Workers' Compensation Claims for Musculoskeletal Disorders and Injuries of the Upper Extremity and Knee Among Union Carpenters in Washington State, 1989–2008

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Background *Numerous aspects of construction place workers at risk of musculoskeletal disorders and injuries (MSDIs). Work organization and the nature of MSDIs create surveillance challenges.*
Methods *By linking union records with workers' compensation claims, we examined 20-year patterns of MSDIs involving the upper extremity (UE) and the knee among a large carpenter cohort.*
Results *MSDIs were common and accounted for a disproportionate share of paid lost work time (PLT) claims; UE MSDIs were three times more common than those of the knee. Rates declined markedly over time and were most pronounced for MSDIs of the knee with PLT. Patterns of risk varied by extremity, as well as by age, gender, union tenure, and predominant work. Carpenters in drywall installation accounted for the greatest public health burden.*
Conclusions *A combination of factors likely account for the patterns observed over time and across worker characteristics. Drywall installers are an intervention priority.* Am. J. Ind. Med. 58:428–436, 2015. © 2015 Wiley Periodicals, Inc.

KEY WORDS: work-related; workers' compensation; construction workers; carpenters; longitudinal analyses; cohort studies; musculoskeletal disorders; injury surveillance

BACKGROUND

Construction workers are at high risk of musculoskeletal disorders and injuries (MSDIs) as well as for continued problems after initial treatment of these problems [Lipscomb et al., 1997; Welch et al., 2009; Reid et al., 2010; Schoonover et al., 2010; Welch et al., 2010; Spector et al., 2011; CPWR, 2013]. Numerous aspects of the work they do, as well as the manner in which the work is organized, place them at risk and make them challenging to follow adequately over time.

Construction work involves heavy activities that can place stress, not only on the low back, but also the peripheral skeleton. Tasks can be highly repetitive and conducted in awkward postures [Mitropoulos et al., 2013; McGaha et al., 2014]. Work often involves the interface of humans and

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tools—both powered and not—that can add weight, force, and vibration [Dale et al., 2011]. Work is done both indoors and outdoors, making factors such as weather, site preparation, and materials delivery potential contributors to variability in physical stress to which workers are exposed. For example, carrying of bulky materials in wind or mud can add physical stress to already heavy work. In addition, the physical effects of the work are likely to be influenced by speed of work production, hiring practices, and the quality of teamwork—all factors that can vary in different economic climates [Mitropoulos and Cupido, 2009].

Onset of musculoskeletal symptoms can be acute and sudden or secondary to cumulative stressors over a considerable period of time. The latter, in particular, can be difficult to attribute clearly to work exposures [Evanoff et al., 2014] and may be less likely to be captured in traditional work-related surveillance sources such as the Survey of Occupational Illness and Injury (SOII) of the Bureau of Labor Statistics or in workers' compensation records [Blessman, 1991; Morse et al., 2000; Rosenman et al., 2000]. Besides these surveillance challenges that are relevant in assessing risk for musculoskeletal problems in any working population, additional issues make construction populations even more challenging to study and intervene on their behalf [Ringen et al., 1995a,b; Welch and Hunting, 2003]. It is common for workers to be employed by numerous contractors over the course of their working lives. There is no fixed workplace, like a factory setting, where work exposures can be observed, measured, or modified more easily. Worksites, even for the same contractor, can be dispersed and many sites will have only a few workers in a given trade present at one time. Work conditions are constantly in flux as the building project progresses, weather changes, and work groups vary.

These analyses were designed to specifically examine the patterns of reported work-related upper extremity (UE) and knee disorders of a musculoskeletal nature among a cohort of union carpenters over the 20-year period from 1989 to 2008. Besides interest in the pattern of claim rates over time, we were also interested in identifying groups of carpenters who were at higher risk of reported events based on their age, gender, type of work, and time they had been in the union.

METHODS

Workers' compensation (WC) records from the Washington State Department of Labor and Industries were linked on an individual basis to union records of hours worked each month from January 1989 through December 2008 for a large cohort of carpenters. The cohort was dynamic with entrances and exits over the observation period. Individuals became eligible for the cohort in the third month they worked union hours. We have previously described the details of data access and linkage [Lipscomb et al., 1997,2000, 2003, 2008].

Union records, from the Carpenters Trusts of Western Washington (CTWW), provided information on date of birth, sex, date of union initiation, and union local affiliation for each carpenter. Union carpenters perform a wide variety of construction tasks. The only surrogate for work exposure we had was based on characterization of the primary work of the union local with which each carpenter was affiliated. The categories included light commercial (three stories or less), heavy commercial (including bridge and roadway construction as well as higher rise building), residential construction, drywall installation, millwrighting, and pile driving, as well as a group of carpenters whose primary local assignment was outside Washington State.

