Incident and recurrent back injuries among union carpenters

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ABSTRACT

Aims: To describe incident and recurrent work-related back injuries among union carpenters, describe the hazard function for each and associated risk factors, and explore predictors of subsequent musculoskeletal back injury based on different definitions of the initial injury.

Methods: This study identified a dynamic cohort of 18 768 carpenters who worked in the State of Washington 1989–2003, their hours worked each month, and their work-related back injuries and medical claims for treatment including ICD-9 codes. Using Poisson regression we calculated rates and rate ratios (RRs) of incident and recurrent injury adjusting for age, gender, union tenure and type of carpentry work. Predictors of subsequent musculoskeletal back injury were explored based on different definitions of the incident injury, as were time periods of greatest risk following return to work.

Results: Recurrent back injuries occurred at a rate 80% higher than initial injuries. Survival curves were significantly different for incident and recurrent injuries, but patterns of relative risk were similar. Individuals with greatest union tenure were at lowest risk, likely reflecting a healthy worker effect or lower physical exposures with seniority. Individuals with long periods of work disability with their first injury were at particularly high risk of subsequent musculoskeletal injury compared with those with no prior history (RR 2.3; 95% CI 2.0 to 2.7), as were individuals with degenerative diagnoses (RR 2.0; 95% CI 1.5 to 2.6). Risk for second injury peaked between 1000 and 1500 h after return to work and then gradually declined.

Conclusions: Carpenters with long periods of work disability following back injury warrant accommodation and perhaps better rehabilitation efforts to avoid re-injury. Challenges to workplace accommodation and limited ability to clearly define readiness to return to work following injury demonstrate the need for primary prevention of back injuries through attention to engineering solutions among carpenters involved in strenuous work.

While most people experience back pain at some time in their lives, many never seek care or lose time from work. Yet for some, back pain results in significant episodes of activity limitation, impairment and disability. There is evidence that both occupational and non-occupationally defined back pain tend to be recurrent,[1–4] as well as some indication that recurrent episodes may be more likely to impair activities.[5 6]

Methods currently used by the Bureau of Labor Statistics to count workplace injuries and illnesses do not differentiate initial events from recurrent ones, and rates of recurrent work-related back injuries are not well-defined. Recurrence is often reported as a prevalence percent[7 8]; information regarding return to work following the first event, when the individual actually became at risk for a recurrent injury, is often missing. In addition, the definitions of recurrence vary widely among the populations studied as do the nature of the data used in analyses, which could explain the wide variability among reports.[9–12]

The rate of recurrence of back pain has been reported to decrease with time after the first event,[13] suggesting that there may be periods of time when preventive measures might have greater impact. Some have reported more recurrences among those with gradual onset of symptoms, while others have reported that acute traumatic events, such as falls, are associated with a greater likelihood of recurrence.[2 14] These findings have been used to suggest that different disease processes may involve different prognoses.

Intuitively, determining the severity of the injury, or disorder, would seem important in predicting outcomes and recurrence. However, the relationships between detectable tissue injury and back pain, impairment and disability are poorly defined – likely, in part, due to lack of diagnostic precision – and for back problems few case definitions have been accepted in the scientific community.[15–19] Consequently, the severity of work-related episodes is often defined in terms of another outcome such as delayed return to work or associated medical costs.

Back disorders are the most commonly reported occupational disorder among construction workers.[20 21] In both the USA[22] and Canada,[23] being employed in construction has also been reported to be associated with delayed return to work following a back injury. Older construction workers are at greater risk of back problems than other blue collar workers[24] and at greater risk of occupational disability from back problems compared with the general population.[25]

Despite their known exposures to recognised occupational risk factors for back pain,[26] their high rates of injury and likelihood of prolonged disability, there is little literature specifically related to occupational back problems among carpenters.[27–30] We know of none that distinguish between initial and recurrent work-related injuries. Measures used to assess severity of acute trauma are not sensitive enough to grade most occupational injuries to carpenters due to a "floor effect". The vast majority of injuries to carpenters treated in the emergency room had an abbreviated injury score (AIS) of 1, indicating minor injury[30]; the rating had little relationship to the length of time out of work. Hospitalisation has been used to control for severity in analyses of disability following work injury.[22] Yet, in Waller's work,[30] 74% of carpenters who were still impaired 6 months after injury had only received outpatient care.

We used combined administrative data sources to identify and describe claims for work-related back disorders in terms of their nature and mechanism, associated paid lost time from work and the ICD-9 (International Classification of Diseases, Ninth Revision) diagnoses assigned for treatment of these injuries among a well-defined cohort of union carpenters. In addition, analyses focused on more clearly defining the hazard functions for incident and recurrent claims and exploring risk factors for these events separately.

METHODS

Data sources

Using data from the Carpenters Trusts of Western Washington (CTWW) and the Washington State Department of Labor and Industries (L&I), we identified a cohort of union carpenters who worked in the State of Washington between 1989 and 2003, their dates of birth, gender, earliest date of union activity, their hours of union work each month and their workers' compensation claims. No race or ethnicity information was available from these sources. Cohort membership was limited to individuals who worked at least 3 months of union hours during this 15-year period and had at least 1 month of eligibility for health insurance through CTWW.

The State of Washington has a state run worker's compensation program which captures medical only claims as well as those which result in lost work time. Claims from companies which self-insure for compensation coverage are only coded in the L&I data if they result in paid lost time from work. The L&I data include the date of injury, American National Standards Institute (ANSI) codes describing the events in terms of body part injured, the nature of the injury, the type of event causing the injury and whether the claim resulted in medical costs or paid lost time from work, which occurs after the third lost day in the State of Washington. We also had access to the medical care claims for the treatment of these injuries including provider assigned ICD-9 diagnosis codes (excluding claims from self-insured employers) through this state run program. Data were extracted on 26 August 2004 allowing 8 months after the last claims were filed in 2003 for full development of the claims, proper identification and capture of the self-insured claims that resulted in paid lost time.

