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Reducing Disability Durations and Medical Costs for Patients With a Carpal Tunnel Release Surgery Through the Use of Opioid Prescribing Guidelines

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Objective: The impacts of compliance with opioid prescribing guidelines on disability durations and medical costs for carpal tunnel release (CTR) were examined. **Methods:** Using a dataset of insured US employees, opioid prescriptions for 7840 short-term disability cases with a CTR procedure were identified. Opioids prescriptions were compared with the American College of Occupational and Environmental Medicine (ACOEM)'s opioid prescribing guidelines for postoperative, acute pain, which recommends no more than a 5-day supply, a maximum morphine equivalent dose of 50 mg/day, and only short-acting opioids. **Results:** Most cases (70%) were prescribed an opioid and 29% were prescribed an opioid contrary to ACOEM's guidelines. Cases prescribed an opioid contrary to guidelines had disability durations 1.9 days longer and medical costs $422 higher than cases prescribed an opioid according to guidelines. **Conclusions:** The use of opioid prescribing guidelines may reduce CTR disability durations and medical costs.

The majority of the economic burden associated with opioid abuse are workplace costs.[1–3] Opioid abuse has been associated with lost productivity,[2] prolonged time on disability,[4,5] and increased work disability claim costs.[6,7] Therefore, reducing the number of unnecessary opioid prescriptions for disability claims has the potential for large societal cost savings.

Most abusers of opioids reported their first exposure to opioids was through a prescription drug[8] and physician opioid prescribing patterns have been associated with opioid abuse and deaths.[9–11] Previous studies have identified physicians prescribing excessive opioids and indicators of inappropriate prescriptions.[12,13] For example, Waljee et al[13] analyzed opioid prescriptions for common upper extremity surgical procedures in a US nationwide sample ($n = 296{,}452$) and found that ~8.8% of cases filled a potentially inappropriate opioid prescription.

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The use of opioid prescribing guidelines is a common recommendation to help prevent unnecessary first exposure to opioids, as well as to help select the correct opioid treatment when opioid therapy is warranted.[14,15] Guidelines have been shown to reduce opioid prescription rates[16,17] and improve health outcomes.[16–18] Research from Washington State workers' compensation (WC) system has shown that opioid dosing guidelines reduced morphine equivalent (ME) doses and the number of opioid-related deaths.[17] While previous studies have found opioid use increases disability durations and medical costs, no study to date has investigated how following opioid prescribing guidelines affects disability durations and medical costs.

The purpose of this study is to analyze how opioid prescriptions modify disability duration and medical costs in short-term disability (STD) disability cases with a carpal tunnel release (CTR) procedure. CTR is an important surgical procedure to investigate due to the high and increasing incidence in the United States.[19,20]

METHODS

Data

This study analyzed data from Truven's MarketScan Commercial Claims and Encounters (CCAE) and Health and Productivity and Management (HPM) databases. The CCAE database contains healthcare utilization data from active employees, early retirees, COBRA-covered, and dependents insured from employer-sponsored plans. The HPM database contains disability leave information including the primary leave diagnosis and disability duration. STD claims from the HPM database were linked to the medical claims in the CCAE database to capture both disability and medical information.

Defining Disability Cases and Time Frames

STD cases were considered for this analysis if disability absence dates occurred between 2007 and 2014 with carpal tunnel syndrome (ICD-9-CM = 354.0) as the primary reason for the leave ($n = 13{,}158$). To capture STD cases that transferred to a long-term disability (LTD) program, LTD records were searched for LTD start dates within 7 days after the STD ended that had carpal tunnel syndrome as the primary reason for the LTD leave. In these circumstances, the LTD return to work (RTW) date was used as the RTW date. For each case, CCAE inpatient services, outpatient services, and outpatient pharmaceutical claim tables were searched for all diagnoses, procedures, and prescriptions, along with their service dates and associated costs. Of the 13,158 carpal tunnel syndrome STD cases, 8271 had a CTR procedure, defined as either having a CPT® code of 64721 or 29848, or an ICD-9-CM procedure code of 04.43. The CTR procedure date had to be between 7 days prior to the first absence date and the RTW date, herein the "disability time frame." Cases with mention of pregnancy (ICD-9-CM = 630–679), malignant cancer (ICD-9-CM = 140–209), burn (ICD-9-CM = 940–949), or radius/ulna fracture (ICD-9-CM = 813.XX) during the disability time frame were excluded. To remove cases with other major surgeries occurring in conjunction with the CTR procedure, cases with an inpatient stay with a service date 1 week before and after the CTR release procedure, herein the ''release time frame,'' were removed. To ensure capture of all applicable medical information, cases without continuous health care coverage 90 days prior to the start of the CTR time frame (herein ''pre-release time frame'') to the RTW date were removed and resulted in a final sample of 7840 cases (Fig. 1). The period after the CTR procedure to the RTW date was defined as the ''post-release time frame'' (Figure S1, http://links.lww.com/JOM/A367).

