.[28]

Medication-assisted treatment included all medications containing buprenorphine. We calculated morphine milligram equivalent (MME) doses using the CDC opioid conversion table[29] and reported doses above the CDC thresholds of 50 and 90 MME/day.[30] We used the number of days' supply in a single prescription to identify supplies of more than 7 days. Long-term opioids were defined as 60 or more days supplied within a calendar quarter.[31]

We linked opioid prescriptions to diagnoses occurring within 3 days before the fill. For workers with claims for more than one condition within the 3-day window, we linked the opioid prescription to the worker's diagnoses by acuity using the following order of priority as recommended in the Centers for Medicaid and Medicare Services guidelines[32]: (1) musculoskeletal surgery; (2) acute musculoskeletal injury; (3) chronic musculoskeletal disorder or recurrent injury; and (4) other (nonmusculoskeletal conditions). When two or more opioid drugs were filled on the same day, the total days' supply was based on the drug with the longest supply length (days' supply from only one of the opioids) and the daily dose of the multiple opioids was based on the sum of the MME divided by the opioid with the longest supply length (number of days).

2.2.3 | Data analysis

For each member, we restricted analysis to the continuous period of coverage after becoming benefits eligible or starting January 2015 if already enrolled in the plan at study initiation. We calculated the annual average prevalence of opioid use stratified by mental health conditions, musculoskeletal conditions, other nonmusculoskeletal health conditions, opioid-related conditions, and age (in 10-year increments) across the entire period. Because workers in the health plan contributed differing periods of time, we reported annual average results to aid comparison to other literature. For all analyses, we excluded workers with diagnoses of any of the following conditions before the initial opioid prescription: malignant or metastatic cancer (ICD-10: C00.x–C26.x, C30.x–C34.x, C37.x–C41.x, C43.x, C45.x–C58.x, C60.x–C76.x, C77.x–C85.x, C88.x, C90.x–C97.x); opioid use disorder (ICD-10: F11); poisoning from opioids (ICD-10: T40.0, T40.1, T40.3, T40.4, and T40.6); other psychoactive substance-related disorders (ICD-10: F13, F14, F15, F16, F18, F19); or prescriptions for buprenorphine, a sedative, or a stimulant. All models were adjusted for age and the following mental health disorders: alcohol-related disorders (F10), nicotine dependence (F17), cannabis-related disorders (F12), mood affective disorders (F30–F39), and anxiety and other nonpsychotic mental disorders (F40–F49).

We quantified the annual incidence of receiving high-dose, large supplies (>7 days), or long-term opioids by each health condition among opioid-naïve patients, defined as eligible to file a claim but who had not filled an opioid prescription for at least 60 days before the first opioid fill during the study, and had no history of OUD (F11), poisoning, or other illicit drugs (F13–F16, F18, F19). For single prescriptions, we computed the risk of receiving a high daily dose of opioids (>50 MME/day) and a supply of more than 7 days in multivariable log-binomial regression models for each health condition among opioid-naïve patients. We ran the same model to compute the risk of long-term opioid use within a year from the first opioid fill among opioid naïve users.

Finally, we quantified the odds ratio between diagnostic conditions and developing an opioid use disorder among all workers prescribed opioids at any point in the study period without regard to being opioid-naive. We defined *opioid use disorder* as receiving an ICD-9/10 diagnosis of opioid use disorder (including poisoning), or receiving a buprenorphine prescription. All analyses were carried out with R statistical software.[33]

3 | RESULTS

There were 19,909 male construction workers in the cohort during the 3.5-year period of observation, with an average of 16,707 workers eligible to file a claim each year (Table 1). On average, 92% of eligible workers filed a claim annually. The largest portion (46.4%) of claims were musculoskeletal conditions ($N = 7752$) of which 2,672 (34%) received an opioid prescription. Of 1,644 workers undergoing surgery for musculoskeletal conditions, 1,002 (61%) started opioids. On average, 3% of workers per year had new long-term opioid use (received a supply of at least 60 days of opioids in a calendar quarter). Nearly 3% of workers also received a prescription for a benzodiazepine within 30 days of filling an opioid prescription. In the 3.5-year study, 304 workers (1.5% of the total sample) received a diagnosis of opioid use disorder; 116 of these individuals had a diagnosis of OUD within 12 months of their first opioid prescription.

