INCIDENCE, COSTS, AND COMPENSATION OF WORK-RELATED INJURIES
AMONG SAWMILL WORKERS IN BRITISH COLUMBIA

by

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ABSTRACT

Objectives:

The primary objective of this study were to investigate the use of hospital discharge records as a tool for work-related serious injury surveillance, including analyses to compare injury reporting patterns using hospital records versus workers’ compensation records and the use of hospital records to investigate the epidemiology and the economic burden of serious work related injuries.

Methods:

The study population was working members of the sawmill industry in the Canadian province of British Columbia between 1989-1998. Hospital discharge records and workers’ compensation claims for a cohort of 5,876 actively employed workers were obtained. Hospitalization records were identified as work-related using ICD-9 external cause of injury codes (E-codes) that indicate place of occurrence, and the responsibility of payment schedule, which identifies workers’ compensation as being responsible for payment. Hospital records were linked and matched to compensation claims by injury diagnosis and available date variables. Claim cost information was collected from the provincial compensation agency.

Results:

Both the E-code and the payment schedule code available in hospital discharge records were useful in capturing work-related injuries requiring hospitalization. The study findings indicate that the compensation agency underreports serious and acute injuries by about 10%.
This study documented that several vulnerable groups of workers, like, non-white people, and specific injury categories, like, overexertion and falls were related with greater under-reporting. For the cost analyses, the median non-health care costs were $16,559 and healthcare costs were $4,377 per sawmill injury (in 1995 Canadian dollars). By median costs, the category of fire, flame, natural & environmental was the most costly cause of injury category. About 9% of the total costs ($12 million) of hospitalized injuries were not compensated by the workers’ compensation system.

Conclusions

Hospital data represent an alternative source of information for serious work-related injuries. Knowing the injuries and costs that remain unreported and/or uncompensated will be helpful to employers, compensation officials, unions, policy makers and other stakeholders to identify vulnerable worker groups and work processes, and subsequently target preventive measures within an industry.
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The candidate is first author on all the manuscripts; he developed the study questions, entered and manipulated the data, performed statistical analyses, and wrote the final manuscripts. Co-authors of the study include Paul A Demers, Mieke Koehoorn, Aleck Ostry, and Emile Tompa—all members of the supervisory committee.
CHAPTER 1
INTRODUCTION

1.1 FORMAT OF THESIS

This doctoral dissertation utilizes a manuscript-based format approved by the Faculty of Graduate Studies at the University of British Columbia (UBC). Following the recommendations of the Faculty of Graduate Studies at UBC, this dissertation begins with an introduction and literature review of the overall program of research ending with the thesis objectives for each manuscript. The second section is composed of the individual manuscripts, each of which includes a literature review, statement of research objectives, results, discussions and conclusions. The last section of the dissertation is a concluding chapter that contains a brief review of the findings reported in the manuscripts followed by a discussion of the implications of the research findings in terms of the overall program of research, and some comments on areas for future research.

Among the six papers that are presented here, two are already published in peer reviewed journals and the remaining four are under review for publication.

1.2 STUDY PURPOSE

The purpose of this doctoral dissertation is to present a program of research centred on the surveillance of work-related injury using hospital discharge data among a cohort of sawmill workers in the Canadian province of British Columbia (BC), including using these records to investigate injury reporting patterns relative to claim data, and the economic consequences and epidemiology of serious injuries. The dissertation includes a series of independent but related
chapters that describe the results of the following six studies/papers: a) an investigation of the validity of hospital discharge records as a tool for work-related serious injury surveillance, b) a comparison of the reporting patterns of workers’ compensation system with that of hospital discharge records, c) an assessment of the validity of injury coding patterns of workers’ compensation records compared to hospital discharge records, d) an estimation of the compensation costs of work-related serious injuries e) an estimation of the hospitalization costs of work-related serious injuries, and f) an epidemiological investigation of work-related sawmill injuries requiring hospitalization. The dissertation ends with a summary and discussion of the key research findings and provides some guidelines for future research directions in terms of the outlined program of research.

1.3 WORK-RELATED INJURY

Work-related injury not only results in suffering and economic burden for the worker and family but also adds to the overall cost to society through lost productivity and increased use of health and welfare services. The International Labor Organization (ILO) states that there are two million work-related deaths worldwide every year which translates into more than 5,000 fatalities per day. According to ILO, for every fatal injury there are around another 500 to 2,000 injuries [ILO, 2002]. Leigh and colleagues [1999] estimated that approximately 100 million occupational injuries including 100,000 deaths occur in the world annually.

