ORIGINAL ARTICLE

Costs and compensation of work-related injuries in British Columbia sawmills

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Objective: To estimate the costs of work-related injury in a cohort of sawmill workers in British Columbia from the perspective of the workers' compensation system.

Methods: Hospital discharge records were extracted from 1989 to 1998 for a cohort of 5786 actively employed sawmill workers. A total of 173 work-related injury cases were identified from these records using the *International classification of diseases—ninth revision* (ICD-9) external cause of injury codes and the responsibility of payment schedule. Workers' compensation records were extracted and matched with hospital records by dates and ICD-9 diagnosis codes. All costs were converted into 1995 constant Canadian dollars using the Provincial General Consumer Price Index for the non-healthcare costs and Medical Consumer Price Index for the healthcare costs. A 5% discounting rate was applied to adjust for the time value of money. For the uncompensated cases, costs were imputed from the compensated cases using the median cost for a similar nature of injury.

Results: 370 hospitalisation events due to injury were captured, and by either of the two indicators (E Codes or payment schedules), 173 (47%) hospitalisation events due to injury, were identified as work related. The median healthcare cost was \$4377 and the median non-healthcare cost was \$16 559 for a work-related injury. The median non-healthcare and healthcare costs by injury were falls, \$19 978 and \$5185; struck by falling object, \$32 398 and \$8625; struck against, \$12 667 and \$5741; machinery related, \$26 480 and \$6643; caught in or between, \$24 130 and \$4389; and overexertion, \$7801 and \$2710. The total cost was \$10 374 115 for non-healthcare and \$1 764 137 for healthcare. The compensation agency did not compensate \$874 871 (8.4%) of the non-healthcare costs and \$200 588 (11.4%) of the healthcare costs.

Conclusion: Eliminating avoidable work-related injury events can save valuable resources.

Severe and non-fatal injuries often require hospitalisation. These injuries have the highest potential of resulting in both short-term and long-term disability, and are among the most costly of all injuries from an economic perspective. When injuries requiring hospitalisations are work related, they typically involve substantial loss of productivity for the injured worker. Studies on cost of injuries are important for providing information on (1) the economic burden of injuries; (2) the comparison of cost burdens of different injuries and diseases; (3) the cost to be incorporated into cost-effectiveness analysis; (4) the most important cost components of specific injuries warranting research on treatment options and prevention efforts; and (5) the trends in costs and projection of future costs.^{1–2} Costs of work-related injuries in the USA have been studied within states,³ across states,⁴ across industries⁵ and within the health services sector,⁶ but little attention has been paid in Canada to the costs generated by such injuries, much of which are preventable.

Most of the cost statistics on work-related injury in Canada have been based on reports from workers' compensation agencies, but these agencies do not capture all work-related injuries, nor do they cover all associated costs.^{7–8} Therefore, it is invaluable to study costs using injury reports from an independent surveillance source to obtain a more comprehensive account of serious injuries. Additionally, estimating costs using an independent source and comparing the findings with the results reported by the workers' compensation systems will disclose the magnitude of the burden shifted to other social safety systems.

Hospital discharge records from provincial healthcare providers can be a useful resource for serious injury surveillance, because the public healthcare system in Canada provides

comprehensive coverage of hospitalisations at the population level. We use data from British Columbia to illustrate its potential. Almost all eligible residents of British Columbia (>4.1 million people) are enrolled with the provincial Medical Services Plan.⁹ The Medical Services Plan captures all medical service records of doctors, specialists, other healthcare practitioners, laboratory services, diagnostics services and hospitalisations. The hospital discharge dataset is a potential source of information on serious work-related injuries. External cause of injury codes and source of payment information are available in hospital discharge records and can be used to identify work-relatedness of an injury requiring hospitalisation.¹⁰ Since April 1989, hospitals in British Columbia started coding an additional digit to the *International classifications of disease* (ICD) diagnosis schedule that enhanced its utility as a work-related injury surveillance system.¹⁰