The WC data contained date of injury, coded descriptions of body part injured, nature of injury sustained, type of injury, and paid lost days (which begins on the 4th day after injury in Washington). Injury codes were assigned based on American National Standards Institute (ANSI) codes until mid-2005 when coding was changed to the Occupational Injury and Illness Classification System (OIICS), developed by the Bureau of Labor Statistics. Only injuries that occurred in months of union work were included in the analyses in order to define injuries and hours of work on the same basis for rate calculations.

After identifying injuries involving the upper extremity (i.e., shoulder, arm, elbow, wrist, hand, fingers, and thumb) or the knee from ANSI or OIICS body part codes, claims were further limited to those consistent with soft tissue injuries or conditions including contusions, dislocations, bursitis, sprain/strains, or conditions of the nervous system based on ANSI/OIICS nature of injury codes. Among claims that resulted in paid lost time from work, the median number of lost days were examined by nature of the injury and type of event causing the injury.

The population and the frequency of their reported claims for work-related MSDIs involving the UE and knee were described separately with basic descriptive statistics. Hours worked and number of claims were stratified by categories of age, gender, time in the union, predominant type of work assignment, and calendar year for crude and multivariate analyses with Poisson regression. Crude rates and adjusted rate ratios (aRR) were calculated using the natural log (ln) of hours worked as the offset variable [Nizim, 2000]. Age and time in the union were allowed to vary over time with hours of work and events accumulating in the appropriate strata over the 20-year period. Separate analyses were conducted for all claims and the subset of events that resulted in paid lost time from work.

All study procedures were approved by the Institutional Review Boards of Duke University Medical Center and the Washington State Department of Health and Human Services.

RESULTS

The population in this 20-year cohort has been described previously in detail [McCoy et al., 2013]. Among a total of 24,830 predominantly male (97%) carpenters who worked 192,371,021 hr in Washington between 1989 and 2008, 3,753 upper extremity and 1,342 knee MSDIs were identified in the matched workers' compensation records. These claims accounted for 18.6% of all workers' compensation claims filed by the cohort (UE 13.6%; knee 5.0%) and 31.1% of their claims that involved paid lost time from work (UE 20.9%; knee 10.2%).

The majority of UE and knee injuries/disorders were coded as sprains/strains, contusions, or ill-defined symptoms (Table I). Just over half (52.2%; n = 1960) of the UE MSDIs were coded as being the result of overexertion, bodily motion or repetitive use; thirty percent (34.3%; n = 1287) were from being struck by/against or caught and 11.8% (n = 441) resulted from falls. Similarly, overexertion type activities accounted for 46.3% (n = 622) of the knee MSDI claims while falls accounted for a slightly greater proportion (27.1%; n = 352) followed by struck by events (24.3%; n = 326). Of note, the median number of lost days was greatest for UE claims from dislocations (n = 123) or nervous system/nerve conditions (n = 121); however, almost all of the UE nervous system/nerve condition claims (92.7%) resulted in paid lost time in contrast to 48% of the dislocations. Among knee claims, the median number of lost days was greatest for knee claims involving ill-defined symptoms (n = 66) followed by bursitis (n = 62) and sprains /strains (n = 62) as well as for injuries caused by falls (n = 87).

There were steady declines in the rates of UE and knee MSDIs over the 20-year period, overall and among the subset that resulted in PLT (Table II). The magnitude of the declines was greater for the PLT events than those overall and for the knee more so than the UE. PLT claims for the knee were nearly five times higher in 1989 than in 2008 (aRR = 4.7; 95%CI: 2.5–8.7). The pattern of declining rates varied somewhat by mechanism of injury and by body region involved as well (Fig. 1A and B). While rates of UE injuries and disorders were consistently higher than those involving the knee, more marked declines were seen in knee MSDIs over time. More pronounced declines in claims resulting from being struck or falling were seen than for those from overexertion such as lifting, pushing, pulling or repetitive activities.

There was little difference in the rates of UE claims overall by categories of age (Table III); carpenters under age 30 had lower rates of claims involving paid lost time (aRR = 0.55; 95%CI: 0.42–0.70 compared to those over age 50). Rates for women were approximately twice those of men (overall aRR = 1.9; 95%CI:1.6–2.3; PLT aRR 2.3; 95%CI: 1.6–3.2). Upper extremity MSDIs decreased steadily with increasing time in the union. Carpenters whose primary work involved drywall installation were at greatest risk of UE

TABLE I. Work-Related Upper Extremity and Knee Musculoskeletal Injuries/Disorders and Paid Lost Days (PLDs) by Nature and Mechanism Among Union Carpenters in Washington State, 1989–2008