An injury is an act that hurts, damages, or results in a sustained loss [Merriam-Webster, 2005]. Injuries are classified as being acts of unintentional or intentional physical damage that result from the transfer of energy [Peek-Asa and Zwerling, 2003]. The types of energy transfer that cause injuries are:

- Mechanical or kinetic energy (e.g., fall)
- Electrical energy (e.g., electrocution)
- Thermal energy (e.g., burns)
- Chemical energy (e.g., poisoning)
- Absence of essential energy (e.g., suffocation)

A work-related injury is defined by the workers' compensation system as one that arises out of or in the course of employment or is due to the nature of employment [Workers' Compensation Board (WCB), 2006]. Thus, in countries which have some sort of compensation systems in place, a worker must have been working when hurt and the injury must have been caused by something to do with the job in order to receive compensation [WCB, 2006].

As a consequence of injury, impairments, functional limitations, and disabilities can happen to the injured employee. An impairment refers to a physiological or anatomical loss or abnormality. An impairment may in some cases give rise to a functional limitation, defined as a restriction of a person's capacities. Lastly, functional limitations may in some cases lead to a disability if they limit the person's ability to engage in activities at home, work, and/or society [Weil, 2001] [Figure 1.1].

In the last five years (2000-2004) there were 5,027,061 work-related compensation claims reported throughout Canada resulting in an average yearly count of 1,005,412 claims [Association of Workers Compensation Boards of Canada, (AWCBC), 2006]. In British Columbia, Canada, data obtained from the provincial compensation agency indicates that over 822,018 time-loss claims were submitted from 1997 to 2004 averaging about 164,404 per year [AWCBC, 2006]. The top 4 injuries in this province for 2000-2004 by time-loss claims were strains (97,390), back strains (79,230), cuts (35,390), and contusions (33,970) and the top 4 injuries by days lost were strains (5.1 million days), back strains (3.4 million), fractures (2.3
million), and contusions (0.8 million) [WCB, 2004]. Over the past ten years, an average of 151 fatal claims has been accepted for compensation annually in the province of British Columbia [WCB, 2004]. From 1993 to 1997, the average accepted, time-loss claim rate was 7 injuries per 100 full-time equivalent workers in BC sawmills compared to the overall provincial average of 5.4 injuries [WCB, 1999].

1.4 PATHWAY OF INJURY AND ASSOCIATED COSTS

The field of injury prevention has provided some solution-oriented models for understanding the hazards. The Haddon matrix, developed by William Haddon, has been used in injury prevention research and intervention [Runyan, 1998; Runyan, 2003]. The Haddon matrix is a grid where the rows represent different phases of an injury (pre-event, event, and post-event), and the columns represent different influencing factors (host, agent/vehicle, physical environment, social environment). The host column represents the person or persons at risk of injury. The agent of injury impacts the host through a vehicle (inanimate object) or vector (person or other animal/organism). Physical environment refers to the actual setting where the injury occurs. Socio-cultural and legal norms of a community constitute the social environment. The phases of an event are depicted on the matrix as a continuum beginning before the event (pre-event), the event itself (event phase), and sequelae of the event (post-event phase).

The objectives of this thesis oriented around identifying the injury and its' costs, rather than investigating its causes. Figure 1.2 provides a framework of the approach taken by this thesis toward injury identification. A work-related injury might or might not be claimed for compensation. Those that reach hospitals can be identified by the work-related indicators available in the hospital discharge records, but, injuries that do not reach hospitals will be
beyond the scope of this investigation. This thesis will also not be able to assess the impact of non-work related injuries that are claimed for compensation.

1.5 WORK-RELATED INJURY: SURVEILLANCE

Monitoring and surveillance of injury helps to estimate the size of a problem; characterize injury trends; design, implement and evaluate preventive programs; improve knowledge of injury among health professionals, policy makers and public; and identify research needs [Kaucke, 1988]. Workers' compensation claims data represents an important source of information on work-related injuries. In a review in 1998, Goldsmith [1998] recommended the use of workers' compensation data for epidemiologic research. He assessed several studies based on data extracted from workers' compensation or disability programs and recommended that valuable information could be derived from it.

However, it is important to keep in mind that the workers' compensation agencies reports do not usually include all workplace injuries: they only include compensated time-loss injuries. The AWCBC (AWCBC) defines a time-loss injury as "an injury for which a worker is compensated for a loss of wages following a work-related injury or receives compensation for a permanent disability with or without time lost in his or her employment" [CCOHS, 2006]. Injury cases not reported to or accepted by a workers' compensation agency or injuries among some work groups that are not covered by the compensation agency (such as the self-employed) might not be included in the published reports.

Azaroff and colleagues [2002] thoroughly investigated the reporting patterns of occupational injury in USA by the Bureau of Labor Statistics, workers' compensation wage-replacement documents, physician reporting systems, and medical records of treatment charged
to workers' compensation. They explained how cases can be lost at successive steps of documentation. Their findings point out that workers constantly risk unfavourable consequences for attempting to report such injuries.