The data were provided with a blinded unique identifier allowing us to merge the records on an individual basis without the use of personal identifiers; these methods have been previously described in detail.[27 28 31]

Events of interest

Workers' compensation claims for back injuries were identified by body part codes designating an injury to the back, trunk or back and neck as well as by medical claims for a back specific ICD-9 code assigned for treatment of the injury. This process captured claims in which the body part code indicated multiple injuries as well as claims that may have had some other body part code designated as the primary injury when first reported. To avoid claims that may have been identified by a single miscoded ICD-9 diagnosis, at least two claims for a back specific diagnosis were required if the body part code did not designate a back injury. Details on the process and specific codes used have been previously described.[32] Up to two injuries were included per carpenter, with incidence approximated by the first back injury claim identified.

Time at risk

After the claims of interest were identified, event histories were created for each individual. Person-hours of work as a union carpenter were used as the measurement of time at risk. Person-time began accumulating for the first back injury when the individual met cohort entry criteria. After an injury, person-time at risk of a second event began accumulating in the next month in which union hours appeared. All person-hours were counted in any month in which an injury occurred. Although time at risk was counted in terms of person-hours, the person-month was effectively the unit of analysis, since it is unknown where in any given month the work hours fell.

Classification of back injury claims

Each back injury claim was classified by the nature and mechanism of injury as defined by ANSI codes, as well as by paid lost time, hierarchy of medical care received and ICD-9 diagnoses. Classifications of time out of work included no paid lost time, return within 1 month, return within 3 months and out of work for more than 3 months. Hierarchy of care included first aid only, outpatient care or inpatient hospital care. ICD-9 diagnoses included groups of codes reflecting sprains, dislocations without fracture, fractures, degenerative conditions, contusions, nerve injury and symptom descriptors; a mixed diagnosis was assigned for individuals with ICD-9 codes that reflected more than one of our case definitions. The methods used to group the diagnoses have been previously described in detail.[32]

Each of these characterisation schemes was used to explore whether the risk of a second back injury, based on different definitions of the incident event, differed from the risk of filing the first claim for a back disorder. It was hypothesised that individuals with degenerative diagnoses, including disc disorders, would be at greater risk of recurrence. In contrast, we felt that those who required only first aid, and those who sustained sprains, which should be self-limiting injuries, should not be at greater risk for a recurrent injury. However, we suspected that the ANSI code classifications of injury nature would prove too crude to detect meaningful differences.

Covariates of interest

Age categories were defined at 10-year intervals. Carpenters typically spend 4 years in apprenticeship; strata were constructed to assess risk in each year of this training and at 2-year intervals afterwards. The union local (branch) affiliation was the only surrogate available for characterising the work done by cohort members. The locals represented by the cohort members were grouped into categories based on the predominant type of carpentry work done by the locals. Assignments of predominant type of work from earlier work with this cohort[26 27 30] were updated through interviews with business agents for each union local. These categories included light commercial, heavy commercial, drywall, millwrighting, piledriving, residential carpentry and a mixed category. Light commercial work involved construction on projects two to three stories high. Heavy commercial work involved high-rise buildings and interstate, freeway and bridge work. Millwrights are carpenters who work in industry and are often involved in the repair and maintenance of heavy machinery. Drywall carpenters in Washington State hang drywall, but they do not tape or finish,

Table 1 Nature and mechanism, paid lost time, medical diagnoses and hierarchy of care for back injury claims, Washington Carpenters, 1989–2003

	Incident (n = 3037), frequency (%)	Recurrent (n = 751), frequency (%)
Mechanism of injury		
Overexertion	1965 (64.7)	510 (67.9)
Bodily reaction	240 (7.9)	65 (8.7)
Fall from height	284 (9.4)	60 (8.0)
Same level fall	185 (6.1)	36 (4.8)
Struck by	174 (5.7)	37 (4.9)
Struck against	65 (2.1)	16 (2.1)
Motor vehicle accident	22 (0.72)	8 (1.1)
Caught	10 (0.33)	2 (0.27)
Explosion	1 (0.03)	–
Abraded	1 (0.03)	–
Unclassified	90 (3.0)	13 (1.7)
Nature of injury		
Sprain	2262 (74.5)	553 (73.6)
Ill-defined symptoms	194 (6.4)	48 (6.4)
Contusion	63 (2.1)	14 (1.9)
Dislocation	54 (1.8)	16 (2.1)
Fracture	26 (0.86)	7 (0.93)
Miscellaneous other (each represents <0.3%)	16 (0.53)	4 (0.54)
Unclassified	26 (0.86)	4 (0.53)
Identified by ICD-9 code	395 (13.0)	105 (14.0)
Medical diagnoses		
First aid (no diagnosis)	163 (5.4)	36 (4.8)
Sprain	930 (30.6)	191 (25.4)
Dislocation without fracture	507 (16.7)	125 (16.6)
Degenerative condition	113 (3.7)	42 (5.6)
Symptom descriptor	98 (3.2)	24 (3.2)
Contusion	48 (1.6)	13 (1.7)
Fracture/cord or injury	14 (0.46)	5 (0.67)
Nerve injury	1 (0.03)	1 (0.13)
Mixed diagnoses	802 (26.4)	227 (30.2)
Unknown diagnosis	353 (11.6)	87 (11.6)
Hierarchy of medical care		
First aid only	163 (5.4)	36 (4.8)
Outpatient care	2771 (91.3)	682 (90.8)
Inpatient care	103 (3.4)	33 (4.4)
Paid lost time from work		
None	1839 (60.6)	429 (57.1)
Up to 2 weeks	336 (11.1)	70 (9.3)
2 weeks to 1 month	123 (4.1)	36 (4.8)
1–3 months	173 (5.7)	52 (6.9)
>3 months	566 (18.6)	64 (21.8)

ICD-9, International Classification of Diseases, Ninth Revision.

in residential or commercial settings. We were unable to identify the type of work of carpenters affiliated with a local outside the State of Washington; for this reason they were combined for the analyses.