	Upper extremity			Knee		
	Overall Frequency (%)	Proportion with PLDs (%)	Median PLDs[c]	Overall Frequency (%)	Proportion with PLDs (%)	Median PLDs[c]
Nature of injury[a]						
Sprain/strain	1,545 (41.2)	28.9	97	713 (46.3)	39.1	62
Contusion	932 (24.8)	8.8	54	205 (15.3)	20.5	20
Ill-defined symptoms	493 (13.1)	34.5	119	197 (12.8)	47.2	66
Nervous system/nerve condition	357 (9.5)	92.7	121	—	—	—
Bursitis	328 (8.7)	23.2	119	107 (8.0)	59.2	62
Dislocation	98 (2.6)	48.0	123	120 (8.9)	29.9	23
Total	3,753 (100.0)	28.1	106	1,342 (100.0)	38.5	59
Mechanism of injury[b]						
Overexertion	1,960 (52.2)	37.8	114	622 (46.3)	42.4	56
Falls	441 (11.8)	27.2	95	352 (26.2)	39.2	87
Struck by/against/caught	1,287 (34.3)	15.0	77	326 (24.3)	30.7	26
All others	65 (1.7)	29.2	315	42 (3.1)	35.7	84
Total	3,753 (100.0)	28.1	106	1,342 (100.0)	38.5	59

[a]Nature of injury based on ANSI nature of injury codes assigned to workers compensation records.
[b]Mechanism of injury based on ANSI or OIICs type of injury codes assigned to workers compensation records.
[c]Median lost days among those claims with lost time.

TABLE II. Stratified Hours Worked, Frequency of Upper Extremity and Knee MSDI Claims, Rates[a] (95% CI) and Rate Ratios[b] (95%CI), Union Carpenters, Washington State 1989–2008 by Calendar Time