Though workers' compensation system should ideally cover healthcare, disability and rehabilitations costs, a number of studies have uncovered that workers often are not covered by it, do not report all injuries or illness, or do not receive adequate compensations. Waller and colleagues [1989] studied injuries to carpenters in Vermont and calculated hospital costs for injuries. They found that only one third of payment came from workers' compensation. Frumkin and colleagues [1995] characterized occupational injuries from injury registry in emergency departments in a poor inner-city population. Only about one quarter received workers' compensation. Stanbury and colleagues [1995] studied patients with confirmed silicosis identified by the silicosis surveillance program in the New Jersey Department of Health from 1979 through 1992. Only 31% of these patients stated that a claim had been filed and 84% of those whose claims were settled were awarded payments. Biddle and colleagues [1998] estimated the rate at which workers suffering from occupational illnesses file for workers' compensation lost wage benefits. They matched a database of reports of known or suspected cases of occupational illness with workers' compensation claims data. Overall, between 9% and 45% of reported workers filed for benefits. Women and employees of small firms were more likely than others to file for worker's compensation and filing rates were found to vary considerably across industries and diagnostic categories. Rosenman and colleagues [2000] in a cross-sectional study of unionized autoworkers individuals diagnosed with neck, upper extremity, and low back work-related musculoskeletal disease found that only 25% of workers with a work-related musculoskeletal condition filed for workers' compensation. The strongest
predictors of filing were severity of the condition, length of employment, annual income, and worker dissatisfaction with coworkers.

Some Canadian researchers have also investigated this issue. Shannon and Lowe [2002] in a Canadian survey reported that among 143 eligible injuries, 40% had not filed a workers' compensation claim. Severity of injury was the strongest predictor of claiming according their study. Kraut [1997] estimated the extent of occupational disease morbidity and mortality in Canada by comparing and contrasting four different data sources: Canadian National Workers' Compensation Boards Statistics, U.S. Bureau of Labor Statistics adjusted to Canadian Workforce, California Physician's First Reports adjusted to the Canadian Workforce, and proportionate model of overall disease incidence obtained through literature review. He concluded that each data source was limited in its ability to provide a true estimate of the extent of morbidity and mortality due to occupational disease in Canada.

Researchers and stakeholders have investigated the use of other data sources for injury surveillance. Layne [2004] provided an analysis of similarities and differences in two different data sources used for the study of occupational injury mortality in the United States from 1992 to 1997: The National Traumatic Occupational Fatalities surveillance system and the Census of Fatal Occupational Injuries. They found each system to vary in methodology, leading to different census counts. Biddle and Marsh [2002] compared the same two national systems that compile fatal occupational injury data in the United States, and evaluated counts for the nation and by state for worker and case characteristics. They recommended use of multiple data sources for comprehensive injury surveillance. Murphy and colleagues [1996] described the strengths and weaknesses of six data collection systems that record occupational injuries and illnesses in USA on a national level, and compared the leading estimates from these systems for 1990. They
concluded that all occupational health databases have limitations when used to summarize the national scope of workplace hazards and a comparison of data from multiple sources might produce more credible estimates.

Work-related injury is greatly under-reported in the informal sectors. For example, traditional worksite injury surveillance methods are often ineffective for farms employing seasonal labor. Many small farms are exempt from mandatory injury reporting and a high proportion of foreign workers and the temporary nature of the work further discourage reporting. Earle-Richardson G and colleagues [2003] used anonymous medical chart data from migrant health centers and regional hospital emergency rooms to account for the work-related events in such places. Canada, with a high proportion of immigrants, may have groups that underutilize social services and underreport workplace injuries. Alternate sources of data may capture these work-related injuries, such as medical services visits or hospitalizations.

There remains a need to investigate different sources of work-related injury surveillance tools and compare these. There is evidence to suggest that a combination of data sources may provide a more comprehensive picture. Yager and colleagues [2001] developed a pilot occupational injury and illness database that incorporated and standardized data across a number of companies of differing sizes and configurations. They favored aggregation of relevant health and safety data across companies to improve statistical power for the assessment of rare injuries within a sector. Oleske and Hahn [1992] combined administrative and clinical data from a network of occupational medicine clinics to evaluate the utility of these data in the surveillance of non-fatal occupational injuries. They recommended that a surveillance system based upon ambulatory care data can be a feasible method for identifying priority areas for the prevention of work-related injuries. Brewer and colleagues [1990] described experience of a clinic-based
 occupational injury surveillance system involving occupational medicine clinics. Their results supported the feasibility of conducting clinic-based occupational injury. Liss and colleagues [1997] explored the use of hospital records for occupational diseases and concluded that it was an underutilized source. Noe and colleagues [2004] demonstrated the use of an emergency department as a data source for work-related injuries in Nicaragua because it captured both the formal and informal workforce injuries. Therefore, the use of some clinical databases may hold promise for workplace injury surveillance and other research.

In summary, we rely heavily on compensation claim data which may underreport work-related injuries; and studies suggest a combination of data sources for a more comprehensive picture. However, limited evidence is available on which data sources to use and their validity/reliability, although some clinical data sources hold promise.