Demographic and Disability Characteristics

The following variables were abstracted from the CCAE and HPM databases: age, sex, history of any previous disability leave, history of a previous disability leave for carpal tunnel syndrome, employee's job industry, health plan type, whether the employee is salaried or in a union, whether the case was in inpatient care during leave, and the number of distinct dates where a CTR procedure was performed. The sum of unique ICD-9-CM codes and the sum of unique procedures codes were used as metrics of disease severity. Comorbidities were defined using ICD-9 diagnosis groupings in Quan et al.[21] Quan et al.'s reweights of the Charlson Comorbidity index were also used as another metric of disease severity.[22] Along with the depression comorbidity defined by Quan et al,[21] if an individual was prescribed an antidepressant during a time frame, the individual was considered to have depression as a comorbidity. Both comorbidity groupings and comorbidity index values were obtained using the *icd* package in the R statistical programming language.[23] Geographically-derived variables were generated by linking each record's Metropolitan Statistical Area or, if unavailable, county with data from the 2007 to 2011 American Community Survey to get the 5-year average values for median household income, population density (number of people per square mile), and percent of residents with a college degree or more. These data were abstracted from the Census API with the function *acs.fetch* in R.[24]

Opioid Prescriptions

National drug codes (NDC) of filled prescriptions were mapped to a compilation of opioid NDCs by the Center for Disease Control (CDC) to determine opioid strength per unit (eg, milligrams per tablet, patch, etc), whether the opioid is considered a long or short acting opioid, and the ME conversion factor.[25] The MME/day was calculated using the following equation: MME/day = Strength per unit (mg) × (Number of Units/Days Supply) × ME conversion factor. Cumulative ME (mg) was the sum of all opioid MMEs within the time frame of interest. When multiple opioid prescriptions were filled during the time frame, the sum of day supply and the average MME/day were used. To determine if an opioid was prescribed for the CTR procedure, the prescription had to be filled within plus or minus 1 week of the CTR date. In addition, the prescription could not be a refill prescription unless it was the same NDC code as an original prescription.

Opioid Prescribing Guidelines

The American College of Occupational and Environmental Medicine's (ACOEM) opioid practice guidelines (effective date of April 20, 2017) were used to compare with the observed CTR opioid prescriptions.[26] For postoperative pain and minor procedures, the guidelines recommend against prescribing: (1) long-acting or extended release opioids, (2) for opioid-naïve patients, greater than a 5-day supply of opioids, and (3) for opioid-naïve patients, prescriptions with a MME/day greater than 50 mg. An opioid-naïve case was defined as an individual who had not filled an opioid prescription within 90 days prior to the CTR procedure.

Risk Factors for Opioid Abuse and Adverse Events

In addition to the prescribing recommendations, the presence of risk factors associated with opioid abuse and adverse events were investigated. History of depression, alcohol abuse, drugs, or

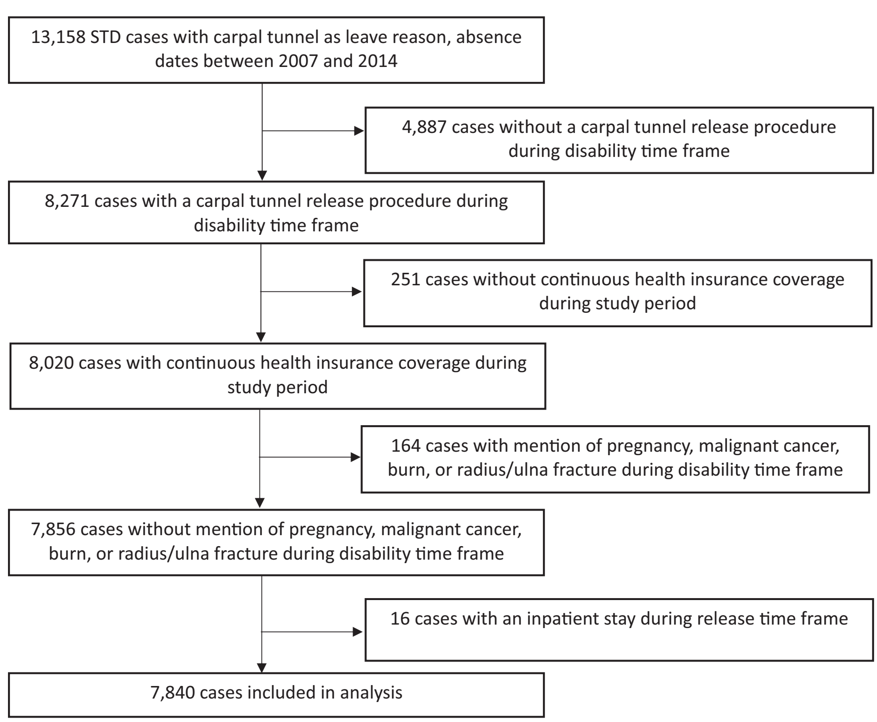

FIGURE 1. Flow diagram of cases included in analysis.