	Hours worked	UE MSDI claims	Rate (95%CI)[a]	RR (95%CI)[b]	Paid lost time UE MSDI claims	Rate (95%CI)[a]	RR (95%CI)[b]
Upper extremity							
year							
1989	6,070,969	123	4.1 (3.4–4.5)	1.9 (1.5–2.4)	41	1.4 (1.0–1.8)	2.4 (1.6–3.7)
1990	7,955,039	192	4.8 (4.2–5.6)	2.3 (1.8–2.8)	62	1.6 (1.2–2.0)	2.8 (1.9–4.2)
1991	8,503,454	229	5.4 (4.7–6.1)	2.5 (2.0–3.0)	76	1.8 (1.4–2.2)	3.1 (2.1–4.6)
1992	9,103,419	219	4.8 (4.2–5.5)	2.2 (1.8–2.7)	66	1.4 (1.1–1.9)	2.6 (1.7–3.8)
1993	8,512,786	227	5.3 (4.7–6.1)	2.5 (2.0–3.1)	94	2.2 (1.8–2.7)	4.0 (2.8–5.7)
1994	8,018,041	194	4.8 (4.2–5.6)	2.3 (1.8–2.8)	53	1.3 (1.0–1.8)	2.4 (1.5–3.6)
1995	8,062,927	195	4.8 (4.2–5.6)	2.3 (1.8–2.8)	60	1.5 (1.2–1.9)	2.7 (1.8–4.0)
1996	8,165,628	187	4.6 (4.0–5.3)	2.1 (1.7–2.6)	55	1.4 (1.0–1.8)	2.4 (1.6–3.6)
1997	8,718,329	220	5.1 (4.4–5.8)	2.4 (1.9–2.9)	59	1.4 (1.1–1.7)	2.4 (1.6–3.6)
1998	9,291,889	219	4.7 (4.1–5.4)	2.2 (1.8–2.7)	55	1.2 (0.91–1.5)	2.1 (1.4–3.2)
1999	10,557,541	233	4.4 (3.9–5.0)	2.1 (1.7–2.5)	61	1.2 (0.90–1.5)	2.1 (1.4–3.1)
2000	11,514,489	285	5.0 (4.4–5.6)	2.3 (1.9–2.8)	70	1.2 (0.96–1.5)	2.2 (1.5–3.2)
2001	10,618,931	182	3.4 (3.0–4.0)	1.6 (1.3–2.0)	44	0.83 (0.61–1.1)	1.5 (0.97–2.3)
2002	9,748,095	189	3.9 (3.4–4.5)	1.8 (1.5–2.2)	49	1.0 (0.76–1.3)	1.8 (1.2–2.7)
2003	9,357,923	147	3.1 (2.7–3.7)	1.5 (1.2–1.8)	31	0.66 (0.47–0.94)	1.2 (0.75–1.9)
2004	9,017,509	131	2.9 (2.4–3.4)	1.4 (1.1–1.7)	37	0.82 (0.60–1.1)	1.5 (0.94–2.3)
2005	9,569,607	123	2.6 (2.1–3.1)	1.2 (0.95–1.5)	28	0.59 (0.40–0.85)	1.1 (0.65–1.7)
2006	11,049,495	138	2.5 (2.1–3.0)	1.2 (0.93–1.5)	28	0.50 (0.35–0.73)	0.91 (0.56–1.5)
2007	13,475,892	159	2.4 (2.0–2.8)	1.1 (0.89–1.4)	42	0.62 (0.46–0.84)	1.1 (0.73–1.7)
2008	15,059,059	161	2.1 (1.8–2.5)	1	42	0.56 (0.41–0.75)	1
	Hours worked	**Knee MSDI claims**	**Rate (95%CI)[a]**	**RR (95%CI)[b]**	**Paid lost time Knee MSDI claims**	**Rate (95%CI)[a]**	**RR (95%CI)[b]**
Knee Year							
1989	6,070,969	64	2.1 (1.7–2.7)	2.9 (2.0–4.1)	28	0.92 (0.64–1.3)	4.7 (2.5–8.7)
1990	7,955,039	81	2.0 (1.6–2.5)	2.8 (2.0–3.9)	37	0.93 (0.67–1.3)	4.7 (2.6–8.5)
1991	8,503,454	74	1.7 (1.4–2.2)	2.4 (1.7–3.3)	37	0.87 (0.63–1.2)	4.4 (2.4–8.0)
1992	9,103,419	90	2.0 (1.6–2.4)	2.6 (1.9–3.7)	37	0.81 (0.59–1.1)	4.0 (2.2–7.3)
1993	8,512,786	75	1.8 (1.4–2.2)	2.4 (1.7–3.4)	38	0.89 (0.65–1.2)	4.5 (2.5–8.2)
1994	8,018,041	59	1.5 (1.1–1.9)	2.0 (1.4–2.8)	31	0.77 (0.54–1.1)	3.9 (2.1–7.2)
1995	8,062,927	63	1.6 (1.2–2.0)	2.1 (1.5–3.0)	29	0.72 (0.50–1.0)	3.6 (1.9–6.7)
1996	8,165,628	52	1.3 (0.97–1.7)	1.7 (1.2–2.5)	23	0.56 (0.37–0.85)	2.8 (1.5–5.4)
1997	8,718,329	68	1.6 (1.2–2.0)	2.1 (1.5–3.0)	28	0.64 (0.44–0.93)	3.2 (1.7–6.0)
1998	9,291,889	78	1.7 (1.3–2.1)	2.3 (1.6–3.2)	28	0.60 (0.41–0.87)	3.0 (1.6–5.7)
1999	10,557,541	94	1.8 (1.5–2.2)	2.4 (1.7–3.3)	29	0.55 (0.38–0.80)	2.8 (1.5–5.2)
2000	11,514,489	97	1.7 (1.4–2.1)	2.3 (1.6–3.2)	33	0.57 (0.41–0.81)	2.9 (1.6–5.3)
2001	10,618,931	58	1.1 (0.85–1.4)	1.5 (1.0–2.1)	24	0.45 (0.30–0.67)	2.3 (1.2–4.3)
2002	9,748,095	57	1.2 (0.90–1.5)	1.6 (1.1–2.3)	21	0.43 (0.28–0.66)	2.2 (1.1–4.2)
2003	9,357,923	59	1.3 (0.98–1.6)	1.7 (1.2–2.4)	18	0.38 (0.24–0.61)	1.8 (0.91–3.7)
2004	9,017,509	45	1.0 (0.75–1.3)	1.3 (0.90–2.0)	17	0.38 (0.23–0.61)	1.9 (0.94–3.8)
2005	9,569,607	61	1.3 (0.99–1.6)	1.7 (1.2–2.5)	19	0.40 (0.25–0.62)	2.0 (1.0–3.9)
2006	11,049,495	51	0.92 (0.70–1.2)	1.2 (0.85–1.8)	10	0.18 (0.10–0.34)	0.91 (0.41–2.0)
2007	13,475,892	59	0.88 (0.68–1.1)	1.2 (0.82–1.7)	14	0.21 (0.12–0.35)	1.0 (0.50–2.2)
2008	15,059,059	57	0.75 (0.58–0.98)	1	16	0.21 (0.13–0.34)	1

[a]Rates expressed as injuries per 200,000 hr of work.
[b]Crude rate ratios; adjustment did not change parameter estimates; Poisson regression.