Most employers in British Columbia are required by law to register their business/firm with the workers' compensation system and pay premiums.¹¹ Employer coverage is usually more comprehensive for large, high-risk and unionised industries. If a worker experiences a work-related injury or illness, the compensation system is required to pay for incurred medical expenses (both medical services and supplies), wage-loss benefits and any necessary rehabilitation services.⁸ The compensation system also provides pension benefits to permanently disabled workers.⁸

Sawmills in British Columbia provide an important work setting to study the costs of work-related injury, as this sector is

Abbreviations: BCLHD, British Columbia Linked Health Database; ICD, International classification of diseases; WCB, workers' compensation board

Table 1 Description of cost categories*

Cost category	Description
Healthcare benefits	<ol style="list-style-type: none"> 1. Treatment by a chiropractor, naturopath, doctor or specialist, or treatment by a physical therapist or massage therapist when referred by a doctor 2. Hospital, laboratory, and x ray services 3. Nursing care 4. Personal-care assistance for seriously injured workers 5. Prescription drugs related to the injury 6. Medical supplies, appliances or equipment, including artificial limbs, canes, dentures, hearing aids, wheelchairs, eyeglasses, crutches, back and leg braces, and some orthotics 7. Home, vehicle or workplace modifications for seriously injured workers
Wage-loss benefits	Compensation benefits, also known as wage-loss benefits, are based on 90% of a worker's average net earnings
Permanent disability benefits	If there is evidence that a work-related injury or disease has permanently disabled a worker, he or she is assessed for permanent disability benefits. The amount will probably be based on the loss of function of the body. If the compensation board determines that the combination of occupation and disability is so exceptional that the functional award does not appropriately compensate, then a loss of earnings award is paid
Vocational rehabilitation	<p>Vocational rehabilitation helps disabled workers get back to work after a compensable injury or the onset of an occupational disease and include:</p> <ol style="list-style-type: none"> 1. Vocational assessment and planning 2. Counselling 3. Work assessment 4. Work site job modification 5. Job readiness and placement assistance 6. Skill development 7. Employability assessments

*Source: WorkSafeBC (Workers Compensation Board of British Columbia).

large and unionised, contributes substantially to the economy of the province and is a relatively hazardous industry, and its workers are covered by the provincial compensation system. Further, a large cohort study on sawmill workers exists in British Columbia, initiated in the 1980s to investigate the risk of cancer associated with the use of chlorophenol fungicides,¹² and later expanded to investigate a wide variety of occupational health issues in the forest industry.¹³

The primary objective of this study was to assess the costs of serious work-related injuries requiring hospitalisation among the active sawmill workers in British Columbia during 1989–98 from the perspective of the workers' compensation insurer. The costs were reported by the severity of injury and demographic characteristics. In addition, we also estimated both workers' compensation costs paid by the compensation system and those costs that should have been paid but were not (ie, the hospital discharge cases not identified in the workers' compensation records).

METHODS AND DATA SOURCES

This investigation examined a subset of the full British Columbia sawmill cohort, who were actively working in the study sawmills at the time of hospital admission. Hospital discharge records and workers' compensation claims for this study population came from the British Columbia Linked Health Database (BCLHD). The BCLHD is a health data resource for research purposes, created and maintained by the University of British Columbia's Centre for Health Services and Policy Research. It contains datasets recording doctors' visits,

hospital discharges, deaths, births, as well as extended care, drug usage and workers' compensation claims since 1985.¹⁴ The datasets are linked to a central registry file of all people in the province covered by the British Columbia Medical Services Plan.¹⁵

As part of previous investigations,¹⁰ we were able to link 5876 of 6512 (90.3%) cohort members actively employed in sawmills on or after 1 April 1989, with their medical services and hospitalisation records using the BCLHD. Work-related injuries were captured among these sawmill workers using the hospital discharge dataset. Hospitalisation records were identified as work-related using the ICD—ninth revision (ICD-9) external cause of injury codes that indicate the place of occurrence and the responsibility of payment schedule, which identifies workers' compensation as being responsible for payment. The methods are described by Alamgir *et al.*⁹

The principal diagnosis for the patient's stay in a hospital and the external cause of injury (ICD-9 E codes) was used to designate the nature and cause of work-related injury, respectively, and each hospitalisation record was then categorised into a meaningful, broad nature of injury categories.