The condition most likely (46%) to be treated with opioids was kidney stones (Figure 1), but this condition was rare (prevalence 1%; $n = 251$) and rarely led to long-term opioid use (2.7%). In contrast, chronic musculoskeletal disorders or recurring musculoskeletal injury were common (43%; $n = 7,151$) and workers with this diagnosis received prescriptions for opioids 24.1% of the time, and of those who started an opioid, 6.3% developed long-term opioid use. Musculoskeletal surgery was less common (prevalence 10% per year) but 40% of these surgical cases received an opioid prescription, with 7.4% developing chronic use. In contrast, only 1% of workers who initiated opioids for dental visits ended up with chronic use.

Among the 5,033 workers initiating opioids (Table 2), high-dose opioids (≥50 MME/day) were most commonly initiated for those undergoing musculoskeletal surgery (54%) compared to those without surgery (23%; relative risk [RR] 1.92; 95% CI 1.30–2.83). Fifteen percent of workers with chronic musculoskeletal disorders who started opioids began with ≥50 MME/day. Opioid supply for more than 7 days was common for those with chronic musculoskeletal disorders (41%, RR 2.65; 95% CI 1.48–4.73), and those with musculoskeletal surgery (28%, RR 1.67; 95% CI 1.23–2.27). Long-term opioid use (>60 days per calendar quarter) was common (RR 4.34;

TABLE 1 Average annual construction worker demographics, diagnoses, and opioid prescriptions data from January 2015 to June 2018

	Average per year	Received prescription opioids per year
Eligible workers	16707	3443
had medical claim	15364 (92%)	3432 (99.7%)
Age at start of year		
Under 30	2836 (17%)	354 (10.3%)
30s	4334 (25.9%)	851 (24.7%)
40s	3758 (22.5%)	788 (22.9%)
50s	4372 (26.2%)	1095 (31.8%)
60+	1407 (8.4%)	354 (10.3%)
Mental health conditions		
Alcohol disorders (F10)	307 (1.8%)	120 (3.5%)
Nicotine dependence (F17)	1483 (8.9%)	659 (19.1%)
Mood disorders (i.e., depression, bipolar) F30–F39	773 (4.6%)	286 (8.3%)
Nonpsychotic mental disorders (i.e., anxiety) F40–F48	1206 (7.2%)	438 (12.7%)
Cannabis disorders	56 (0.3%)	23 (0.7%)
Other illicit drug disorders	91 (0.5%)	35 (1%)
Other (non-MSK) health conditions		
Cancer (metastatic or malignant)	281 (1.7%)	132 (3.8%)
Kidney stones	251 (1.5%)	168 (4.9%)
Abdominal pain	802 (4.8%)	378 (11%)
Dental visit (prevention or treatment)	6418 (38.4%)	1852 (53.8%)
Musculoskeletal (MSK) conditions		
Any MSK condition	7752 (46.4%)	2672 (77.6%)
Chronic MSK disorder or recurring MSK injury	7151 (42.8%)	2504 (72.7%)
Chronic MSK disorder	7106 (42.5%)	2490 (72.3%)
Recurring MSK injury[a]	686 (4.1%)	316 (9.2%)
Acute MSK injury[a]	2734 (16.4%)	1195 (34.7%)
MSK surgery	1644 (9.8%)	1002 (29.1%)
MSK surgery and chronic MSK disorder or recurring MSK injury	1473 (8.8%)	883 (25.7%)
MSK surgery and acute MSK injury	394 (2.4%)	307 (8.9%)
MSK body region (acute or chronic)		
Back/torso MSK injury or disorder	5025 (30.1%)	1788 (51.9%)
Lower extremity MSK injury or disorder	2435 (14.6%)	1020 (29.7%)
Upper extremity MSK injury or disorder	2507 (15%)	1066 (31%)
Opioid-related conditions		
Opioid use disorders (OUD; F11)	132 (0.8%)	61 (1.8%)
Opioid poisoning (T40.0, T40.1, T40.3, T40.4, T40.6)	11 (0.1%)	3 (0.1%)
Prescription for buprenorphine	67 (0.4%)	22 (0.6%)
Total opioid-related conditions (OUD, poisoning or buprenorphine)	151 (0.9%)	69 (2%)
Long-term opioid use (≥60days supply in a calendar quarter)	518 (3.1%)	518 (15%)
Benzodiazepine fill within 30 days of opioid fill	430 (2.6%)	430 (12.5%)