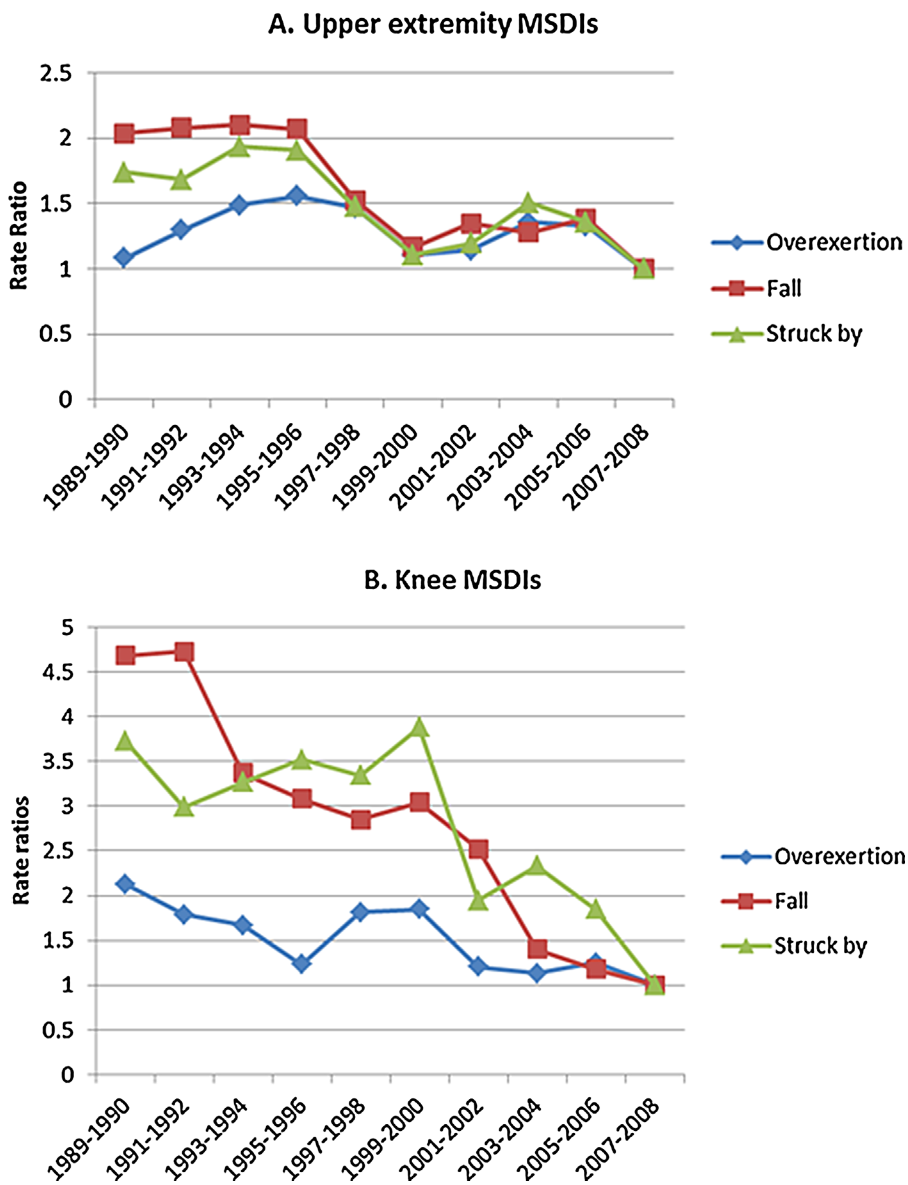

FIGURE 1. Pattern of workers compensation claims over time by mechanism of injury, union carpenters Washington State, 1989 to 2008.

MSDIs, particularly those involving PLT (aRR = 1.9; 95% CI:1.5–2.4 compared to those in light commercial work). Pile drivers were at lowest risk with rates about half those of carpenters in light commercial work.

There were modest, but steady, increases in the rates of MSDIs of the knee with increasing age overall and for PLT claims (Table III). In contrast to patterns seen for the UE, women had no appreciably higher rates of knee MSDIs than their male counterparts. As with the UE, knee rates were generally higher among those with less time in the union. Drywall installers had the highest rate of knee claims just as they did for the UE, but the magnitude was considerably less.

DISCUSSION

We combined union administrative records with WC claims from the State of Washington to improve surveillance of reported work-related MSDIs of the upper extremities and knee among a large cohort of union carpenters. MSDIs of UE and the knee were common among these carpenters, accounting for nearly 20% of all WC claims they filed in the 20-year period (1989–2008). Furthermore, they accounted for a disproportionate share of claims involving PLT. MSDIs of UE were nearly three times more prevalent than those involving the knee.