The severity of injury was coded in the hospitalisation record by admission type as elective, urgent or emergency.

The BCLHD has information on all injuries and illnesses compensated by the workers' compensation agency of British Columbia.¹⁴ Claim records had information on date of injury, ICD-9 codes, source of injury, nature of injury and the body parts involved. The compensation claim records for this study population were extracted from and matched with the work-related injury hospitalisation records by worker study identifier, date of injury relative to the admission and separation dates, and ICD-9 codes of the hospital discharge records with the ICD-9 codes of the compensation claim records.¹⁶ For each matched injury claim, comprehensive compensation cost data for up to 7 years were collected directly from the workers' compensation board (WCB). The claim cost information was classified by type of compensation benefits: healthcare only, short-term disability (time loss), long-term disability (permanent disability), vocational rehabilitation and death. Table 1 presents the descriptions of the costs.

As noted, costs were calculated from the workers' compensation agency perspective. Costs incorporated in the analysis include short-term and long-term wage replacement costs, hospital care service costs and rehabilitation costs. Costs for short-term and long-term disability and vocational rehabilitation were aggregated into non-healthcare costs for some analyses.

As costs were incurred from 1989 to 1998, these had to be discounted and adjusted for inflation for comparability. All costs were converted into constant Canadian dollars, with 1995 as the base using the Provincial General Consumer Price Index for the non-healthcare costs and Medical Consumer Price Index for the healthcare costs.¹⁷

A 5% discounting rate was applied to adjust for the time value of money and all values were discounted to 1995.¹⁷ For the uncompensated cases, costs were imputed from the compensated cases using the median cost for a similar nature of injury. Total costs and median costs were calculated on the basis of the cause and nature of injury. Costs that the workers' compensation agency did not seem to compensate were also reported.

RESULTS

For the 5876 active sawmill workers, 370 hospitalisation events due to injury were captured between 1989 and 1998. By either of the two indicators (E Codes or payment schedules), 173 (47%) of the hospitalisations were identified as work related.

Of these 173 hospitalisations, 136 (79%) were matched to a compensation claim. Thus, 37 (21%) of the work-related injuries requiring hospitalisation were not matched to a workers' compensation claim.

Approximately 95% of the work-related injuries requiring hospitalisation resulted in a short-term disability claim and about one half of the injuries also resulted in a long-term disability claim (calculations exclude the 37 that were not in the WCB records). However, only 13% of the 136 hospitalised due to injuries required vocational rehabilitation. Figure 1 shows claim outcome categories by cause and nature of work-related injury. About 89% of caught in or between, 75% of fire, flame, natural and environmental, 67% of cutting and piercing, and 63% of machinery-related injuries resulted in long-term disability. In terms of nature of injury, 83% of the fracture of upper limb, 83% of the open wounds, 83% of the burns and 65% of the fracture of lower limb resulted in long-term disability.

Table 2 lists the median and total costs for all 173 work-related injuries requiring hospitalisation among this study population. The median cost of a work-related injury was almost \$20 000. In terms of total costs, the most expensive cost category was long-term disability (almost half of total costs); it was also associated with the highest median costs. Table 2 also reports the distribution of costs by quartiles to describe the range of data.

Table 3 lists the median costs for all 173 work-related injuries requiring hospitalisation among this study population stratified by severity of injury and demographic characteristics. The more severe cases were associated with higher median costs for healthcare and non-healthcare. The costs were also higher for younger and non-white workers.

Table 4 lists the median and total costs for healthcare and non-healthcare expenses for all work-related injury categories among the study population. By median costs, the category of fire, flame, natural and environmental was the most costly cause of injury, and the category of open wounds was the most costly nature of injury for both non-healthcare and healthcare costs. In terms of total costs, the category of machinery-related injuries was the most costly cause of injury, and the category of open wounds the most costly category for nature of injury for both non-healthcare and healthcare costs.

Figure 2 depicts the compensation patterns of the identified work-related injuries. The injuries without a workers' compensation claim were associated with \$874 871 (8.4% of total) of non-healthcare costs and \$200 588 (11.4%) of healthcare costs.