1.6 CODING ACCURACY IN ADMINISTRATIVE DATASETS

Coding accuracy is a serious concern for any database system and for epidemiological researchers using such data. The increased use of administrative and aggregated data in epidemiological research further underscores the significance of coding accuracy and data validation. The use of external sources for case identification and case validation are two ways of investigating data quality and validity of results. Administrative health data usually originate from administering health care services, enrolling members into health systems/insurance plans, and reimbursing for services. The primary producers of administrative data are the health care providers and private health care insurers. Administrative data are readily available, inexpensive to acquire, computer readable, typically encompass large populations, and suitable for longitudinal analysis. The use of administrative data is based, however, on the assumption that it provides reasonably valid information on injury or disease diagnoses. Evaluation of the
validity of these datasets is vital to use them for epidemiological investigations and surveillance purposes.

A number of studies examining the accuracy of diagnosis codes in such datasets has been published. Langley and colleagues [2006] studied the level of accuracy in coding for injury principal diagnosis and the first external cause code for public hospital discharges in New Zealand for the period 1996-1998. They recommended that users of that data can have a high degree of confidence in the injury diagnoses coded under the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM). Farhan and colleagues [2005] reviewed medical records from patients at a Saudi Arabia hospital following the guidelines of ICD-9-CM for accuracy and completeness of documentation and coding of primary and secondary diagnoses and procedures performed. Of the items abstracted, 70% were assigned a correct code according to their investigation.

Neale and colleagues [2003] aimed to assess the interrater reliability of coding in the Queensland Trauma Registry in Australia. Interrater agreement between coders was high for external cause, intent, and place of injury. Agreement between the raters for Injury Severity Score was found to be very high. The accuracy of coding in the Queensland Trauma Registry was sufficiently high to ensure that quality data were available for research, audit and review.

LeMier M and colleagues [2001] evaluated the accuracy of external cause of injury codes (E codes) reported in computerized hospital discharge records. According to them, the detail codes (complete E codes) reported in hospital discharge codes were less reliable and must be used with caution. Macintyre [1997] aimed to ascertain the reliability of injury data in the Victorian inpatient database in Australia. Nearly half the errors in the principal diagnosis were minor, involving the last two digits. External cause codes were more complete than diagnosis
codes. Thus, they found the use of the principal-diagnosis code and E-codes for injury surveillance to be feasible and reliable.

Evaluation of the validity of codes of the work-related injury surveillance tools is vital because safety interventions at workplaces are often based on reports generated from these data sources.

1.7 EPIDEMIOLOGY OF WORK-RELATED INJURY IN CANADA

Occupational epidemiology identifies the demographic and work-related risk factors associated with work-related injury, describes the injuries, and provides important clues as to where and how interventions measures can be undertaken. Epidemiological studies on occupational injury in Canada are limited in number relative to other health outcomes. A few studies have identified common injury categories in different industrial sectors and investigated injury incidence by work group and tasks that should help guide future prevention efforts.

Pickett and colleagues [1999] used a national registry for the surveillance of fatal farm injuries to describe these injuries and compare rates with those in other industries. The leading mechanisms of fatal injury were tractor rollovers, blind runovers, extra-rider runovers, and entanglements in machinery. Compared with other industries, agriculture was found to be the fourth most dangerous in Canada in terms of fatal injury, behind mining, logging and forestry, and construction. Saar and colleagues [2006] described the incidence and nature of farm-related deaths and injuries in British Columbian farms from 1990-2000. After analyzing farm fatalities and farm injury hospitalizations data, they found higher rates of non-machinery-related injuries resulting in hospitalizations among young adult BC farmers.
Yassi and colleagues [2005] studied time-loss claims data for 1992-2002 from the workers' compensation agencies in Canadian healthcare workplaces. According to their findings, musculoskeletal injuries consistently comprised the majority of time-loss claims in this sector. Needlestick injuries, infectious diseases and stress-related claims infrequently resulted in time-loss claims. Sibley and colleagues [2005] studied the epidemiology of occupational injuries experienced by Canadian rotor-wing health care providers. The frequent cases were for hand lacerations, leg contusions and acute back injuries. Overall, an injury rate of 3.2 injuries per person per year was reported. Lifting was cited as a common factor in injury.

Choi and colleagues [1996] investigated patterns and risk factors for sprains and strains in Ontario in 1990 using Ontario workers' compensation data. With respect to occupations, nurses and truckers had a higher-than-expected risk. Overexertion, bodily reaction from involuntary motions, running and stretching, and slippery surfaces were associated with a high risk of occurrence of sprains and strains.

Breslin and colleagues [2006] identified risk factors of work injuries among Canadian adolescents and young adults, and examined provincial differences in medically attended work injury rates. Saskatchewan youth were about twice as likely to be injured at work compared to Ontario youth. All jobs showed higher risk than administrative clerical jobs, and visible minorities, students, and 15-17 year olds had a reduced likelihood of work injury than their counterparts.