Abbreviations: CPT, Current Procedural Terminology; ICD, International Classification Diagnostic.

[a]MSK surgery (CPT codes: 20005-21010; 21500-22900; 62263-63746; 64400-64999); acute injury (ICD10: S00.x-S99.x; T00.x-T14.x); chronic MSK (ICD10: M00-M25, M30-M36, M40-M54, M60-M79, M80-M94, G54.0-G57.0) or recurring acute (acute injury code repeated after 30 days).

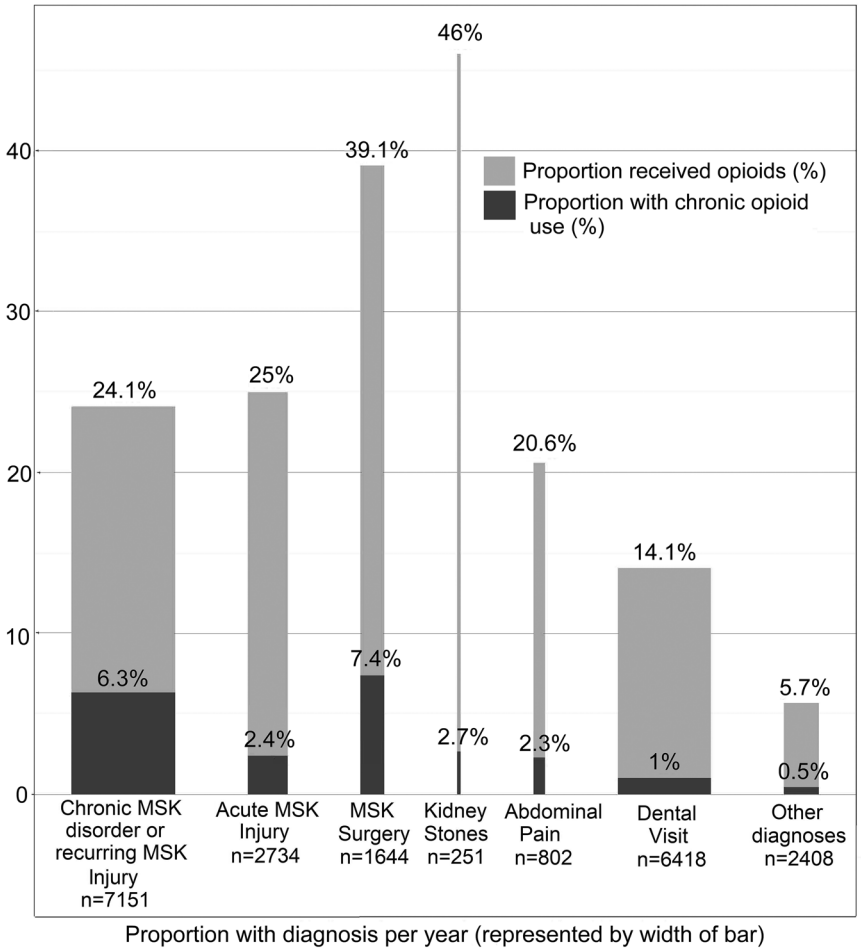

FIGURE 1 Prevalence of construction workers who received opioids within 3 days of diagnosis by the proportion with each diagnosis. Gray columns show the fraction of workers who were initiated on opioid therapy and black columns show the fraction of workers who had long-term opioid use, where long-term is defined as ≥60 days of prescription opioids supply in a subsequent 90-day period. Column widths are proportional to the number of workers within each diagnostic category (see text for ICD-9 and -10 codes). Musculoskeletal (MSK) surgery column includes workers with MSK surgery, with or without chronic MSK disorder or acute MSK injury. ICD, International Classification of Disease

95% CI 1.81–10.40) among those with chronic musculoskeletal disorders within 1 year of the first opioid prescription for this condition.