In total, \$1 075 459 (9%) was not compensated by the workers' compensation system.

DISCUSSION

This study described the costs of work-related serious injuries requiring hospitalisation among the sawmill workers in British Columbia. We estimated costs using data from the provincial compensation system for healthcare (medical services) and non-healthcare services (vocational rehabilitation, permanent disability payments and lost-time payments). Our study found median non-healthcare costs of \$16 559 and healthcare costs of \$4377 per injury, and total non-healthcare costs of \$10 374 115 and healthcare costs of \$1 764 137. Comparison of cost statistics across studies is difficult because of the differences in the healthcare system, compensation patterns and coverage, components of costs included, and workforce and industries studied.

Some other studies around the world have quantified the economic burden of injuries. Waehrer *et al*¹⁷ estimated occupational injury costs per worker across the states in the US. Injury data from the Bureau of Labor Statistics and costs data from workers' compensation records were analysed. In the state of Washington, the costs of non-fatal cases with at least 1 day of work loss per employee was found to be \$864. Eastridge *et al*¹⁸ analysed costs of motorcycle-related injuries in Texas and estimated charges of \$36 334 –\$39 390 per injury. Sorensen *et al*¹⁹ studied the economic consequences of cases of falls that presented to nursing homes in the US. The most costly was the fall category with multiple injuries, which accounted for \$22 368.

Rautiainen *et al*²⁰ aimed to determine the cost burden from compensated injuries in Finnish agriculture, using workers' compensation records. The mean cost of cases due to injury in 1996 was estimated at ?1340. Small *et al*²¹ examined the demographics, injury profile and cost of pedestrian accidents in a central city hospital in Sydney, Australia. The average length of stay was 13.4 days costing \$A16 320 per admission. Singh *et al*²² studied head injuries through a prospective 6-month study to evaluate the expenditure incurred by patients with head injury in a modern neurosurgical centre in India. The total expenditure in cases of minor head injury was Rs 7800 per patient, in moderate head injury was Rs 22 172 per patient and in severe head injury, it was Rs 32 852 per patient. The total cost incurred by patients who underwent surgery was Rs 33 100 for each operated patient (1 Indian rupee = 0.02 U S dollars).

Figure 1 Claim outcome categories by cause and nature of work-related injury.

Table 2 Costs* for all 173 work-related injuries requiring hospitalisation among active sawmill workers

Statistic	Healthcare costs	Non-healthcare costs
Mean	10 197	59 966
Median	4 377	16 559
Standard deviation	15 152	111 101
Skewness	3.05	3.85
Standard error of skewness	0.19	0.19
Range	96 427	822 806
Minimum	493	0
Maximum	96 920	822 806
Sum	176 4137	10 374 115
Percentiles		
25	2 402	7 129
50	4 377	16 559
75	10 182	67 367

*All costs in 1995 constant Canadian dollar and costs imputed for 37 hospitalisations not linked to a claim.

Nilsen *et al*²³ reviewed studies that calculated injury costs. On the basis of 12 studies that met the inclusion criteria, the average total cost per injury case was US\$3536, whereas the average share of indirect to total cost per injury case was 71%.

Our estimates of costs are likely to be underestimates of societal costs because we took the perspective of the workers' compensation agency. This perspective ignores costs such as those associated with pain and suffering, as well as those related to home care, lost leisure time, out-of-pocket expenses for the worker, spouse or family members; and ambulance fees, retraining, recruiting and overtime costs for the employers.^{2 17} Although it is recommended to calculate costs of an illness or injury from the societal perspective so that all costs are included irrespective of where the burden falls,¹⁷ information available to us was insufficient to consider all costs in this study. The WCB covered healthcare costs for a compensated injury, including the medical services and supplies required to help the worker recover from a compensable injury.⁸ Long-term disability costs apply to work-related injury or disease that permanently disables a worker.⁸ The WCB-covered vocational rehabilitation programme helps disabled workers get back to work after a compensable injury.⁸ Thus, the WCB covers some important cost components associated with an injury. The costs captured in this study included the important costs associated with a work-related injury.