psychosis were defined using Quan et al.'s[21] comorbidity groupings. In addition, benzodiazepine prescriptions occurring during the release time frame were investigated.

Outcomes

The number of calendar days from the CTR procedure to the RTW date and the sum of all medical costs from the CTR date to the RTW date were the outcomes studied. Medical costs were adjusted to 2014 equivalent costs using the Consumer Price Index by month and year.

Statistical Analysis

Chi-squared tests were used to compare demographic and risk factors frequency by whether a case filled an opioid prescription during the release time frame. The probability of being prescribed an opioid contrary to guidelines by year of the release procedure was calculated to test for changes in prescribing behaviors, excluding releases performed in 2006 due to limited sample size ($n = 3$). To understand the impact of opioid prescribing on disability durations and medical costs, the data were subset to only include claims that were prescribed an opioid, opioid-naïve, and had only opioid prescriptions for the CTR procedure ($n = 4109$). This subset reduces the potential confounding effect of condition severity on the relationship between opioid prescribing and outcomes. Survival models were used in this analysis to account for the eight cases who did not RTW. Nonparametric Kaplan–Meier (KM) estimations were used to assess how opioid day supply, cumulative ME, and ME/day, discretized into quantiles, influenced disability duration, and medical costs. Chi-squared P values from log-rank tests were used to assess statistical significance between groups.

The influence of following opioid prescribing guidelines on disability duration and medical costs was tested using KM estimations and lognormal multiple variable survival models. Disability durations and medical costs followed a lognormal distribution better than Weibull, exponential, and Gaussian distributions. Covariate missing data, all less than 16% of data per variable, were imputed based on the observed empirical distributions. In our modeling procedures, household income was scaled by subtracting the mean and dividing by the standard deviation to stabilize fit estimates. Due

TABLE 1. Characteristics of Short Term Disability (STD) Cases With a Carpal Tunnel Release (CTR) Procedure

Category	All, $n = 7{,}840$	Not Prescribed Opioid for CTR, $n = 2{,}353$	Prescribed Opioid for CTR, $n = 5{,}487$	P Value*
Sex				0.318
Female	4,757 (60.7%)	1,448 (61.5%)	3,309 (60.3%)	
Male	3,083 (39.3%)	905 (38.5%)	2,178 (39.7%)	
Age, yrs				<0.001
≥18 and <30	236 (3%)	74 (3.1%)	162 (3%)	
≥30 and <40	1,199 (15.3%)	323 (13.7%)	876 (16%)	
≥40 and <50	2,346 (29.9%)	657 (27.9%)	1,689 (30.8%)	
≥50 and <66	4,059 (51.8%)	1,299 (55.2%)	2,760 (50.3%)	
Health plan type				<0.001
Consumer-driven health plan	2,138 (27.3%)	742 (31.5%)	1,396 (25.4%)	
Point of service	3,104 (39.6%)	895 (38%)	2,209 (40.3%)	
Preferred provider organization	2,598 (33.1%)	716 (30.4%)	1,882 (34.3%)	
Previous disability program utilization				0.006
No	4,297 (54.8%)	1,234 (52.4%)	3,063 (55.8%)	
Yes	3,543 (45.2%)	1,119 (47.6%)	2,424 (44.2%)	
Previous disability program utilization for carpal tunnel				0.001
No	7,132 (91%)	2,100 (89.2%)	5,032 (91.7%)	
Yes	708 (9%)	253 (10.8%)	455 (8.3%)	
Transferred to LTD from STD				0.898
No	7,770 (99.1%)	2,331 (99.1%)	5,439 (99.1%)	
Yes	70 (0.9%)	22 (0.9%)	48 (0.9%)	
Number of unique diagnoses during release time frame				0.067
1	2,136 (27.2%)	682 (29%)	1,454 (26.5%)	
≥2 and <4	3,256 (41.5%)	963 (40.9%)	2,293 (41.8%)	
≥4 and <20	2,448 (31.2%)	708 (30.1%)	1,740 (31.7%)	
Number of unique procedures during release time frame				0.068
≥1 and <3	1,924 (24.5%)	604 (25.7%)	1,320 (24.1%)	
≥3 and <5	2,114 (27%)	652 (27.7%)	1,462 (26.6%)	
≥5 and <8	1,798 (22.9%)	540 (22.9%)	1,258 (22.9%)	
≥8 and <45	2,004 (25.6%)	557 (23.7%)	1,447 (26.4%)	
Comorbidity index score during release time frame†				0.982
0	7,491 (95.5%)	2,247 (95.5%)	5,244 (95.6%)	
1	252 (3.2%)	77 (3.3%)	175 (3.2%)	
>1	97 (1.2%)	29 (1.2%)	68 (1.2%)	

LTD, long-term disability.
*P value from chi-squared test.
†From Quan et al[22].