Analyses

Descriptive statistics were generated on age, gender, time in the union, predominant type of work and hours worked by the cohort. Kaplan–Meier survival curves were constructed to compare incident and recurrent claims. Incident and recurrent back injuries were described, separately, by each of the classification schemes. Crude and stratified incidence rates were calculated per 200 000 h worked, or the equivalent of 100 carpenters working full-time for 1 year. Age and time in the union were both treated as time-varying variables, with events and time at risk accumulating in the appropriate strata over time. Poisson regression was used to calculate crude rates and rate ratios (RRs) as well as adjusted rate ratios because of its utility in the analyses of longitudinal cohort data such as these, allowing maximal use of available data.[33] Claims for the first back injury identified for each carpenter were analysed separately from second events.

Next, each of the classification schemes were used in separate models to explore whether the risk of recurrence, based on different definitions of the incident back injury, differed from the risk of filing an incident claim for a back disorder. In each case those with no prior claim served as the referent group. Second injuries that resulted from acute trauma (falls, struck by) were excluded from these latter analyses since we saw no biologically plausible reason that a prior injury should contribute to subsequent acute trauma. Lastly, injury rates (95% CI) were calculated in windows of time representing 1000–2000 h increments of cumulative hours at risk following return to work. This analysis was done to explore whether periods of time could be identified when carpenters were at greater risk for a second back injury after they returned to work. All analyses were conducted with SAS v 8.2.

RESULTS

Cohort

We identified a dynamic, retrospective cohort of 18 768 carpenters who worked in the State of Washington between 1989 and 2003 who had hours worked after meeting the cohort entry criteria. The mean time the carpenters were observed over the 15 years was 45 months (median 23.0). The cohort was predominantly male (n = 17 879; 97.4%) and relatively young at first observation (range 17–76 years, mean 35 years, median 34 years). Time in the union at first entry into the cohort ranged from less than 1 year to 48 years (mean 6.1 years, median 1 year).

Identification and description of incident and recurrent back injuries

Overall, 4148 back injuries were reported by the cohort over 15 years. The number of events per person ranged from none to seven. Using our case definitions, 3037 incident and 751 recurrent back injury claims were identified. The distributions of the incident and recurrent injuries are remarkably similar by mechanism and nature of injury, medical diagnoses assigned for their treatment, type of medical care received and associated paid lost time from work (table 1). The mean difference in time lost from work was slightly higher for recurrent than for incident injuries (126 vs 110 days).

There were 151 individuals who were never observed working union hours again after their first back injury, leaving 2886 carpenters in the risk pool for a second event. Excluding 22 individuals who filed their initial claims in 2003, who may have returned to work after our observation period, 74% (n = 117) of those who never returned to work had paid lost time of over 60 days. These individuals were more likely to be assigned a degenerative diagnosis (7%; n = 9), fracture (4%; n = 5) or mixed diagnoses (40%; n = 52) than individuals who returned to work, and their injuries were more likely to have resulted from a fall from a height (n = 25; 19%). Thirty-five (27%) sustained injuries to other body parts as well. However, only 8.5% (n = 11) received hospital care for their injury. Consistent with this, the majority of injuries were coded as having resulted from overexertion or bodily motion (63%; n = 81).

Injury rates and risk factors

Incident injuries occurred at an overall rate of 5.4 per 200 000 h worked; recurrent events occurred at a rate of 9.5 per 200 000 h worked (RR 1.8). Kaplan–Meier curves demonstrating the survival functions for incident and recurrent claims are presented in fig 1. Although the survival curves for incident and recurrent injuries are significantly different from each other (log-rank test p<0.001), the patterns of relative risk are fairly similar for incident and recurrent back injuries (table 2). Because the youngest and oldest work groups are small, and consequently the least stable, age 30 to <40 years was chosen as the reference cell. Crudely, the youngest workers were at greatest risk of both incident and recurrent back injury, but this did not remain the case when adjusting for gender, time in the union and predominant type of work. Women had higher rates of incident events and slightly lower recurrent events. Overall back injury risk declined with increasing time in the union. Individuals who work predominantly in drywall were at consistently higher risk than their union counterparts doing other types of work.

Crude rates and rate ratios of a second back injury resulting from overexertion or bodily motion are presented in table 3 for each of the different classification schemes for incident cases, as are the adjusted rate ratios. Overall, these subsequent back injuries of a musculoskeletal nature occurred at a rate of 6.8 (95% CI 6.3 to 7.9) per 200 000 h worked; this is 30% higher than rates of initial back injuries. Minimal differences in risk of second injury were observed based on the mechanism of the first back injury. The few carpenters whose nature of injury had been coded as a fracture were at particularly high risk of a second back injury when compared with those with no prior history, but their fractures were not confirmed by appropriate ICD-9 codes. Individuals with a medical diagnosis of degenerative conditions or mixed diagnoses, those who required inpatient care for their first injury, and those who were out of work a month or longer with their initial event were at greater risk of reporting a second work-related back injury of a musculoskeletal nature. The parameter estimates for age, gender and predominant type of work were not significantly different in these models and they are not presented here.

Of note is the higher rate of injury between 1000 and 1500 h after return to work (fig 2). Other than in this period, the rate of second injuries decreased slowly over the first 6000 h after return to work (representing 3–4 years of fulltime work among this cohort) and then declined rather dramatically.

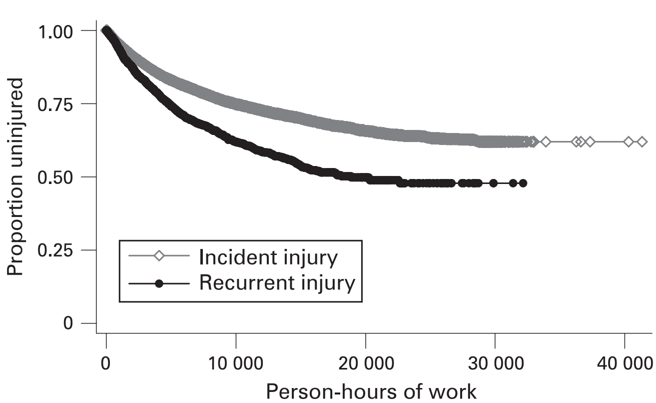

Figure 1 Kaplan–Meier survival curves for incident and recurrent back injuries, Washington carpenters, 1989–2003.