Barroetavena [2001] in an epidemiologic investigation of injury mortality among sawmill workers in British Columbia found the overall fatality rate to be 18.1 per 100,000 person-years for the period of 1950-1990. Machine operators and mobile equipment operators were the occupational groups with the highest crude fatality rates. Over 80% of the deaths were caused by
severe trauma to the head, spinal cord, or multiple sites. This study and the current thesis have used the same cohort of sawmill workers.

There are limited studies of non-fatal injuries in Canada; differences in injury risk and rates by work group and work tasks need to be investigated in Canadian context.

1.8 COST OF WORK-RELATED INJURY

Cost of illness/injury (COI) studies are important for providing information on 1) the economic burden of injuries; 2) the comparison of economic burden by disease or condition; 3) the cost to be incorporated into cost-effectiveness analysis; 4) the most important components of specific injuries warranting research on treatment options and prevention efforts; 5) the trends in costs and projection of future costs; and 6) evidence based decision making for prevention resource allocation [Koopmanschap, 1998].

Some economic costs of workplace injury and illness are readily evident (Figure 1.1). These include medical costs, lost time at work, and the administration of programs for those injured. Others, however, are not that easy to quantify: the loss of life, changes in the future work activity and earnings of the injured, impacts on households of injured or ill workers, diminishing quality of life [Weil, 2001].

Different points of view (perspectives) can also lead to different cost estimates. The society's perspective considers costs to all sectors of society. The government's perspective considers costs to the government only, such as costs to the health care and justice systems. The health care providers' perspective considers costs imposed on various types of hospitals, health maintenance organizations, and other health care providers [Choi and Pak, 2002; Drummond, 1997].
A study published in 1998, estimated that the total cost of intentional and unintentional injuries in Canada was greater than $12.7 billion per year or 8% of the total direct and indirect costs of illness ranking fourth after cardiovascular disease, musculoskeletal conditions and cancer [Health Canada, 1998]. This study estimated that unintentional injuries alone cost Canada more than $8.7 billion annually. More than $4.2 billion of the total is in direct cost to the health care system and approximately $4.5 billion is the indirect cost of loss of productivity due to impairment, disability and premature death. [Health Canada, 1998]. When injuries involve an employed segment of the society, the costs are usually a lot higher. In the province of British Columbia, a total of 2.8 million days were lost from work due to work-related injury in 2004 and the claim costs for only year 2004 was $12,166 million [WCB, 2004].

Costs of occupational injury studies in Canada are scarce or non-existent. Locker et al. [2003] estimated the economic burden of agricultural machinery injuries that occurred in Ontario, between 1985 and 1996. The total economic burden of these injuries over the 12-year study period was estimated to be $228.1 million, or $19.0 million annually (1995 Canadian dollars). By extrapolation, the economic burden of all farm injuries in Canada was estimated by them to be between $200 and 300 million annually.

There are a handful of such studies published in the USA. Some studies have estimated costs within industrial sectors. Waehrer and colleagues [2005] studied costs of occupational injury and illness within the health services sector using 1993 nonfatal incidence data drawn from the Bureau of Labor Statistics Annual Survey. Medical costs were from the claims information, productivity (wage) costs were calculated using the Current Population Survey and pain and suffering costs were estimated from data on jury verdicts. Costs of injuries and illnesses were to nursing aides and orderlies US$2,200 million; to registered nurses US$900 million and
for licensed practical nurses US $40 million. Leigh and colleagues [2001] estimated the costs of job-related injuries in agriculture in the United States for 1992. The authors reviewed data from national surveys to assess the incidence of fatal and non-fatal farm injuries. Agricultural occupational injuries cost an estimated $4.57 billion in 1992. Direct costs are estimated to be $1.66 billion and indirect costs, $2.93 billion.

Leigh and colleagues [2004] ranked industries using total costs and costs per worker. Cost data were derived from workers' compensation records, estimates of lost wages, and jury awards. The following industries were at the top for average cost (cost per worker): taxicabs, bituminous coal and lignite mining, logging, crushed stone, oil field services, water transportation services, sand and gravel, and trucking. Industries high on the total-cost list were trucking, eating and drinking places, hospitals, grocery stores, nursing homes, motor vehicles, and department stores.

A few others have tried to estimate costs by states and national level. Waehrer and colleagues [2004] also estimated occupational injury and illness costs per worker across states. Analysis was conducted on injury data from the Bureau of Labor Statistics and costs data from workers' compensation records. In the state of Washington, the costs of nonfatal cases with at least 1 day of work loss per employee was $864, whereas, the total costs for non-fatal cases were $1,241 million and the total costs for fatal cases were $317 million. Presence of sectors like farming, agricultural service, forestry, fishing, mining, transportation and public utilities were important in explaining the high costs across states.