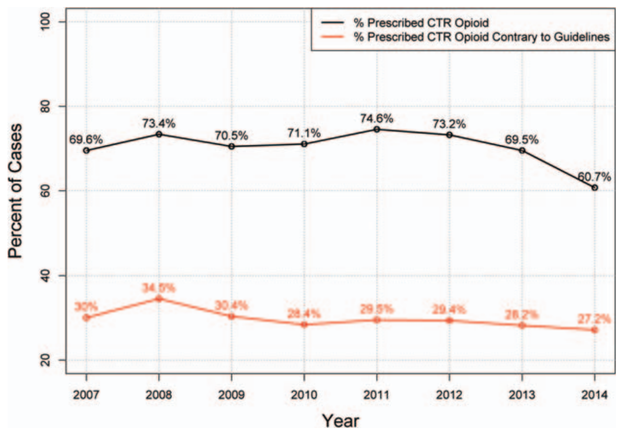

FIGURE 2. Year trends in opioid prescribing for carpal tunnel release (CTR).

to the high number of potential covariates in the multiple variable regressions, 100 bootstrap estimations with a backwards variable selection procedure were used to find predictors that were statistically associated (P value < 0.05) with the outcomes in at least 60% of the bootstrap samples.[27] Significant variables were then fit to the full dataset to produce estimates of the relationship of following guidelines on disability durations and medical costs, while controlling for confounders.

As a sensitivity analysis, the data were further subset to exclude any cases filling an opioid prescription later than the day after CTR procedure. Therefore, in this subset, no subsequent opioids were filled between the day after CTR and the day they returned to work. By including only cases filling an opioid prescription before or around the CTR procedure ($n = 2812$), the impact on disease severity and/or bad surgical outcomes to the disability durations and medical costs was attenuated. Both KM estimations and the bootstrapped-stepwise multiple regression technique were used to test the association of following guidelines on disability durations and medical costs in this subset.

To assess generalizability of our results to a population who received a CTR procedure but did not have a disability claim, demographic, severity metrics, and opioid prescribing statistics from 7840 random cases with a CTR procedure from the CCAE database without an STD or WC claim were compared to our study population using chi-squared tests.

All statistical tests were considered significant at a P value of 0.05. Microsoft's SQL Server 2012 and R Foundation's R version 3.1 were used for data management and analysis, respectively.[28]

RESULTS

Demographics

There were more women (60.7%) than men (39.3%) with a CTR procedure in our sample set (Table 1). The average age at time of disability was 49 years. The majority of cases did not have a previous STD claim (54.8%) and did not transfer to LTD from STD (99.1%).

Opioid Prescribing Patterns

A higher percentage of cases were prescribed an opioid during the release time frame (70%) than during the pre-release or post-release time frames (24.5% and 27.1%, respectively). The percent of cases prescribed an opioid for CTR peaked in 2011 (74.6%) and modestly decreased every year after (Fig. 2). For individuals filling an opioid prescription for the CTR procedure, an average of 1.1 prescriptions was filled with a median supply of 5 days (Table 2). The median (interquartile range [IQR]) ME per day and cumulative ME were 45 (32–60) mg/day and 200 (150–300) mg, respectively (Table 3). The ME dosage was typically higher during the release time frame than the pre/post-release time frames, whereas, the days of supply and cumulative dose were typically higher in the pre/post-release time frames than the release time frame. Of the opioids prescriptions filled, the most common opioid classes for CTR were hydrocodone/acetaminophen (69.2%), oxycodone/acetaminophen (19.9%), and codeine/acetaminophen (6.4%) (Table S1, http://links.lww.com/JOM/A367).

Prevalence of Risk Factors

In the pre-release time frame, 17.4% of cases had a documented depression diagnosis (Table S2, http://links.lww.com/JOM/A367), where individuals filling an opioid prescription tended to be more likely to have a depression diagnosis (17.9%) than those who did not fill an opioid prescription (16.1%), (chi-squared P value $= 0.059$). Only 0.5% of cases prescribed an opioid were also prescribed a benzodiazepine during the release time frame. Diagnoses of drug abuse, alcohol abuse, and psychosis were rare in this study population (less than 1%).