DISCUSSION

Among this large cohort of union carpenters, second back injuries occurred at a rate 80% higher than initial events. Although the mean difference in lost time from work was modestly higher for second injuries than for the first, the distributions of the first and second back injuries were remarkably similar in terms of mechanism and nature of injury, as well as medical diagnoses received for treatment. These findings are consistent with similar injuries from like work exposures being responsible for both initial and subsequent injuries among members of the cohort.

Carpenters between 30 and 40 years of age were at greatest risk of back injuries, after adjusting for gender, time in the union and predominant type of work. The fact that we observed individuals with the greatest union tenure carrying the lowest risk likely reflects a healthy worker effect or changes in direct physical exposure that occur with more seniority in the trade. Consistent with other reports,[28] carpenters involved in drywall work were at relatively high risk of back injury compared with their union colleagues in other forms of work; residential carpenters were at higher risk of initial injury but not for a second event (based on a small number of observations).

The risk ratios for a subsequent musculoskeletal injury based on the different mechanisms and nature of injury were quite similar, consistent with our hypothesis that the ANSI codes assigned to the initial injury would not be sensitive enough to identify individuals at greater risk of a second injury. We observed no differences in risk of a second injury between those who had first aid only compared with outpatient medical care for their first injury. Individuals with the longest period of work disability with the first back injury were at particularly high risk (2.3 times greater than risk for first event), consistent with the fairly recent report of Wasiak *et al*[34] based on analyses of compensation data. Carpenters whose medical diagnoses reflected a degenerative condition or multiple diagnoses were at greater risk of a second injury, as were those who required hospitalisation or were out of work for a month or more; all likely reflect more severe initial injuries or pathology at the time of injury. However, multiple diagnoses are more likely to be assigned to individuals with more medical encounters and may reflect evolving clinical impressions sometimes accompanied by more testing among individuals with delayed recovery. Consistent with Waller's findings,[29 30] it was rare for a carpenter to require hospitalisation for a back injury, even among those who never returned to carpentry work.

The risk of a back injury of a musculoskeletal nature peaked at 1500 h of time after return to work from a previous injury, and gradually decreased with increasing time back at work. This time represents close to a year of full-time work for many of these union carpenters. We have no data on accommodation or restricted work after injury. It is possible that these carpenters received less taxing duties upon return from an earlier injury or they may have looked for ways to limit stressful exposures on their own when first coming back to the job. However, the overall nature of construction work makes light duty assignments unlikely, particularly for extended periods of time.

Consistent with our findings, among Canadian workers who had lost-time back compensation cases, the risk of recurrence was greater in the first year after injury, especially for those with longer periods of absence from work.[5] Of note, recurrence was not defined by the filing of another injury report (as in our

Table 2 Stratified time at risk, frequency of back injuries, crude rates* and rate ratios†, and adjusted rate ratios‡, incident and recurrent claims, Washington carpenters, 1991–2003