Miller and Galbraith, [1995] estimated the costs of occupational injury in the United States using national expenditure data. Overall, workplace injuries cost the U.S. an estimated $140 billion annually. This estimate includes $17 billion in medical and emergency services, $60
billion in lost productivity, $5 billion in insurance costs, and $62 billion in lost quality of life. Leigh and colleagues [1997] estimated the total direct ($65 billion) plus indirect ($106 billion) costs annually in the civilian American workforce using national and large regional data sets collected by the Bureau of Labor Statistics, the National Council on Compensation Insurance, the National Center for Health Statistics, the Health Care Financing Administration, and other governmental bureaus and private firms.

A few studies estimated costs by states. Neumark and colleagues [1991] estimated the annual economic costs of occupational injuries and illnesses in Pennsylvania in 1988: foregone earnings costs resulting from occupational injuries and illnesses were estimated at between $1.22 billion and $2.02 billion and estimates of medical costs ranged from $740 million to $797 million. Leigh and colleagues [2001] estimated costs associated with occupational injuries and illnesses in California in 1992. They aggregated and analyzed national and California data sets collected by the U.S. Bureau of Labor Statistics, California Workers' Compensation Insurance Rating Bureau, California Division of Industrial Relations, the National Center for Health Statistics, and the U.S. Health Care Financing Administration. The direct costs were $7.04 billion and the indirect costs were $13.62 billion. Injuries cost $17.8 billion (86%) and illnesses $2.9 billion (14%).

Most of these cost studies acknowledged that their estimates were likely to be low because they ignored such costs as pain and suffering and home care provided by family members, and because the numbers of occupational injuries and illnesses were likely to be underreported by the data sources. Most of the costs of injury studies are done in the USA, and the USA has different health care system and social safety nets from Canada.
1.9 RESEARCH NEEDS AND STUDY JUSTIFICATION

Hospital discharge records represent a readily existing source of data for the monitoring of severe injuries. These records have information on the nature, cause and severity of injuries, and are collected autonomously outside of the contentious arena of attribution. Despite their potential to capture work-related injury, little research has been carried out on their validity and completeness. In Canada, a few studies have attempted to identify work-related events using hospital discharge records, but have focused on capturing a specific range of events, such as those related to agricultural machineries, or occupational asthma [Dimich-Ward et al., 2004; Locker et al., 2002, Liss et al., 2000]. Hospital discharge records have the potential to be a valuable data resource for surveillance because of the comprehensive public health care system in Canada.

Once hospital discharge records can be established as a potential tool for severe non-fatal injuries, the next logical step should be comparing and contrasting it with the workers’ compensation claims to examine the agreements between these two sources. Hospital dataset will never capture all injuries, but it will provide a great comparison tool as people would expect the work-related hospitalizations to be compensated.

Epidemiologic study of work-related injuries has been stalled by the lack of a comprehensive and independent reporting system. Among the information sources available, workers’ compensation systems are currently considered a major surveillance tool. However, documented underreporting of work-related injuries by the workers’ compensation systems has led to an interest in exploring different sources of information for use. If hospitalization records can be established as a surveillance tool for serious injuries, this can be used alone and in conjunction with the workers’ compensation data to act as a more comprehensive and reliable
source of injury information. Epidemiologic studies based on these new surveillance tools will provide new information which can be incorporated into health and safety interventions.

Workers' compensation data have been used by health services and population health researchers to study the epidemiology, outcomes, and costs of work-related injury, and also to examine the value of the services provided by the compensation systems. The use of workers' compensation data for research purposes is based, however, on the supposition that it provides realistically valid information on injury diagnoses. Evaluation of the validity of the workers' compensation system dataset is vital because this data source provides the most commonly used source of information on work-related injuries to date. Hospital discharge records provide a new source to compare the validity of important diagnosis codes in the compensation systems reports.

Most of the cost statistics on work-related injury in Canada have been based on official reports from workers' compensation agencies, but these agencies do not capture all work-related injury nor do they cover all associated costs. Therefore, it is invaluable to study costs using injury reports from an independent and different surveillance source to obtain a more complete 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 reveal the magnitude of the burden shifted to other social safety systems. [Appendix-2: Diagram on Work related injury identification]
1.10 THE MANUSCRIPTS

1.10.1 FIRST PAPER

The first paper of this thesis identifies and describes work-related serious injuries among sawmill workers in British Columbia, Canada using hospital discharge records, and compares the agreement and capturing patterns of the work-related indicators available in the hospital discharge records.

1.10.2 SECOND PAPER

This chapter investigates the concordance between hospital discharge records and workers' compensation records for work-related serious injuries among this cohort of sawmill workers. It also examines the extent to which workers' compensation capturing patterns vary by cause, severity of injuries, and demographic characteristics of workers.

1.10.3 THIRD PAPER

This part of the study assesses the validity of injury related diagnostic codes in the British Columbia's workers' compensation agency's dataset using a hospital discharge dataset as the comparative standard. Hospital records are matched to the compensation records for each injury record and the levels of agreement by injury category are examined.