Opioid Prescribing Contrary to Guidelines

Opioids were prescribed contrary to ACOEM's guidelines in 28.9% of the CTR cases. In opioid-naïve cases, 16.9% and 15.2% were prescribed an MME/day greater than 50 mg and supplied greater than 5 days, respectively. Only 0.3% of cases were prescribed a long-acting/extended release opioid. Improvements in prescribing opioids according to ACOEM's guidelines can be seen in recent years, with the lowest percent of cases prescribed an opioid contrary to guidelines in 2014, our most recent year of data (Fig. 2). Of the 475 cases filling an opioid prescription for CTR prior to surgery, 44.6% had a prescription

TABLE 2. Number of Opioids Prescribed and Days of Supply for Those Who Filled an Opioid Prescription

			Day Supply					
Time Frames*	Cases Receiving Prescriptions	Average Number of Prescriptions	5th %ile	25th %ile	Median	Mean	75th %ile	95th %ile
Pre-release	1,919	2	2	5	13	30	40	95
Release†	5,487	1.1	2	3	5	6	7	15
Post-release	2,127	1.9	2	4	8	22	21	87

*Pre-release = time frame between 90 and 7 days prior to CTR procedure, release = time frame between 7 days prior and post CTR procedure, post-release = time frame from 7 days after CTR to RTW date.
†Statistics exclude opioid refill prescriptions not for the CTR procedure.

TABLE 3. Opioid Prescription Morphine Equivalent Characteristics-Statistics Only for Individuals Filling an Opioid Prescription

	Morphine Milligram Equivalents Per Day						Cumulative Morphine Equivalents, mg					
Time Frames*	5th %ile	25th %ile	Median	Mean	75th %ile	95th %ile	5th %ile	25th %ile	Median	Mean	75th %ile	95th %ile
Pre-release	10	21	30	47	45	85	75	150	300	1318	1000	4500
Release†	20	32	45	66	60	100	100	150	200	345	300	600
Post-release	15	30	40	50	56	94	100	150	300	987	675	3300

*Pre-release = time frame between 90 and 7 days prior to CTR procedure, release = time frame between 7 days prior and post CTR procedure, post-release = time frame from 7 days after CTR to RTW date.
†Statistics exclude opioid refill prescriptions not for the CTR procedure.

that was contrary to ACOEM's guidelines. Whereas, of the 4857 cases filling an opioid prescription for CTR on the day of surgery or after, 41.1% had a prescription that was contrary to ACOEM's guidelines.

Impact of Prescription Characteristics on Disability Durations and Medical Costs

The numbers of days supplied and cumulative ME were significantly associated with longer disability duration (P values < 0.001, Fig. 3). For example, the median disability duration for cases filling prescriptions with more than a 6-day supply was 49 days, whereas the median disability duration for cases with a 3-day supply or less was 43 days. No association with ME/day and disability durations was observed (P value $= 0.139$). The day supply, cumulative ME, and ME/day were all associated with medical costs (P values < 0.002, Figure S2, http://links.lww.com/JOM/A367). In particular, a strong dose–response was observed between cumulative ME and medical costs. Cases prescribed a cumulative dose less than or equal to 150 mg had median medical costs of $4417 and cases prescribed a cumulative ME dose of more than 300 mg had median medical costs of $5600.

Impact of Following Guidelines on Disability Durations and Medical Costs

Using Kaplan–Meier estimations, the median disability durations for cases prescribed an opioid according to guidelines was 44 days, significantly less than the median durations for cases prescribed opioids contrary to guidelines (47 days, P value < 0.001, Table 4). After controlling for potentially confounding variables, cases prescribed an opioid contrary to guidelines had significantly longer disability durations than those prescribed an opioid according to guidelines ($\beta = 0.043$, P value $= 0.014$, Table 5). Results of the bootstrap procedures are presented in SM Table S3, http://links.lww.com/JOM/A367. Holding all covariates within the model constant at their average values, individuals prescribed an opioid contrary to guidelines had disability duration that were 1.9 days longer.

Using Kaplan–Meier estimations, the median medical costs for cases prescribed an opioid according to guidelines was $4505, significantly less than the median medical costs for cases prescribed opioids contrary to guidelines ($5017, P value < 0.001). After controlling for potentially confounding variables, cases prescribed an opioid contrary to guidelines had significantly higher medical costs than those prescribed an opioid according to guidelines ($\beta = 0.085$, P value ≤ 0.001). Holding all covariates within the model constant at their average values, our analysis found individuals prescribed an opioid contrary to guidelines had medical costs $422 higher than cases prescribed an opioid according to guidelines. The relationship between following guidelines and disability duration or medical costs typically held across all record years (Figure S3, http://links.lww.com/JOM/A367).