	Incident (n = 3037)					Recurrent (n = 751)				
	Hours at risk	Injuries	Crude rate (95% CI)	Crude RR (95% CI)	Adjusted RR (95% CI)	Hours at risk	Injuries	Crude rate (95% CI)	Crude RR (95% CI)	Adjusted RR (95% CI)
Age										
<20	530 900	25	9.6 (6.5 to 14.4)	1.6 (0.98 to 2.5)	1.0 (0.71 to 1.5)	12 339	1	16.8 (2.4 to 119.3)	1.4 (0.23 to 12.9)	0.88 (0.16 to 4.8)
20 to <30	19 871 546	655	6.4 (5.9 to 6.9)	1.0 (0.93 to 1.2)	0.85 (0.78 to 0.94)	1 857 725	89	9.4 (7.6 to 11.6)	0.80 (0.64 to 1.0)	0.63 (0.51 to 0.78)
30 to <40	39 872 789	1243	6.1 (5.8 to 6.5)	1	1	5 728 404	341	11.7 (10.5 to 13.0)	1	1
40 to <50	33 818 763	756	4.4 (4.1 to 4.8)	0.72 (0.65 to 0.80)	0.82 (0.75 to 0.89)	5 705 218	232	8.1 (7.1 to 9.2)	0.69 (0.59 to 0.81)	0.79 (0.68 to 0.92)
50 to <60	15 969 901	313	3.8 (3.4 to 4.3)	0.63 (0.54 to 0.73)	0.77 (0.68 to 0.87)	2 279 633	85	7.4 (6.0 to 9.1)	0.63 (0.50 to 0.79)	0.78 (0.63 to 0.96)
60+	2 833 793	36	2.6 (1.9 to 3.6)	0.42 (0.28 to 0.62)	0.53 (0.39 to 0.72)	295 298	3	2.0 (0.65 to 6.3)	0.17 (0.06 to 0.50)	0.21 (0.08 to 0.56)
Gender										
Female	1 935 818	73	7.2 (5.7 to 9.1)	1.4 (1.0 to 1.9)	1.3 (1.1 to 1.7)	266 718	12	9.0 (5.1 to 15.9)	0.97 (0.55 to 1.7)	0.91 (0.56 to 1.5)
Male	110 959 277	2952	5.2 (5.0 to 5.4)	1	1	15 611 134	738	9.3 (8.7 to 10.0)	1	1
Time in the union										
<1 year	7 936 623	340	8.3 (7.4 to 9.3)	2.0 (1.7 to 2.3)	1.7 (1.5 to 1.9)	143 936	10	13.5 (7.0 to 25.9)	1.7 (0.91 to 3.2)	1.7 (0.97 to 3.1)
1 to <2 years	8 648 889	337	7.7 (6.9 to 8.6)	1.8 (1.6 to 2.1)	1.6 (1.4 to 1.8)	428 328	31	14.9 (10.5 to 21.2)	1.9 (1.3 to 2.7)	1.9 (1.4 to 2.6)
2 to <3 years	7 263 326	257	6.8 (6.0 to 7.7)	16 (1.4 to 1.9)	1.4 (1.2 to 1.6)	607 917	40	13.3 (9.8 to 18.3)	1.7 (1.3 to 2.3)	1.7 (1.3 to 2.3)
3 to <4 years	6 199 130	201	6.3 (5.5 to 7.3)	1.5 (1.3 to 1.8)	1.3 (1.2 to 1.6)	671 684	61	16.9 (13.0 to 21.9)	2.1 (1.6 to 2.8)	2.1 (1.7 to 2.8)
4 to <6 years	9 951 689	294	5.8 (5.2 to 6.5)	1.4 (1.2 to 1.6)	1.2 (1.1 to 1.4)	1 396 611	70	9.9 (7.8 to 12.6)	1.3 (0.99 to 1.6)	1.2 (0.98 to 1.5)
6 to <8 years	7 654 640	214	5.5 (4.8 to 6.3)	1.3 (1.1 to 1.6)	1.2 (1.0 to 1.3)	1 384 801	78	11.0 (8.8 to 13.8)	1.4 (1.1 to 1.8)	1.3 (1.1 to 1.7)
8 to <10 years	7 023 305	168	4.7 (14.1 to 5.5)	1.1 (0.95 to 1.4)	1.0 (0.86 to 1.2)	1 355 887	64	9.5 (7.4 to 12.1)	1.2 (0.93 to 1.5)	1.1 (0.89 to 1.4)
10+ years	58 368 968	1226	4.2 (3.9 to 4.4)	1	1	9 891 378	397	7.9 (7.2 to 8.7)	1	1
Predominant work										
Drywall	18 584 830	724	7.8 (7.3 to 8.4)	1.6 (1.4 to o 1.9)	1.5 (1.4 to 1.7)	3 704 563	234	12.6 (11.1 to 14.4)	1.3 (1.1 to 1.6)	1.3 (1.1 to 1.6)
Residential	1 439 915	69	9.7 (7.7 to 12.3)	2.0 (1.5 to 2.7)	1.7 (1.3 to 2.2)	189 935	12	12.6 (7.2 to 22.2)	1.3 (0.75 to 2.3)	1.0 (0.61 to 1.7)
Millwright	2 091 624	58	5.5 (4.3 to 7.2)	1.2 (0.86 to 1.6)	1.2 (0.94 to 1.6)	336 429	16	9.5 (5.8 to 15.5)	0.98 (0.76 to 1.3)	1.1 (0.69 to 1.7)
Piledriver	7 302 610	99	2.7 (2.2 to 3.3)	0.57 (0.45 to 0.72)	0.60 (0.49 to 0.74)	756 049	14	3.7 (2.2 to 6.3)	0.38 (0.23 to 0.65)	0.41 (0.26 to 0.66)
Non-Washington	1 675 735	51	6.0 (4.5 to 7.9)	1.3 (0.90 to 1.7)	1.2 (0.93 to 1.6)	133 426	5	7.5 (3.1 to 18.0)	0.38 (0.23 to 0.65)	0.70 (0.33 to 1.5)
Mixed commercial	50 431 010	1127	4.5 (4.2 to 4.7)	0.93 (0.82 to 1.1)	0.96 (0.86 to 1.1)	6 625 257	260	7.9 (7.0 to 8.9)	0.81 (0.66 to 1.0)	0.83 (0.69 to 1.00
Light commercial	12 586 487	413	6.2 (5.6 to 6.8)	1.3 (1.1 to 1.5)	1.3 (1.2 to 1.5)	1 788 993	85	9.5 (7.7 to 11.8)	0.98 (0.76 to 1.3)	1.0 (0.80 to 1.3)
Heavy commercial	17 278 765	390	4.8 (4.3 to 5.3)	1	1	2 279 369	110	9.7 (8.0 to 11.6)	1	1

*Rates are per 200 000 h worked; †Poisson regression models; ‡adjusted for age, gender, time in the union and predominant type of work.
RR, rate ratio.

Table 3 Crude rates and rate ratios, and adjusted rate ratios of subsequent musculoskeletal back injuries based on definition of incident injury, Washington Carpenters, 1989–2003