1.10.4 FOURTH PAPER

This chapter evaluates the costs of work-related injury in this cohort of sawmill workers and describes the costs not compensated by the workers' compensation agency. For each work-
related injury category, the median and total non-health care costs and healthcare costs are determined.

1. 10.5 FIFTH PAPER

This study estimates the hospital costs of treating work-related injury among the cohort of sawmill workers in British Columbia. The median stay in hospitals in days and the median hospital costs are presented. The total hospital costs for all the work-related injuries as well as proportion of total hospital costs that the provincial compensation agency does not compensate are estimated.

1. 10.6 SIXTH PAPER

The goals of this investigation are to describe work-related injuries requiring hospitalization by cause, nature, and body parts for a ten-year period among the sawmill workers and identify the job categories and demographic characteristics that are associated with higher risk of sustaining work-related injury.

1.11 STUDY POPULATION AND DATA SOURCES

1.11.1 THE SAWMILL INDUSTRY

In the province of British Columbia, about 30,000 workers (2% of the workforce) were working in the logging and forestry industry during the study period of 1993-1998 [BC Statistics, 2004]. Sawmills and other lumber mills are hazardous work environments due to the nature of the work processes, the types of equipment used, and materials handled [Demers and
Teschke, 1998]. From 1993 to 1997, the average accepted, time-loss claim rate was 7 injuries per 100 full-time equivalent workers in BC sawmills compared to the overall provincial average of 5.4 injuries [WCB, 1999]. From 1993 to 1997, the WCB paid more than $325 million for claims in forest products manufacturing. There were 41,932 health-care-only claims costing a total of $11.5 million, 23,800 time-loss (short term disability, and long term disability) costing $297.4 million, and 35 fatalities costing $10.9 million [WCB, 1999]. Therefore, the sawmill industry in British Columbia represents an important workplace setting to investigate the use of hospital discharge records for work-related injury surveillance and costs of such injury because of its hazardous work environments and importance to the local economy.

1.11.2 DATA SOURCES

For this study, two administrative datasets from the British Columbia Linked Health Database (BCLHD) - the workers' compensation claims and hospital discharge records - were used. The demographic and work-history data were already collected on the study population using employee records as part of previous studies. Additionally, claim costs from the workers' compensation system were collected, and the standard hospital billing chart from the Health Ministry was used for the cost analysis. Access to the full set of data was gained mainly through the BCLHD maintained by the Centre for Health Services and Policy Research at the University of British Columbia.

1.11.3 THE STUDY POPULATION

The BC Sawmill Cohort originally included 28,827 workers employed for at least one year between 1950 and 1998 by one of 14 large BC sawmills. There were 7,496 cohort members
who died or were lost to follow-up or left the province prior to April 1989. Of the remaining 21,301 workers, a total of 19,972 were linked with health outcome data and therefore eligible for inclusion in this study. The study participants were followed from April 1989 to the study end date (December 1998), date of death, date of last observation, or the health outcome of interest (work-related injury) which ever occurred earlier. [Appendix 4: The Sawmill Cohort]

Of the study mills, six were located on Vancouver Island, five on the south coast of BC mainland, and three in the interior of the province. At each mill, data were abstracted from personnel records to construct two files. One with personal information including worker’s name and date of birth; and another with the job history including hire date, work department, and start and end dates for each new job held at the mill [Hertzman et al, 1997; Teschke, 1998].

1.11.4 BRITISH COLUMBIA LINKED HEALTH DATABASE

The British Columbia Linked Health Database (BCLHD) is a health data resource created and maintained by the University of British Columbia Centre for Health Services and Policy Research [CHSPR, 2004]. It contains datasets recording physician visits, hospital discharges, deaths, births, as well as extended care, drug usage, and workers’ compensation claims [CHSPR, 2004]. The data sets are all linked to a central registry file of all persons in the province covered by the BC Medical Services Plan (MSP). [See Appendix-3: British Columbia Linked Health Database Contents for more information]. Almost all eligible residents of BC (over 4.1 million people) are enrolled with MSP [BC Ministry of Health, 2004]. Members of the BC Sawmill Cohort Study were linked with hospitalization records and claims records using the BCLHD. As part of previous studies, 19, 972 members of the BC Sawmill Cohort Study were linked with hospitalization records using the BCLHD by April 1989. They were linked to the
BCLHD by probabilistic linkage using names, birth dates and where available Social Insurance Numbers as identifiers [Hertzman et al., 1997]

1.11.5 HOSPITAL DISCHARGE DATA

The hospital discharge dataset consists of all separations (discharges, transfers, and deaths) for in-patients or day surgery patients admitted to acute care hospitals in British Columbia [CHSPR, 2004]. Among many other variables, admission and separation dates, and payment modes (indicating agency responsible for paying medical costs) are recorded along with the name of hospital. Each record is described as elective, urgent or emergency. There are up to 16 ICD-9 (International Classification of Diseases) diagnosis codes available to describe the event. The first is considered the primary reason for hospitalization. The ICD-9 nature of injury codes and ICD-9 cause of injury codes were used in the study to identify and describe injury events.