We also examined the odds of having an opioid use disorder within 1 year after filling an opioid prescription for a musculoskeletal condition versus several nonmusculoskeletal diagnoses (kidney stones, abdominal pain, or a dental visit; see Figure 2). Those diagnosed with chronic musculoskeletal disorders had the highest OR (95% CI) of developing opioid use disorder 4.71 (3.09–7.37) followed by those with musculoskeletal surgery 1.89 (1.26–2.79) or acute musculoskeletal injury 1.53 (1.02–2.26). Other diagnoses that were often prescribed opioids showed no elevated odds of developing opioid use disorder. MSK disorders or injuries of the back or torso were more frequently associated with incident opioid use (26.1%) than lower or upper extremity MSK disorders or injuries. Workers who received multiple opioid drugs in the same prescription were nearly five times more likely to develop an opioid use disorder (OR 4.84, 95% CI 2.96–7.71). Workers given high doses (≥50 MME/day) doubled their likelihood of opioid use disorder (OR 2.06; 95 CI 1.39–3.08), and those prescribed more than 7 days' supply were seven times more likely (OR 7.2; 95 CI 4.51–12.02). Workers with long-term opioid prescriptions were nearly ten times more likely (OR 9.95; 95 CI 6.66–14.94) to be treated for OUD.

4 | DISCUSSION

This study showed that nearly half of the construction workers were diagnosed with chronic musculoskeletal disorders, and one-quarter of those with chronic musculoskeletal disorders received an opioid prescription of whom 6.3% developed long-term opioid use. Those diagnosed with chronic musculoskeletal disorders were more than four times as likely to develop an OUD than those started on opioids for other diagnoses. Those initiating opioids for other diagnoses (including kidney stones, abdominal pain, and dental visits) were not at increased risk of having an opioid dependency. High doses, prescriptions greater than 7 days, and prescriptions more than 60 days in a calendar quarter were strongly associated with a new OUD (approximately 2, 7, and nearly 10 times greater, respectively, compared to those prescribed fewer opioids). Our first hypothesis was that workers with acute or chronic musculoskeletal disorders were more likely to initiate an opioid than those with other conditions. Instead, we found that those with a diagnosis of kidney stones and abdominal pain were most likely to receive opioids, although few workers had claims for these diagnoses. However, the greatest number of workers who received opioids had a musculoskeletal diagnosis. The data supported our second hypothesis: among work-

TABLE 2 Among 5,033 workers initiating opioids, relative risk of high opioid dose and supply in first prescription and long-term opioids by diagnoses