TABLE III. Stratified Hours Worked, Frequency of Upper Extremity and Knee Musculoskeletal Claims, Rates[a] (95%CI) and Adjusted Rate Ratios[b] (95%CI), Union Carpenters, Washington State 1989–2008

	Hours worked	UE MSDI claims	Rate (95%CI)[a] UE MSDI claims	aRR (95%CI)[b]	Paid lost time UE MSDI claims	Rate (95%CI)[a]	aRR (95%CI)[b]
Upper extremity							
Age							
<30	32,542,722	723	4.4 (4.1–4.8)	1.1 (0.93–1.2)	144	0.89 (0.75–1.0)	0.55 (0.42–0.70)
30–<40	63,159,376	1,400	4.4 (4.2–4.7)	1.2 (1.1–1.4)	394	1.3 (1.1–1.4)	0.93 (0.77–1.1)
40–<50	60,781,105	1,084	3.6 (3.4–3.3)	1.1 (0.99–1.2)	329	1.1 (0.97–1.2)	0.93 (0.77–1.1)
50+	35,415,373	532	3.0 (2.8–3.3)	1	183	1.0 (0.89–1.2)	1
Gender							
Female	3,187,355	117	7.3 (6.1–8.8)	1.9 (1.6–2.3)	37	2.3 (1.7–3.2)	2.3 (1.6–3.2)
Male	188,719,682	3,623	3.8 (3.7–4.0)	1	1,014	1.1 (1.0–1.1)	1
Time in the union							
<2 year	25,251,790	633	5.0 (4.6–5.4)	1.4 (1.3–1.6)	156	1.2 (1.1–1.4)	1.4 (1.2–1.8)
2–<4 years	19,336,436	486	5.0 (4.6–5.5)	1.4 (1.3–1.6)	124	1.3 (1.1–1.5)	1.5 (1.2–1.9)
4– <6 years	16,303,299	378	4.6 (4.2–5.1)	1.3 (1.2–1.5)	96	1.2 (0.96–1.4)	1.3 (1.1–1.7)
6– <8 years	15,121,172	295	3.9 (3.5–4.4)	1.1 (0.96–1.2)	95	1.3 (1.0–1.5)	1.4 (1.1–1.4)
8–<10 years	13,873,415	260	3.7 (3.3–3.5)	1.0 (0.91–1.2)	73	1.1 (0.84–1.3)	1.1 (0.84–1.4)
10 years and over	102,484,910	1,701	3.3 (3.2–3.5)	1	509	1.0 (0.91–1.1)	1
Predominant work							
Drywall	36,673,255	964	5.3 (4.9–5.6)	1.3 (1.1–1.5)	326	1.8 (1.6–2.0)	1.9 (1.5–2.4)
Residential	3,077,068	65	4.2 (3.3–5.4)	0.93 (0.71–1.2)	11	0.72 (0.40–1.3)	0.68 (0.36–1.3)
Millwright	3,497,881	74	4.2 (3.4–5.3)	1.1 (0.83–1.4)	22	1.3 (0.82–1.9)	1.3 (0.78–2.0)
Pile driver	11,275,835	115	2.0 (1.4–2.4)	0.52 (0.42–0.64)	25	0.44 (0.30–0.66)	0.45 (0.29–0.70)
Mixed commercial	43,141,929	808	3.7 (3.5–4.0)	0.94 (0.83–1.1)	224	1.03 (0.91–1.2)	1.1 (0.83–1.4)
Heavy commercial	39,571,780	695	3.5 (3.3–3.8)	0.87 (0.77–0.99)	172	0.87 (0.75–1.0)	0.88 (0.68–1.1)
Out of Washington	34,921,611	607	3.5 (3.2–3.8)	0.86 (0.76–0.98)	161	0.92 (0.79–1.1)	0.92 (0.71–1.2)
Light commercial	18,336,177	364	4.0 (3.6–4.4)	1	90	0.98 (0.80–1.2)	1
	Hours worked	**Knee MSDI claims**	**Rate (95%CI)[a] Knee MSDI claims**	**aRR (95%CI)[b]**	**Paid lost time Knee MSDI claims**	**Rate (95%CI)[a]**	**aRR (95%CI)[b]**
Knee Age							
<30	32,542,722	230	1.4 (1.2–1.6)	0.75 (0.61–0.93)	81	0.50 (0.40–0.61)	0.60 (0.43–0.85)
30–<40	63,159,376	415	1.3 (1.2–1.5)	0.81 (0.69–0.96)	152	0.48 (0.41–0.56)	0.69 (0.53–0.90)
40–<50	60,781,105	441	1.5 (1.3–1.6)	0.97 (0.83–1.1)	175	0.58 (0.49–0.67)	0.90 (0.71–1.2)
50+	35,415,373	252	1.4 (1.3–1.6)	1	106	0.60 (0.49–0.72)	1
Gender							
Female	3,187,355	20	1.3 (0.81–2.0)	0.9 (0.58–1.4)	7	0.44 (0.21–0.92)	0.84 (0.40–1.8)
Male	188,719,682	1,318	1.4 (1.3–1.5)	1	507	0.53 (0.49–0.59)	1
Time in the union							
<2 year	25,251,790	209	1.7 (1.4–1.9)	1.3 (1.1–1.5)	65	0.51 (0.40–0.66)	1.2 (0.87–1.6)
2–<4 years	19,336,436	165	1.7 (1.5–2.0)	1.3 (1.1–1.5)	78	0.81 (0.65–1.0)	1.9 (1.4–2.5)
4– <6 years	16,303,299	105	1.3 (1.1–1.6)	0.98 (0.79–1.2)	36	0.44 (0.32–0.6)	1.0 (0.71–1.5)
6– <8 years	15,121,172	101	1.4 (1.1–1.6)	1.0 (0.82–1.3)	43	0.57 (0.42–0.77)	1.3 (0.92–1.8)
8–<10 years	13,873,415	84	1.2 (0.98–1.5)	0.92 (0.73–1.2)	29	0.42 (0.29–0.60)	0.92 (0.62–1.4)
10 years and over	102,484,910	678	1.3 (1.2–1.4)	1	266	0.52 (0.46–0.59)	1