In our sensitivity analyses, after excluding cases filling an opioid prescription later than the day after CTR surgery, KM estimations still found cases prescribed an opioid according to guidelines had significantly lower disability duration (median = 40, 40, IQR = 25 to 55) than those prescribed an opioid contrary to guidelines (median = 41, IQR = 27 to 59, P value $= 0.004$, Table S4, http://links.lww.com/JOM/A367). These results are attenuated when compared with the full population comparison. Similarly, in this subset, cases prescribed an opioid according to guidelines had significantly lower medical costs (median = $4057, IQR = $2850 to $6053) than those prescribed an opioid contrary to guidelines (median = $4496, IQR = $2971 to $6938, P value ≤ 0.001). In multivariable analysis controlling for confounders, the variable indicating if a case was prescribed an opioid contrary to guidelines

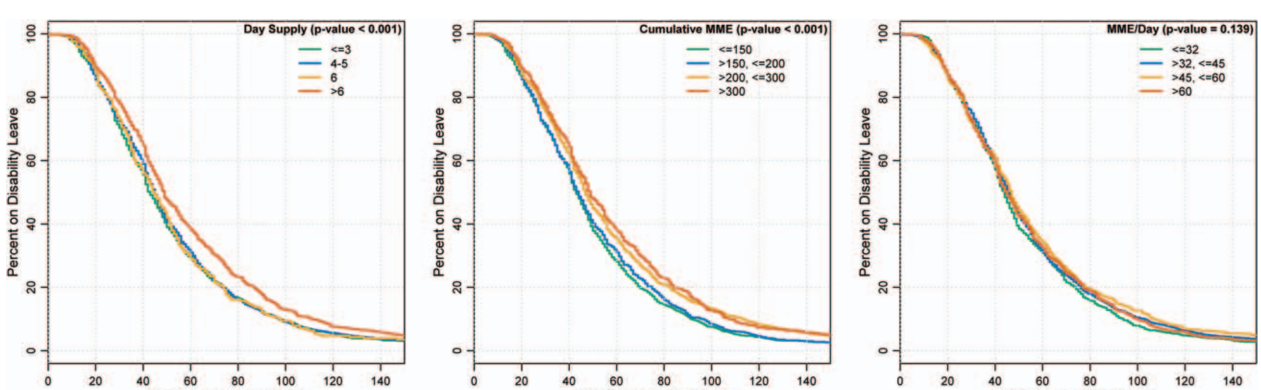

FIGURE 3. Kaplan–Meier curves of percent on disability leave over time by day supply, cumulative morphine milligram equivalents (MME), and MME/day.

TABLE 4. Kaplan–Meier Estimations of the Difference in Disability Duration and Medical Costs by Whether the Opioid-Naïve Case Was Prescribed an Opioid According or Contrary to ACOEM's Recommendations

		Disability Duration, days						Medical Costs, $					
	N	5th %ile	25th %ile	Median	Mean	75th %ile	95th %ile	5th %ile	25th %ile	Median	Mean	75th %ile	95th %ile
Opioid according to guidelines	1,864	13	28	44	54	65	122	1,739	3,079	4,505	5,978	6,980	13,726
Opioid contrary to guidelines	2,245	15	29	47	59	73	137	1,868	3,300	5,017	7,136	8,104	18,135

was only significant for medical costs (picked in 100% of bootstrapped samples), but not disability days (picked in 52% of the bootstrapped samples). For medical costs, results are similar to the full sample with individuals prescribed an opioid contrary to guidelines had medical costs $391 higher than cases prescribed an opioid according to guidelines (Table S5, http://links.lww.com/JOM/A367).

Comparison With Non-Disability Cases

Our sample population tended to have more females, be slightly younger, be less likely to have a depression diagnosis prior to the CTR, and more unique procedure codes during the release time frame than a random sample of cases with a CTR procedure who did not file a disability claim (Table S6, http://links.lww.com/JOM/A367). Our sample did have a significantly higher percent of cases prescribed an opioid for CTR (70%) than the non-disability sample (66.4%). The percent of cases prescribed an opioid contrary to ACOEM's guidelines was slightly higher in our sample (29% vs 28%), although not statistically significant (P value = 0.162).

DISCUSSION

In this study, most STD cases with a CTR procedure filled an opioid prescription for postoperative pain and were prescribed an opioid consistent with the current ACOEM opioids guidelines recommendations. Depression was the most common risk factor for opioid abuse observed in our population. Cases prescribed an opioid contrary to guidelines had longer disability days and higher medical costs than cases prescribed an opioid according to guidelines. Based on the associated results, these findings also infer appropriateness of these guidelines.