This study calculated costs for different injury categories and ranked them. For example, according to our findings, reducing or preventing even one burn injury could save about \$54 000 for the compensation agency. Our findings also suggest a prevention focus on open wounds, machinery-related, and fire and environmental causes are the key areas to focus on if a marked reduction in work-related injury burden is being sought.

According to the workers' compensation board statistics, 28 950 full-time equivalent sawmill workers with insurance coverage in British Columbia in 1997 sustained a total of 1737 time-loss injuries at work.²⁴ If we assume that all time-loss injuries resulted in hospitalisation and were similar in costs, according to our findings, on the basis of a median cost of \$19 506, the total costs for this sector are estimated at \$33 881 922 in 1995 constant dollars. According to the official statistics, the reported costs were 34.1 million to the board in 1997 dollars, suggesting that our predicted results were close to the official costs.

The median costs of injury were found to vary by severity of injury. Both healthcare and non-healthcare costs for emergency

Table 3 Costs* by severity of injury and demographic characteristics for 173 work-related injuries among active sawmill workers

Characteristic	Median non-healthcare costs	Median healthcare costs
Admission category		
Elective (29)	7 801	2 710
Urgent (84)	12 174	3 598
Emergency (60)	58 187	9 458
Gender		
Male (170)	51 906	15 048
Female (3)	15 314	3 996
Age (years)		
<24(9)	41 232	7 964
25–34 (43)	7 801	2 710
35–44 (49)	17 517	5 534
45–54 (47)	22 439	5 954
>55 (25)	10 540	2 710
Race		
White (156)	14 258	3 996
South and East Asian (17)	23 782	8 102

*All costs in 1995 constant Canadian dollar.

and urgent cases were higher than elective cases. We could not explore the relationship of sex, as the study population did not have enough female workers. The high costs of younger workers and non-white workers might be explained by the fact that they were engaged in relatively hazardous work processes.

The strength of this study was the use of readily available and large administrative datasets. Our study also captured the actual compensated costs for each claim rather than estimating these from secondary sources or using average claim costs. This study used distinct consumer price indexes for healthcare costs and non-healthcare costs for British Columbia to account for the inflation. It also used a 5% discount rate to adjust for the time value of money. Sensitivity analyses with rates of 3–7% would also result in substantial cost burdens.

This study had a number of limitations in its method. It captured only serious injuries resulting in hospital admission; less serious injuries among the study population were not captured. Thus, the costs were not comprehensive for all

Figure 2 Costs (in 1995 constant Canadian dollar) and compensation by the workers' compensation system.

Table 4 Costs* by cause and nature of injury for 173 work-related injuries among active sawmill workers

	Median (range) non-healthcare costs	Median (range) healthcare costs	Total non-healthcare costs (%)	Total healthcare costs (%)
Cause of injury (n)				
Fire, flame, natural and environmental (7)	189 768 (2 332–458 024)	33 276 (1 819–77 737)	1 205 313 (11.62)	222 439 (12.6)
Struck by falling object (13)	32 398 (0–822 806)	8 625 (543–96 920)	1 422 771 (13.71)	193 232 (10.95)
Machinery related (49)	26 480 (0–372 567)	6 643 (493–60 923)	2 667 333 (25.71)	494 666 (28.04)
Cutting and piercing (9)	24 706 (5 116–354 008)	9 450 (1 024–69 405)	797 005 (7.68)	151 655 (8.59)
Caught in or between (9)	24 130 (6 793–667 183)	4 389 (538–26 163)	1 015 909 (9.79)	78 421 (4.44)
Falls (30)	19 978 (810–411 727)	5 185 9686–48 345)	1 510 234 (14.56)	248 963 (14.11)
Struck against (24)	12 667 (0–352 351)	5 741 (527–33 276)	1 066 883 (10.28)	208 781 (11.83)
Overexertion (16)	7 801 (0–68 770)	2 710 (1031–28 145)	167 791 (1.62)	65 746 (3.72)
Other† (16)	7 801 (487–204 925)	2 710 (569–44 208)	520 876 (5.02)	100 234 (5.68)
Total (173)	16 559	4 377	10 374 115	1 764 137
Nature of injury (n)				
Open wounds (35)	51 517 (0–354 008)	9 967 (849–60 923)	2 713 382 (26.15)	399 815 (22.66)
Burns (9)	48 023 (2332–458 024)	5 954 (1819–77 737)	1 270 825 (12.24)	241 144 (13.66)
Fracture—upper limb (27)	39 713 (4205–372 567)	8 277 (538–53 475)	1 639 447 (15.8)	290 442 (16.46)
Fracture—lower limb (23)	22 439 (8682–208 266)	5 794 (1617–29 644)	1 198 338 (11.55)	207 397 (11.75)
Fracture of head and trunk (23)	9 200 (0–822 806)	5 534 (527–96 920)	2 365 076 (22.79)	332 780 (18.86)
Dislocation, sprains, strains (35)	7 801 (0–166 564)	2 710 (686–28 145)	464 752 (4.47)	120 957 (6.85)
Superficial and crushing injury (12)	4 203 (0–112 845)	2 644 (695–35 886)	318 624 (3.07)	94 599 (5.36)
Other ‡ (9)	4 790 (0–189 768)	2 270 (493–33 276)	403 670 (3.89)	77 003 (4.36)
Total (173)	16 559	4 377	10 374 115	1 764 137