(*Continued*)

TABLE III. (*Continued.*)

	Hours worked	Knee MSDI claims	Rate (95%CI)[a] Knee MSDI claims	aRR (95%CI)[b]	Paid lost time Knee MSDI claims	Rate (95%CI)[a]	aRR (95%CI)[b]
Predominant work							
Drywall	36,673,255	305	1.7 (1.5–1.9)	1.2 (0.94–1.4)	125	0.68 (0.57–0.81)	1.2 (0.89–1.7)
Residential	3,077,068	24	1.6 (1.1–2.3)	1.0 (0.65–1.6)	7	0.45 (0.22–0.95)	0.76 (0.35–1.7)
Millwright	3,497,881	23	1.3 (0.87–2.0)	0.89 (0.57–1.4)	13	0.74 (0.43–1.3)	1.3 (0.68–2.3)
Pile driver	11,275,835	55	0.97 (0.75–1.3)	0.68 (0.49–0.93)	22	0.39 (0.26–0.59)	0.68 (0.42–1.1)
Mixed commercial	43,141,929	313	1.5 (1.3–1.6)	1.0 (0.82–1.2)	131	0.61 (0.51–0.72)	1.1 (0.77–1.5)
Heavy commercial	39,571,780	235	1.2 (1.1–1.4)	0.81 (0.65–1.0)	78	0.39 (0.31–0.49)	0.67 (0.47–0.95)
Out of Washington	34,921,611	235	1.3 (1.2–1.5)	0.93 (0.75–1.2)	79	0.45 (0.36–0.56)	0.79 (0.56–1.1)
Light commercial	18,336,177	134	1.5 (1.2–1.7)	1	53	0.58 (0.44–0.76)	1

*Differences in total hours or injuries across age, gender, time in the union, and predominant work are due to missing data for some individuals.
[a]Rates expressed as injuries per 200,000 hr of work. [b]Adjusted for age, gender, tenure, and predominant type of work; Poisson regression.

Marked declines in rates of MSDIs of the UE and knee were seen over time. These changes were more pronounced for PLT claims—especially those involving the knee. These patterns may reflect a number of things. They could represent safer work environments that result in fewer and less severe injuries. They may also reflect greater opportunity for injured workers to access light duty work; during this period of time there were numerous efforts to control workers' compensation costs including widespread focus on more rapid return to work after injury. Finally, patterns may reflect changes in reporting over time as the construction economy fluctuated drastically. It is of note that union carpenters have private health insurance coverage through jointly trusteed labor-management funds. This would potentially allow them to receive care covered by their insurance and outside of the WC system. Further their 65% decline in PLT knee claims was considerably higher than the decline of 30% seen statewide [Spector et al., 2011]. However, MSDIs of the knee decreased more markedly than those of the UE among these carpenters. This would seem to indicate more is going on than care-shifting, which we would not expect to be differential based on which extremity were involved.

When adjusting for gender, time in the union, and a crude designation of predominant type of work, older carpenters did not have higher rates of UE claims overall, but they did have higher rates of events that resulted in paid lost time from work. For knee injuries, older carpenters were at greater risk overall as well as for events resulting in PLT. For both outcomes, the proportion of events with PLT increased with increasing age. Other reports suggest older construction workers have lower rates of work-related injury than their younger counterparts, yet older workers' injuries are more severe and costly [Bhattacharya and Park, 2012; Schwatka et al., 2012]. Although this pattern may be rationalized as being in line with an individual's biological state [Silverstein 2008; Margolis 2010], one should not dismiss the potential for age-related differences in work exposures, injury reporting, and care seeking which could influence the patterns observed.