	Diagnoses					
	Chronic MSK disorder	Acute MSK injury	MSK surgery	Dental visit	Abdominal pain	Kidney stones
Prevalence with diagnosis, *n* (%)	892 (19%)	771 (16%)	654 (14%)	1384 (29%)	197 (4%)	179 (4%)
50 MME or more per day in first fill						
With diagnosis, *n* (%)	130 (15%)	170 (22%)	356 (54%)	336 (24%)	52 (26%)	56 (31%)
Without diagnosis, *n* (%)	1182 (30%)	1142 (28%)	956 (23%)	976 (29%)	1260 (27%)	1256 (27%)
RR	0.52	0.81	1.92	0.89	1.07	1.16
p	<.001	.01	<.001	.09	.59	.21
>7 Days supply in first fill						
With diagnosis, *n* (%)	361 (41%)	95 (12%)	180 (28%)	22 (2%)	21 (11%)	13 (7%)
Without diagnosis, *n* (%)	452 (12%)	718 (18%)	633 (15%)	791 (23%)	792 (17%)	800 (17%)
RR	2.65	0.83	1.67	0.10	0.51	0.37
p	<.001	.13	<.001	<.001	0.001	<.001
Long-term opioids[a] in a calendar quarter						
Prevalence of diagnosis among those with 1-year follow-up	671 (20%)	544 (16%)	452 (13%)	982 (29%)	134 (4%)	126 (4%)
With diagnosis, *n* (%)	76 (11%)	18 (3%)	9 (2%)	9 (1%)	4 (3%)	0 (0%)[b]
Without diagnosis, *n* (%)	56 (2%)	114 (4%)	123 (4%)	123 (5%)	128 (4%)	132 (4%)
RR	4.34	1.19	0.78	0.33	0.65	–
p	<.001	.59	.53	.004	.39	–

Note: Log-binomial multiple regression models, adjusted for age, mental health; Diagnoses are those within 3 days before opioid fill. Assignment of MSK diagnoses for multiple diagnoses in same claim by acuity: MSK surgery before acute injury before chronic MSK disorder; opioid naïve defined as eligible to file a claim but opioid free for 60 days before fill and no history of opioid use disorder (F11), poisoning, or other illicit drugs (F13–F16, F18, F19).

Abbreviations: MME, morphine milligram equivalent; MSK, musculoskeletal; RR, relative risk.

[a]Long-term opioids are at least 60 days' supply in a single calendar quarter within a year from first opioid fill.

[b]Excluded from model.

ers initiated on opioids, workers with chronic musculoskeletal disorders were more likely to develop OUD than those prescribed opioids for other conditions including a (nonrecurring) acute injury.

Our results showed high dosage of MME was not commonly prescribed to patients with chronic musculoskeletal disorders, differing from findings in older studies.[30] Among workers initiating opioids, the first prescription of opioids exceeded the 50 MME threshold promulgated by the CDC[30] in 15% of patients with chronic musculoskeletal disorders and in 54% of those who underwent musculoskeletal surgery. Like other studies,[3,34] we found that multiple prescriptions of opioids and long-term prescriptions were more important risk factors for developing OUD than high daily dose. Opioids were commonly prescribed for musculoskeletal surgery (61%), consistent with other studies.[35] Our findings show that conditions associated with acute pain, like dental procedures, carry a relatively low risk for long-term opioid use. In contrast, chronic musculoskeletal disorders have a high risk of long-term opioid use. Others have shown a higher rate of opioid overdose among patients with long-term opioid use[36-39] further highlighting the risk of long-term opioid use. Our study also found that MSK disorders or injuries of the back or torso were more frequently associated with incident opioid use. Ly[40] reported that among patients with claims for recurrent low back pain, 26.2% received tramadol and 32.3% received nontramadol opioids. Furthermore, Ly[40] found that these patients often receive opioids before trying physical therapy or NSAIDs.

Our results are consistent with studies that show opioids are commonly prescribed for acute and chronic musculoskeletal pain.[41-43] However, the prevalence of opioid use and opioid use disorder among this construction cohort is much higher than other populations. Moshfegh and George[44] found that the risk of developing long-term opioid use among opioid-naïve patients with new musculoskeletal disorders was less than 1%,—far below the 6.3% risk we found among construction workers diagnosed with chronic musculoskeletal disorder and the 2.4% risk among the workers with acute musculoskeletal injuries. Another study[34] showed that 12% of construction workers received chronic prescriptions, suggesting workers seek treatment for ongoing pain. Notably, we used general health insurance data, not workers' compensation data, and found high rates of acute and chronic musculoskeletal conditions associated with opioid use. The higher rates of musculoskeletal conditions captured in general health insurance data are likely the consequence of underreporting of work-related injuries in Workers' Compensation data, reflecting cost-shifting of claims to general