*All costs in 1995 constant Canadian dollar.

†Includes transportation, drowning, suffocation, foreign body; explosion, firearms, hot substances, electricity; other and unspecified.

‡Includes internal injury—chest, abdomen, pelvis, injuries to nerves and spinal cord; traumatic complications, non-medicinal substances, unspecified, others.

Main messages

- Work related injuries are not always reported for workers' compensation, and workers' compensation agencies do not compensate all claims filed to them.
- The median costs of injury were found to vary by severity of injury.
- Both healthcare and non-healthcare costs for emergency and urgent cases were higher than elective cases.
- Approximately 95% of the work-related injuries requiring hospitalisation resulted in a short-term disability claim and about one half of the injuries also resulted in a long-term disability claim.
- The high costs of younger workers and non-white workers might be explained by the fact that they were engaged in relatively hazardous work processes.
- Approximately 95% of the work-related injuries requiring hospitalisation resulted in a short-term disability claim and about one half of the injuries also resulted in a long-term disability claim.
- About 21% of the work-related injuries requiring hospitalisation were not matched to a worker's compensation claim.
- The median cost of a work-related injury was almost \$20 000.

injuries in this sector. This study depended heavily on the accuracy of the diagnosis codes and dates of both hospital and compensation database, and the matching rules used for identifying a claim matched to a hospitalisation. There might be some inaccuracies in the linking method to extract the right claims for the hospitalisation cases resulting in mismatches. Information on cost was available up to 2005, which provided 7 years to develop costs for all the injury events, as the last injury captured in our study was in 1998. However, major costs

Policy implications

- Knowing the costs, causes and nature of costly injuries will help employers, compensation officials and other stakeholders to identify vulnerable job groups and work processes. This information can be used to design and implement targeted preventive measures in an industry.
- Comparison of cost statistics across studies is difficult because of the differences in the healthcare system, compensation patterns and coverage, components of costs included and workforce and industries studied.
- If injuries among employed persons are not appropriately compensated, policy and prevention decisions may not be based on accurate or complete evidence or relative importance of causes and nature of injury and the cost of some work-related injuries will continue to be paid by other segments of the social safety net.

were probably developed within the first 7 years after an injury event.

Research on the cost of workplace injury has an important role in many aspects of industrial hygiene initiatives. Knowing all the associated costs and the causes and nature of costly injuries will help employers, compensation officials and other stakeholders to identify vulnerable job groups and work processes. This information can be used to design and implement targeted preventive measures in an industry. If injuries among employed persons are not appropriately compensated, policy and prevention decisions may not be based on accurate or complete evidence or relative importance of causes and nature of injury, and the cost of some work-related injuries will continue to be paid by other segments of the social safety net. For example, the burden of uncompensated wage-losses may be borne by the federal unemployment insurance system or the employee and their family, and the

healthcare costs were probably covered by the provincial healthcare system.

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