If an estimated 29% of the 577,000 CTR procedures nationally occurring per year[20] were prescribed an opioid according to ACOEM's guidelines, there is an opportunity for an estimated savings of $71 million per year in medical costs. Further, with

TABLE 5. Lognormal Survival Regression Model Results Quantifying the Impact of Prescribing Opioids Contrary to ACOEM's Guidelines on Disability Duration and Medical Costs ($n = 4{,}109$)

	Disability Duration Model, days			Medical Cost Model, $		
Variable	β	Standard Error	P Value	β	Standard Error	P Value
Intercept	3.345	0.103	<0.001	7.668	0.037	<0.001
Opioid prescribed contrary to guidelines	0.043	0.017	0.014	0.085	0.018	<0.001
Age	−0.003	0.001	0.006	–	–	–
Sex (male = 1, females = 0)	−0.056	0.019	0.004	–	–	–
Previous disability program utilization	0.05	0.018	0.005	–	–	–
Number of unique diagnoses during disability	0.02	0.003	<0.001	0.03	0.003	<0.001
Number of unique procedures during disability	0.018	0.001	<0.001	0.016	0.002	<0.001
Inpatient stay during leave	–	–	–	0.532	0.106	<0.001
Number of CTR procedures	0.528	0.021	<0.001	0.496	0.021	<0.001
Comorbidities during disability:*						
Diabetes mellitus	−0.081	0.031	0.008	–	–	–
Pulmonary disease	–	–	–	−0.109	0.042	0.01
Iron-deficiency anemia	–	–	–	−0.374	0.109	0.001
Case industry:						
Manufacturing durable goods	0.113	0.021	<0.001	−0.141	0.029	<0.001
Manufacturing Nondurable Goods	0.142	0.028	<0.001	−0.086	0.034	0.013
Services	0.1	0.037	0.007	–	–	–
Transportation Communications Utilities	–	–	–	−0.147	0.029	<0.001
Retail Trade	0.07	0.038	0.068	–	–	–
Finance, insurance, real estate	–	–	–	−0.119	0.034	<0.001
Geographical area variables:						
Median household income (scaled)	–	–	–	0.066	0.009	<0.001
Percent of college graduates	−0.708	0.144	<0.001	–	–	–
Health plans:						
Preferred provider organization plan	–	–	–	−0.067	0.018	<0.001
Consumer-driver health plan	−0.106	0.02	<0.001	–	–	–
Case salaried	−0.237	0.024	<0.001	–	–	–
Case in union	0.119	0.021	<0.001	–	–	–

*Comorbidity groupings from Quan et al.[21]

39% of the work force participating in an STD benefit program,[29] use of ACOEM's guidelines would similarly be estimated to reduce total disability durations by 124,000 days per year. These results add to the growing literature that documents the potential employer and societal savings from curtailing overuse of opioids.[3,5,30] In addition, decrease in opioid use/abuse has been shown to have a positive effects on the worker's mental, physical, and social well-being.[31] That this study found those prescribed an opioid ahead of the surgery were more likely to receive an opioid prescription contrary to guidelines, which was associated with worse outcomes, suggests another line of intervention to improve outcomes.

To our knowledge, this is the first study to quantify the impact associated with following opioid prescription guidelines on disability durations or medical costs. It should be noted that current ACOEM's guidelines (effective in 2017) were applied to historical records between 2007 and 2014. Therefore, prescribers may have been following guidelines at the time of service, which, in the case of ACOEM, did not previously specify a dose limit. Yet, there is longstanding recognition that higher doses are more hazardous. The more recent cases reflected a trend that may indicate compliance to guidelines. Nonetheless, by applying current guidelines across historical data, one can observe trends in prescribing behaviors and elucidate the areas to improve in prescribing opioids. In addition, prescriptions observed in these analyses are only those filled; therefore, the actual rate of opioid prescriptions may be higher. There are several opioid guidelines to compare prescription patterns,[32,33] but ACOEM's guidelines were used in this analysis, which contain more specificity than most.