The observed patterns of MSDIs were also different for the UE than the knee by gender; women were at a two-fold higher risk of UE MSDIs than men, but we saw no appreciable differences in their rates for MSDIs of the knee. Women may do work that is more UE intensive, the tools may fit men's larger hands better, or inherent differences in upper extremity strength could play a role in these findings. Previous work indicates that women are more likely to report repetitive stress compared to their male counterparts in the same job [Eng et al., 2011], but this report included few trade workers. Given the differences in patterns observed for the knee and the UE, it seems unlikely that we are only seeing a propensity for women to seek more medical care than men.

Those with less union tenure were at slightly greater risk, which is a pattern that has been consistent for most outcomes we have explored in this cohort [Lipscomb et al., 2003, 2008, 2013; McCoy, 2013]. Based on these data alone, it is unclear the extent to which these patterns reflect differences by time in the union in experience, training, job tasks, exposures, and injury reporting. Additionally, these patterns may reflect, in part, the healthy worker survivor effect [Arrighi and Hertz-Picciotto, 1994; Seibert et al., 2001; Werner et al., 2005].

We have previously described drywall installers as being at high risk of work-related injury [Lipscomb et al., 2000; Schoenfisch et al., 2013]. In these analyses, drywall installers not only had the highest rates of MSIDs of the UE and the knee, but they also accounted for the largest number of events. Even though their risk differential is modest, based on the numbers of workers in the group, they carry a significant public health burden for these problems. Their physical exposures associated with carrying, lifting, and holding drywall, as well as fall hazards posed by work at height and postural instability, are well-documented [Chiou et al., 1997, 2000; Pan et al., 1999; Pan and Chiou, 1999; Lipscomb et al., 2000; CPWR, 2013; Schoenfisch et al., 2013, 2014a,b; Dasgupta et al., 2014]. Given the very fast-paced nature of this type of work, it seems likely that production pressures make a contribution to their injury experiences as well. NIOSH has published recommendations to prevent drywall installers' injuries from overexertion and falls —both contributors in this study to UE and knee MSDIs [NIOSH, 2006]. However, it is unclear to what extent these recommendations are realized in practice.

The major strength of these analyses is in the access to this large, well-defined cohort and the ability to link their work hours and WC claims on an individual basis. These things allowed us to take a cohort approach to analyses of WC claims including calculation of rates and adjusted rate ratios across age, gender, time in the union, predominant work, and calendar time. Such occupational injury surveillance data are uncommon. Workers' compensation records alone lack information on the population at risk, and BLS SOII data are based on aggregate reporting of hours for a probability sample of employers. However, these data also have limitations. We had no information on actual work tasks or exposures relevant to the development of musculoskeletal disorders and injuries, and whether these varied by age, gender, time in the union or calendar time. We also had no input from workers on how, or why, they chose to report work injuries. It seems reasonable that motivations and behaviors could have varied over time and by worker characteristics as well. Finally, our outcomes of interest were based on ANSI and OIICS coding structures and are subject to miscoding error. In a prior report of back injuries [Lipscomb et al., 2008], 13% of events captured in the WC system were miscoded, and this miscoding was differential by PLT status.

CONCLUSIONS

These linked administrative data provide a rich source for occupational surveillance on a high-risk population that can be difficult to study for numerous reasons, and the findings provide an example of the utility of internal comparisons within the cohort. The marked decline in the burden of upper extremity and knee MSDIs in this cohort over 20 years is encouraging. However, the potential for such patterns to reflect—at least in part-care-shifting suggests a need to examine other sources of health outcomes data for these workers. Similarly, we cannot clearly discern the reasons for the relatively high rates of UE MSDIs observed among females and UE and knee MSDIs among workers in their apprenticeship years. Given patterns observed by extremity, the gender differences are hard to attribute to long-recognized differences in patterns of the seeking of medical care between men and women but perhaps related to differences in exposures within the same job.

Carpenters in drywall installation account for the greatest burden of MSDIs of the UE and the knee in this cohort. They should be the focus of targeted efforts to develop and enhance the adoption of practical efforts to improve their safety and health. Specifically, efforts are needed to more clearly understand the hazards of their work including task-based exposure to risk factors for acute and musculoskeletal injury, the role of production pressures, workers' use of recommended injury prevention approaches, and new materials that have the potential to reduce physical load (e.g., light weight drywall). Future efforts to describe the burden of UE and knee MSDIs should also examine the potential long-term implications [Wilder et al., 2002] of such conditions like osteoarthritis.

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