	Opioid users (N = 5057)	Opioid abuse (N=116)	OR	CI
Ever had opioid Rx for musculoskeletal condition:				
Chronic MSD or recurring MS injury	1905 (37.7%)	86 (74.1%)	4.71	3.09 - 7.37
Acute MS injury	1147 (22.7%)	46 (39.7%)	1.53	1.02 - 2.26
MS Surgery	1238 (24.5%)	46 (39.7%)	1.89	1.26 - 2.79
Back/torso MSD or injury	1318 (26.1%)	72 (62.1%)	4.11	2.78 - 6.12
Lower extremity MSD or injury	944 (18.7%)	41 (35.3%)	1.99	1.32 - 2.96
Upper extremity MSD or injury	867 (17.1%)	32 (27.6%)	1.67	1.07 - 2.54
Ever had opioid Rx for other conditions:				
Kidney stones	249 (4.9%)	6 (5.2%)	1.09	0.41 - 2.35
Abdominal pain	322 (6.4%)	10 (8.6%)	0.84	0.40 - 1.59
Dental visit (prevention or treatment)	1791 (35.4%)	45 (38.8%)	1.11	0.75 - 1.63
Ever had opioid Rx with following:				
multiple opioid drugs in same prescription	249 (4.9%)	28 (24.1%)	4.84	2.96 - 7.71
multiple scripts in same day from different doctors	46 (0.9%)	4 (3.4%)	1.83	0.50 - 5.21
dose >= 50 MME/day	2241 (44.3%)	75 (64.7%)	2.06	1.39 - 3.08
dose >= 90 MME/day	581 (11.5%)	32 (27.6%)	2.41	1.53 - 3.70
Supply > 7 days in a single script	1917 (37.9%)	95 (81.9%)	7.20	4.51 - 12.02
Supply >= 60 days in a single calendar quarter	517 (10.2%)	65 (56.0%)	9.95	6.66 - 14.94

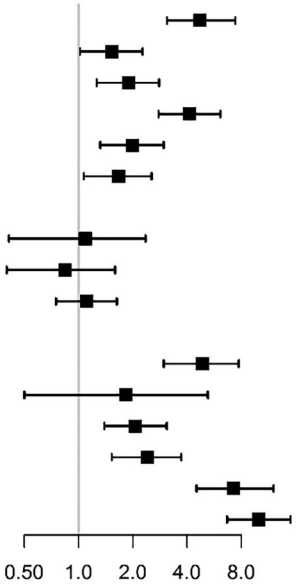

FIGURE 2 Odds of opioid use disorder among those receiving opioid prescriptions (n = 5,057). Forest plot of multivariable logistic regression models for the outcome of opioid use disorder (diagnosis of opioid use disorder or poisoning, or receiving buprenorphine) and a predictor variable (musculoskeletal condition, other diagnosis, or the opioid prescriptions) after adjusting for age, gender, mental health among workers who received opioids and followed for up to 1 year after the fill of the first prescription. Each opioid prescription was linked to a visit up to 3 days before the prescription. If more than one diagnosis was assigned on a single visit or claim, the assigned claim followed the order of acuity (musculoskeletal [MSK] surgery, acute MSK injury, chronic MSK disorder, other diagnosis). The odds ratio shows the odds of developing an opioid use disorder within 1 year after filling an opioid prescription assigned to one or more of the health conditions or to the dose and supply of opioids. The first opioid prescription filled in the database for each worker was used in this analysis. MME, morphine milligram equivalents; MSK, musculoskeletal

health insurance,[45,46] partly due to the difficulty of attributing chronic conditions to specific work incidents. In addition, the average annual prevalence of OUD in this sample of 0.8% is likely underestimated since only workers who seek medical treatment could receive a diagnosis and some workers may seek treatment for health conditions unrelated to OUD so fail to receive a diagnosis for OUD.[47] Past studies suggest that other reasons for the underestimation of OUD diagnosis among construction workers is due to failure to seek treatment from lack of health insurance,[48] suffering from mental distress so avoid seeking treatment,[49] and low job security so fear of taking time off work.[50-52] Despite this limitation, health claims provide a means to show associations between prescription opioids and development of OUD among those workers who seek treatment.