The most applicable study for comparison is Waljee et al[13]'s study, which used Truven's CCAE database to look at inappropriate prescriptions for upper extremity surgical procedures including CTR. The authors found 62% of CTR patients filled an opioid prescription, with 8.8% of all patients having a potentially inappropriate opioid prescription. Although Waljee et al[13] found a lower rate of opioid prescriptions for CTR than our STD population (70%), their rate matches better with our non-disability claim CTR sample (66.4%). Of note, Waljee et al did not consider preoperative prescriptions and considered opioids up to 6 weeks after surgery, as opposed to 1-week preoperative and 1-week postoperative in this study. The lower rate of inappropriate prescriptions in the Waljee et al study as compared with our study is likely due to different definitions of appropriateness. For example, the researchers used a higher maximum dose (100 vs 50 MME/day) and defined opioid-naïve as those who had not filled an opioid prescription within 6 weeks prior to procedure (compared with 90 days in our study). Our results show that prescription rates started to decline in 2011, which aligns with research by Dart et al,[34] who found prescriptions of opioids peaked in 2012 at 62 million prescriptions dispensed per quarter. Our analysis of yearly trends in opioid prescriptions and adherence to opioid guidelines for CTR indicates moderate improvements in both categories in recent years.

In a representative sample of the US commercially-insured population with at least one opioid prescription, Shah et al[35] reported approximately 70% of patients received an initial duration of opioids less than or equal to 7 days, similar to our distribution of day supply (70% received less than or equal to 6 days). The authors found that continued opioid use was associated with long-acting opioids used as initial treatment, higher initial doses of opioids, days' supply of the first opioid prescription, and number of opioid prescriptions in the first episode of opioid use. A sharp increase in chronic opioid use after the fifth day of therapy was observed, which mimics our findings that patients receiving above a 6-day supply of opioids had significantly higher disability duration and medical costs. Given Shah et al[35] found continued opioid use was associated with the initial opioid prescription in their sample, future research should investigate how adherence to opioid guidelines influences long-term outcomes including continued opioid use, drug/alcohol abuse, or disability recurrence.

Opioid prescriptions contrary to ACOEM's guidelines may be surrogate measurements for other information pertaining to the case including disease management. Although several disease severity metrics were controlled for in our multiple variable analysis, opioid prescriptions may characterize additional variability in disease severity not captured. The opioid prescription may also be a metric of prescriber or patient *perception* of severity. For example, higher MME/day may be associated with either the provider's or the patient's perception of severity and pain for CTR. In addition, previous research has shown that patient characteristics including race, age, and sex influence opioid prescriptions and the provider's perception of a patient's pain,[36–39] which highlights the necessity of opioid prescribing guidelines to aid clinicians in objective treatment decisions.

Our findings indicate that a large portion of CTR cases are inappropriately prescribed opioids. Prescription drug monitoring programs (PDMP) may be used by health systems to analyze opioid prescribing data to find potentially inappropriate prescribing behavior and illegal activity. For example, New York City found that 1% of prescribers wrote 31% of the opioid prescriptions.[40] In addition to using guidelines, retraining physicians on best practices may be needed to reinforce safe opioid prescribing patterns. Research from Utah has shown that physician education on recommended opioid prescribing practices was associated with improved prescription patterns including 60% to 80% less prescription for long-acting opioids for acute pain.[18]

Opioid prescribing in WC cases was not investigated because the CCAE database may not track all medical claims for WC cases, as WC medical claims are generally handled by another carrier that is different from the enrollee's medical benefit carrier. Many CTR procedures may stem from work related injuries and previous research has shown opioid prescribing to be common in WC cases.[6,41] For example, opioids accounted for ∼30% of the prescriptions and ∼27% of the prescription dollars paid in California's WC system between 2005 and 2014.[41] As the lost time data are worse in worker's compensation patients,[42] this study's results are likely considerable underestimates of the national impacts. Future research should investigate the appropriateness of opioid prescription in the WC system for CTR.

Our study has several strengths including the utilization of a nationwide sample of CTR cases with a rich set of longitudinal information on diagnoses and procedures. The percentage of cases prescribed an opioid contrary to ACOEM's guidelines in our population of STD cases was similar to our random sample of a non-disability population, providing evidence that our results may be generalizable to other populations. The findings that following opioid prescribing guidelines reduced disability duration and medical costs were robust across our bootstrapping procedures.

Our study has several limitations. One limitation is that these results are based on claims data that did not specify the exact condition for which the opioid was prescribed. Instead, defined time frames were used and additional rules to infer if an opioid was prescribed for the CTR. If such an error was non-differential, it would bias towards the null. Another limitation is not having more precise information on disease severity. Multiple metrics of disease severity were used including the number of diagnoses and procedures, inpatient hospitalization, and a comorbidity index to try to control for this confounding effect. However, without objective measures of nerve injury such as a nerve conduction test, a provider's or patient's subjective perception of paresthesia and/or pain severity may dictate the type of opioid prescription, although prior evidence suggests superior results with CTR that is not mild.[43,44]

CONCLUSION

Our results highlight the need for improvement in judicious prescribing of opioids for CTR. When opioids are chosen for CTR pain management, opioid prescribing in accordance with the ACOEM guidelines appears superior in returning a patient to health and reducing medical costs.

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