Definition of incident injury	Hours at risk	Injuries	Crude rate (95% CI)	Crude RR (95% CI)	Adjusted RR* (95% CI)
Mechanism of injury					
Incident (no prior injury)	113 057 915	3037	5.3 (5.1 to 5.5)	1	1
Overexertion	11 171 118	392	6.8 (6.2 to 7.5)	1.3 (1.2 to 1.4)	1.3 (1.2 to 1.4)
Bodily reaction	1 477 561	35	4.8 (3.4 to 6.7)	0.91 (0.69 to 1.2)	1.4 (1.3 to 1.5)
Fall from height	1 400 817	56	7.7 (5.9 to 10.1)	1.5 (1.2 to 1.8)	0.98 (0.75 to 1.3)
Same level fall	1 030 261	32	6.2 (4.4 to 8.8)	1.2 (0.89 to 1.5)	1.5 (1.2 to 1.9)
Struck by/against	1 295 957	41	6.2 (4.5 to 8.4)	1.2 (0.91 to 1.5)	1.3 (1.0 to 1.7)
Motor vehicle accident	112 169	4	7.1 (12.7 to 19.0)	1.4 (0.60 to 3.1)	1.3 (0.55 to 3.1)
NEC/unknown	388 883	15	1.5 (0.96 to 2.2)	1.5 (0.96 to 2.2)	–†
Nature of injury					
Incident (no prior injury)	113 057 915	3037	5.3 (5.1 to 5.5)	1	1
Sprain	12 967 053	452	5.8 (4.1 to 8.3)	1.1 (0.82 to 1.5)	1.3 (0.99 to 1.7)
Ill-defined symptoms	388 883	15	6.8 (6.2 to 7.5)	1.3 (1.2 to 1.4)	1.3 (1.2 to 1.5)
Contusion	405 545	33	5.9 (3.4 to 10.4)	1.1 (0.70 to 1.8)	1.2 (0.74 to 1.8)
Dislocation (herniated disc)	317 615	12	3.1 (1.3 to 7.6)	0.60 (0.29 to 1.2)	0.75 (0.38 to 1.5)
Fracture	83 030	5	9.7 (3.6 to 25.7)	1.8 (0.81 to 4.1)	2.5 (1.2 to 5.4)
Unclassified/identified by ICD-9	242 405	66	1.7 (0.41 to 6.6)	0.31 (0.10 to 0.99)	–†
Medical diagnoses					
Incident (no prior injury)	113 057 915	3037	5.3 (5.1 to 5.5)	1	1
First aid (no diagnosis)	1 190 434	30	5.1 (3.5 to 7.2)	0.96 (0.72 to 1.3)	1.3 (0.98 to 1.7)
Sprain	5 353 432	154	5.7 (4.8 to 6.7)	1.1 (0.95 to 1.2)	1.1 (0.96 to 1.2)
Dislocation without fracture	2 979 704	106	7.0 (5.7 to 8.4)	1.3 (1.1 to 1.5)	1.4 (1.2 to 1.6)
Degenerative condition	684 061	31	9.1 (6.4 to 12.9)	1.7 (1.3 to 2.3)	2.0 (1.5 to 2.6)
Symptom descriptor	394 386	12	6.2 (3.5 to 10.9)	1.2 (0.75 to 1.8)	1.1 (0.71 to 1.7)
Contusion	317 307	1	0.63 (0.09 to 4.5)	0.12 (0.03 to 0.57)	0.14 (0.03 to 0.61)
Fracture/cord or injury	48 570	0	–	–	–
Mixed diagnoses	4 076 261	179	1.6 (1.4 to 1.8)	1.6 (1.4 to 1.8)	1.7 (1.5 to 1.9)
Unknown diagnosis	1 873 357	62	6.2 (4.8 to 8.1)	1.2 (1.0 to 1.4)	–†
Medical care					
Incident (no prior injury)	113 057 915	3037	5.3 (5.1 to 5.5)	1	1
First aid only	1 190 434	30	5.0 (3.5 to 7.2)	0.96 (0.21 to 1.3)	1.3 (0.97 to 1.7)
Outpatient care	15 266 201	526	6.7 (6.2 to 7.4)	1.3 (1.2 to 1.4)	1.3 (1.2 to 1.1)
Inpatient care	460 876	19	7.4 (4.6 to 11.9)	1.4 (0.94 to 2.1)	1.6 (1.1 to 2.3)
Paid lost time from work					
Incident (no prior injury)	113 057 915	3037	5.3 (5.1 to 5.5)	1	1
None	11 267 523	340	6.0 (5.4 to 6.6)	1.1 (1.0 to 1.2)	1.2 (1.1 to 1.3)
1 to <2 weeks	2 065 501	54	5.1 (3.9 to 6.7)	0.96 (0.72 to 1.2)	1.1 (0.87 to 1.3)
2 to <4 weeks	770 843	26	6.5 (4.4 to 9.6)	1.2 (0.89 to 1.7)	1.3 (0.99 to 1.8)
1–3 months	962 436	40	8.1 (5.9 to 11.1)	1.5 (1.2 to 2.0)	1.8 (1.4 to 2.3)
>3 months	1 851 207	115	11.8 (9.8 to 14.3)	2.3 (1.9 to 2.6)	2.3 (2.0 to 2.7)

*Adjusted for age, gender, time in the union and predominant type of work; †missing or unknown omitted from adjusted models; no significant change in other parameter estimates. ICD-9, International Classification of Diseases, Ninth Revision; NEC, not elsewhere classified; RR, rate ratio.

study), but by exacerbation of symptoms and work absence after return. There was also a gradual increase in the duration of absence with each recurrence, potentially representing worsening symptoms or pathology, or, perhaps, the tendency of caregivers to recommend longer absence from work with recurrent episodes.

Limitations and strengths

There are a number of limitations and strengths to this work. Our approximation of an incident case does not guarantee that the person had never experienced a previous work-related back injury, and we recognise there was some misclassification in the assignment of initial and recurrent cases. We considered different definitions of incidence that would require an injury-free observation period of a year or two to be considered at risk for an incident injury. We elected not to do this because we would have lost important information about those newest to the union who are known to be at high risk of injury.[27 28 31 32]

The State of Washington captures medical only claims as well as those which result in lost work time, which is a distinct advantage. However, because claims from companies which self-insure are only coded if they result in paid lost time from work, we know we did not capture all injuries that occurred when carpenters worked for contractors who self-insured for workers' compensation. We also could not identify the records of medical care with ICD-9s for the self-insured claims.

Unfortunately, because of lack of data, we were unable to look at risk differentially by race or ethnicity, which could have been enlightening and important. Through the 1990s this cohort was almost exclusively Caucasian. While this pattern largely remains, there is an increasing immigrant presence in this area of the country, even in the union workforce.

Our definitions of incident and recurrent injuries were based on reported work-related cases and should not be confused with any prior history of back problems. Additionally, risk factors for recurrence of back pain can vary depending on the definition of

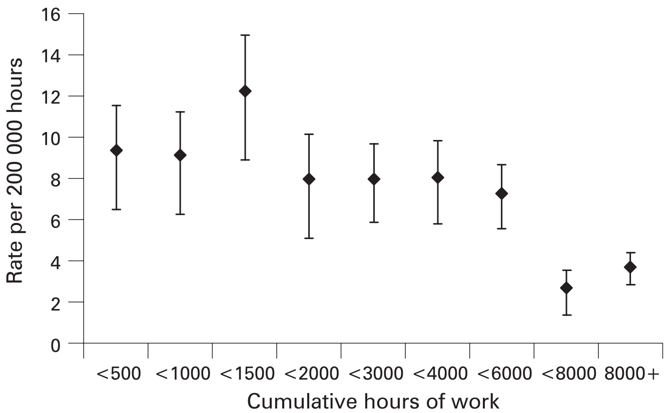

Figure 2 Rates of subsequent musculoskeletal back injury in windows of time after return to work, Washington carpenters, 1989–2003.

recurrence.[6] We evaluated risk for any recurrent injury defined as the filing of a new worker's compensation claim for a back injury, and we also explored whether information about the first injury predicted the filing of a subsequent claim for a back injury of a musculoskeletal nature. Some of these carpenters (n = 127) had their first compensation claims re-opened, including 27 of the 751 (3.6%) who filed second claims; these events were not considered a recurrent injury based on our definition.