Due to the physically demanding nature of their work, construction workers are at high risk for chronic musculoskeletal disorders. Construction and mining industries have the highest rates of opioid prescriptions for work-related injuries.[34] Healthcare providers should use caution when initiating opioids in construction workers and other laborers, as these patients have high physical exposures at work. The high rates of opioid use and overdose seen in hazardous occupations also emphasize the need for primary prevention, to reduce physical exposures that lead to initial or recurring painful health conditions.[53] Ideally, physical, complementary, and psychological therapies would be substituted for chronic opioid therapy.[54]

These findings highlight an important role that work injuries play in driving the opioid epidemic among hazardous or physically demanding occupations. A previous study of opioid overdoses in Utah found that half of those who died from an opioid-related overdose had previously been treated for a job-related injury.[55] Data from Massachusetts[12,16] showed that the occupational groups with the highest rates of fatal overdose have high rates of musculoskeletal injuries. These data also showed that workers in occupations with lower availability of paid sick leave and lower job security had higher opioid-related mortality. These findings suggest that the need to return to work soon after an injury or to work while in pain might contribute to the high rates of opioid use and opioid-related overdose deaths seen among construction workers and other workers who often lack paid sick leave and have intermittent or insecure work.

5 | LIMITATIONS

Health claims cannot account for all contributing factors to opioid misuse, including mental health conditions and other substance use, which are incompletely captured by claims. Long-term opioid use and opioid use disorder may be undercounted by health claims. These outpatient claims would not capture opioid prescriptions given

before discharge from the hospital. Likewise, OUD is not always captured by diagnostic codes or prescription buprenorphine. Data from a single healthcare provider and pharmacy benefit plan are unable to capture all opioids taken by the workers, who may fill prescriptions outside of their health plan, or use illicit opioids. Workers may have filled opioid prescriptions from other providers or paid cash for prescriptions, which would not be recorded by the pharmacy benefit provider. We classified workers as "opioid naïve" if they had not been prescribed any opioid within a 60-day window before the first opioid prescription in our database, but acknowledge that some of these workers may have received opioids earlier. It is not known how many opioids were actually consumed from the filled prescriptions.

A strength of the study is the large sample of workers with individual-level medical claims and prescriptions. Our study found robust associations between treatment for chronic musculoskeletal disorders and musculoskeletal surgery with long-term opioid use and opioid use disorder. Construction workers are at high risk given their high rates of overdose deaths.[15] Clinicians and employers should consider their roles in preventing long-term opioid use and misuse. Employers should explore means to prevent work conditions that lead to pain among workers; clinicians should follow recommended guidelines,[30] prescribing doses less than 50 MME/day and supplies less than 7 days of opioids, with careful monitoring and substituting alternative treatments for pain when feasible.

6 | CONCLUSIONS

Opioids are commonly prescribed for pain relief among construction workers through their personal health insurance. A substantial number of workers who initiate opioids become long-term users, and these long-term users have a nearly 10-fold risk of developing opioid use disorder within a short period of time. Opioids should be more judiciously prescribed, particularly for workers in hazardous and physically demanding occupations, with greater use of alternative pain management treatments.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

AUTHOR CONTRIBUTIONS

Ann Marie Dale and Brian F. Gage designed the study, obtained funding, and reviewed and edited the paper. Skye Buckner-Petty and Ann Marie Dale obtained the study data. Ann Marie Dale, Brian F. Gage, and Skye Buckner-Petty contributed to data analysis and data visualization. All authors contributed to interpreting the data, drafting and formatting the manuscript, gave final approval of the version to be submitted for review and published, and agreed to be accountable for all aspects of the work.

ETHICS APPROVAL AND INFORMED CONSENT

Institutional review and ethics approval was obtained from the Human Subjects Office at Washington University in St. Louis, Missouri, USA. There was a waiver of consent as this was a secondary data analysis and the data were deidentified.

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