As is always the case in analyses of workers' compensation records, anything which influences whether a person files a compensation claim will be reflected in the results. In contrast to many construction workers,[21] these union carpenters have private insurance coverage, removing some concerns that non-work-related care ended up in the workers' compensation system.

We did not have information on psychosocial issues or work environment. However, because of the frequent overlap of significant work organisation issues and physical work exposures,[35 36] we believe this information would be most enlightening with more precise knowledge of work exposures.[37] We recognise that there is misclassification in the process of assigning predominant work that may well have muted the effects we observed, and beyond type of work of the local with which the carpenter affiliated, we had no real exposure information.

Despite these limitations, we were able to observe the reported, work-related back injury experiences of a large well-defined cohort of carpenters. The 15-year observation period allowed sufficient time and statistical power to explore risk factors for both incident and recurrent events and to assess periods when carpenters may be most at risk of a subsequent injury after returning to work.

The analytical methods we chose, specifically survival techniques of Kaplan–Meier curves and Poisson regression, allowed the use of all the data available for each carpenter. Access to coded compensation data and the records of actual medical care allowed us to consider the impact of the different characteristics of a prior injury on the development of a later musculoskeletal injury. The combination of work records from the union and workers' compensation claims allowed us to clearly identify when a carpenter had returned to work regardless of whether the individual may have changed employers. This knowledge of the true population at risk of recurrence is a factor missing in many reports of recurrent back injuries.

Main messages

- Back injuries are responsible for a significant burden of injury among union carpenters, with second events occurring at a rate 80% higher than initial injuries.
- Distributions of first and second back injuries are similar in terms of mechanism and nature of injury as well as medical diagnoses assigned for treatment.
- Risk factors based on age, gender, time in the union and predominant type of work are similar for initial and recurrent back injuries.
- Carpenters with long periods of work disability with a first injury are at particularly high risk of subsequent musculoskeletal injury, as are individuals with degenerative diagnoses, and should be targets for secondary prevention efforts.
- Individuals remain at greater risk for a considerable period of time (3+ years) following return to work after an initial event; risk peaked between 1000 and 1500 h after return to work.

Policy implications

- Challenges to workplace accommodation and our limited ability to clearly define readiness to return to work following injury demonstrate the need for primary prevention of back injuries among carpenters involved in strenuous work.
- These efforts should focus on engineering changes rather than personal behaviour modification.

CONCLUSIONS

Back injuries are responsible for a significant burden of injury among these union carpenters. After having an injury, individuals remain at greater risk of a second event of a musculoskeletal nature for a considerable period of time (3+ years). In large part, the ANSI coded compensation data reflecting the nature and mechanism of injury are not particularly helpful in identifying individuals who are at greater risk of a recurrent back injury. We did find some indication that more severe initial injuries put individuals at risk of a second event and they should be targeted for secondary prevention efforts. In this industry where there are considerable challenges to workplace accommodation because of the heavy nature of the work, individuals who are out of work for over a month, especially over 3 months, warrant accommodation and, perhaps, better rehabilitation efforts/attention to avoid re-injury. However, this is in fact more challenging than it might first appear.

While there is some evidence that even individuals with severe and chronic pain following work-related back injuries can reduce their risk of recurrent problems, including new work-related claims,[38] there are also reports that patterns of recurrence following functional restoration efforts are consistent with the episodic nature of low back pain.[39] In addition, techniques such as functional capacity testing often fail to accurately identify when individuals are ready to safely return to work following injury.[40] Considering these issues in light of the lack of any particularly strong predictors of recurrence, strongly suggests a need for primary prevention of back injuries among these workers involved in strenuous tasks. Synthesis of data from other working populations[41] indicates that interventions, at least for lifting and handling tasks, should focus on engineering solutions rather than changes in individual worker behaviours.

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REFERENCES

1. **Baldwin MJ,** Johnson WG, Butler RJ. The error of using returns-to-work to measure the outcomes of health care. *Am J Ind Med* 1996;**29**:632–41.
2. **Biering-Sorenson F.** A prospective study of low back pain in a general population. I. Occurrence, recurrence and aetiology. *Scand J Rehabil Med* 1983;**15**:71–9.
3. **Carey TS,** Garrett JM, Jackman A, *et al*. Recurrence and care seeking after acute back pain: results of a long-term follow-up study. North Carolina Back Pain Project. *Med Care* 1999;**37**(2):157–64.
4. **Cassidy JD,** Cote P, Carroll LJ, *et al*. Incidence and course of low back pain episodes in the general population. *Spine* 2005;**30**(24):2817–23.
5. **Rossignol M,** Suissa S, Abenhaim L. The evolution of compensated occupational spinal injuries: a three-year follow-up study. *Spine* 1992;**17**(9):1043–7.
6. **Wasiak R,** Kim J, Pransky G. Work disability and costs caused by recurrences of low back pain: longer and more costly than in first episodes. *Spine* 2006;**31**(2):219–25.
7. **McDonald MJ,** Sorock GS, Volinn E, *et al*. A descriptive study of recurrent low back pain claims. *J Occup Environ Med* 1997;**39**(1):35–45.
8. **Spengler DM,** Bigos SJ, Martin NA, *et al*. Back injuries in industry: a retrospective study. *Spine* 1986;**11**:241–5.
9. **Marras WS,** Ferguson SA, Burr D, *et al*. Low back pain recurrence in occupational environments. *Spine* 2007;**32**(21):2387–97.
10. **Wasiak R,** Pransky G, Verma S. Recurrence of low back pain: definition-sensitivity analysis using administrative data. *Spine* 2003;**28**(19):2283–91.
11. **Wasiak R,** Pransky GS, Webster BS. Methodological challenges in studying recurrence of low back pain. *J Occup Rehabil* 2003;**13**(1):21–31.
12. **Elders LAM,** Burdorf A. Prevalence, incidence, and recurrence of low back pain in scaffolders during a 3-year follow-up study. *Spine* 2004;**29**(6):101–16.
13. **Tsai SP,** Bernacki EJ, Dowd C. Health care utilization and costs for injury in a corporate setting. *J Community Health* 1991;**16**(2):93–102.
14. **Heliovaara M,** Makela M, Knect P, *et al*. Determinants of sciatica and low-back pain. *Spine* 1991;**16**(6):608–14.
15. **Wickstrom G.** Drawbacks of clinical diagnoses in epidemiologic research on work-related musculoskeletal morbidity. *Scand J Work Environ Health* 1982;**8**(Suppl 1):97–9.
16. **Hestbaek L,** Leboeuf-Yde C, Manniche C. Low back pain: what is the long-term course? A review of studies of general patient populations. *Eur Spine J* 2003;**12**:149–65.
17. **de Vet HC,** Heymans MW, Dunn KM, *et al*. Episodes of low back pain: a proposal for uniform definitions to be used in research. *Spine* 2002;**27**(21):2409–16.
18. **Griffith LE,** Hogg-Johnson S, Cole DC, *et al*. Low-back pain definitions in occupational studies were categorized for a meta-analysis using Delphi consensus methods. *J Clin Epidemiol* 2007;**60**:625–33.
19. **Natvig B.** The epidemiology of soft tissue rheumatism. *Best Pract Res Clin Rheumatol* 2002;**16**(5):777–93.
20. **Courtney TK,** Simon M, Webster BS. Disabling occupational injury in the U.S. construction industry, 1996. *J Occup Environ Med* 2003;**44**(12):1161–8.
21. **Center to Protect Workers' Rights**. *The construction chart book: The U.S. construction industry and it's workers*. 3rd ed. Washington, DC: CPWR, 2002:95–8.
22. **Cheadle A,** Franklin G, Wolhagen C, *et al*. Factors influencing the duration of work-related disability: a population-based study of Washington State workers' compensation. *Am J Public Health* 1994;**84**(2):190–6.
23. **McIntosh G,** Frank J, Hogg-Johnson S, *et al*. Prognostic factors for time receiving workers' compensation benefits in a cohort of patients with low back pain. *Spine* 2000;**25**(2):147.
24. **Petersen JS,** Zwerling C. Comparison of health outcomes among older construction and blue-collar employees in the United States. *Am J Ind Med* 1998;**34**:280–7.
25. **Arndt V,** Rothenbacher D, Daniel U, *et al*. Construction work and risk of occupational disability: a ten year follow up of 14474 male workers. *Occup Environ Med* 2005;**62**:559–66.
26. **Schneider S,** Susi P. Ergonomics and construction: a review of potential hazards in new construction. *Am Ind Hyg Assoc J* 1994;**55**(7):131.
27. **Lipscomb HJ,** Dement JM, Loomis DP, *et al*. Surveillance of work-related musculoskeletal injuries among union carpenters. *Am J Ind Med* 1997;**32**:629–40.
28. **Lipscomb HJ,** Dement JM, Gaal J, *et al*. Work-related injuries in drywall installation. *Appl Occup Environ Hyg* 2000;**5**(10):794–802.
29. **Waller JA,** Payne SR, Skelly JM. Disability, direct cost, and payment issues in injuries involving woodworking and wood-related construction. *Accid Anal Prev* 1990;**22**(4):351–60.
30. **Waller JA,** Payne SR, Skelly JM. Injuries to carpenters. *J Occup Med* 1989;**31**(8):687–92.
31. **Lipscomb HJ,** Dement J, Li L. Work-related falls among union carpenters in Washington State before and after the vertical fall arrest standard. *Am J Ind Med* 2003;**44**(2):157–65.
32. **Lipscomb HJ,** Cameron W, Silverstein B. Back injuries among union carpenters in Washington State, 1989–2003. *Am J Ind Med* 2008;**51**(6):463–74.
33. **Checkoway H,** Pearce N, Crawford-Brown D, eds. Cohort studies. In: *Research methods in occupational epidemiology*. New York, NY: Oxford University Press, 1989:103–69.
34. **Wasiak R,** Verma S, Pransky G, *et al*. Risk factors for recurrent episodes of care and work disability: case of low back pain. *J Occup Environ Med* 2004;**46**(1):68–76.
35. **Bernard B,** Sauter S, Fine LJ. *NIOSH HETA report 90-013-3277*. Cincinnati, OH: National Institute for Occupational Safety and Health, 1993.
36. **Bongers PM,** Winter CR, Kompier MA, *et al*. Psychosocial factors at work and musculoskeletal disease. *Scand J Work Environ Health* 1993;**19**:297–312.
37. **Lipscomb HJ,** Kucera KL, Epling C, *et al*. Upper extremity musculoskeletal symptoms and disorders among a cohort of women employed in poultry processing. *Am J Ind Med* 2008;**51**(1):24–36.
38. **Garcey P,** Mayer T, Gatchel RJ. Recurrent or new injury outcomes after return to work in chronic disabling spinal disorders. Tertiary prevention efficacy of functional restoration treatment. *Spine* 1996;**21**(8):952–9.
39. **Gross DP,** Battie MC. Predicting timely recovery and recurrence following multidisciplinary rehabilitation in patients with compensated low back pain. *Spine* 2005;**30**(2):235–40.
40. **Gross DP,** Battie MC. Functional capacity evaluation performance does not predict sustained return to work in claimants with chronic back pain. *J Occup Rehabil* 2005;**15**(3):285–94.
41. **Martimo KP,** Verbeek J, Karppinen J, *et al*. Effect of training and lifting equipment for preventing back pain in lifting and handling: systematic review. *BMJ* 2008;**336**:429–31.