The International Classification of Diseases (ICD) is the classification system used to code and classify mortality data from death certificates. The International Classification of Diseases, Clinical Modification (ICD-9-CM) was used to code and classify morbidity data from the inpatient and outpatient records, and other administrative databases included in the BCLHD during the study period. The ICD-9-CM is based on the World Health Organization's Ninth Revision, International Classification of Diseases [ICD-9-CM]. ICD-9-CM was the official system of assigning codes to diagnoses and procedures associated with hospital utilization in the United States and Canada before ICD-10 became available. In this study, the terms ICD-9 and ICD-9-CM are used synonymously.
1.11.6 WORKERS’ COMPENSATION DATA

The BC Linked Health Database has information on all claims compensated by the Workers’ Compensation Board of BC (WCB) from the year 1987 onwards [CHSPR, 2004]. The detailed information on the injury related claims include injury date, ICD-9 codes, source of injury, nature of injury, and body parts involved.

1.11.7 CLAIM COSTS

For an injury claim, comprehensive compensation cost data for up to 7 years after the event were collected directly from the WCB. The claim cost information was classified by level of compensation benefits: health care only, short-term disability (time-loss), long-term disability (permanent disability), vocational rehabilitation and fatality.

1.11.8 HOSPITAL BILLING INFORMATION

Standard Ward Rate for the daily charge for hospital stays was collected from the British Columbia provincial Ministry of Health. It is used also for inter-provincial and workers’ compensation billing purposes. This rate is calculated yearly and is also site-specific [BC Ministry of Health, 1989-1998].

1.11.9 ETHICS APPROVAL

The study was approved by the behavioural research ethics board of the University of British Columbia.
FIGURE 1.2: IDENTIFICATION OF A WORK-RELATED INJURY

- Work-related Hospitalized Injury
  - Not Filed for Compensation → Identified by Place of Occurrence in hospital records
  - Filed for Compensation
    - Claims Accepted → Identified through linkage with compensation records
    - Claims Rejected → Identified by Responsibility of payment in hospital records
1.12 REFERENCES

http://www.awcbc.org/english/board_data.asp


CCOHS, 2006. Canada's National Centre for Occupational Health and Safety
http://www.ccohs.ca/oshanswers/information/injury_statistics.html


http://www.m-w.com/


2.1 INTRODUCTION

Workers' compensation claims data represents an important source of information on work-related injuries. Compensation statistics are compiled using only officially reported and accepted claims. However, several recent studies in the USA [Waller et al., 1989; Frumkin et al., 1995; Stanbury et al., 1995; Biddle et al., 1998; Rosenman et al., 2000] and Canada [Shannon and Lowe, 2002] have found that workers injured in the workplace do not always report injuries or file a claim for workers' compensation. Work-related injuries may not be reported to compensation systems for numerous reasons, such as discouraging supervisors and coworkers, job insecurity, legal status, procedural complications, unawareness about the system, high odds of having a claim rejected, injury not serious enough, and social stigma [Herbert et al., 1999; Rosenman et al., 2000; Shannon and Lowe et al., 2002]. Additionally, workers' compensation does not accept all of the claims filed [Stanbury et al., 1995; Herbert et al., 1999].

In addition to workers' compensation claims data, other sources of information including emergency department reports, physician claims data, police reports, newspaper clippings, surveys, and workplace incident reports have been explored as a means to determine the number of non-fatal work-related injuries [McCurdy et al., 1995; Hayden et al., 1995; Murphy et al., 1996; van Charante and Mulder, 1998, Morse et al., 2001; Tercero et al., 2004]. Hospital

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discharge records represent yet another readily available source of data for the monitoring of severe non-fatal injuries. Hospital discharge records have detailed information on the nature, cause and severity of injuries in Canada, and the records are collected objectively outside of the contentious arena of attribution. Despite their potential to capture work-related injury, little research has been carried out on their validity and completeness [Sorock et al., 1993; Baker et al., 1999]. In Canada, a few studies have attempted to identify work-related events using hospital discharge records, but have focused on capturing a specific range of events, such as those related to agricultural machineries or occupational asthma [Dimich-Ward et al., 2004; Locker et al., 2002, Liss et al., 2000]. According to our knowledge, studies in Canada have neither used hospital data for more general injury surveillance nor validated its use against other available indicators. Hospital discharge records have the potential to be a useful data resource for surveillance because of the public health care system in Canada, and the comprehensive coverage of hospitalizations at the population level.

The challenge in utilizing hospital discharge data for work-related injury research is differentiating work from non-work-related injuries. The International Classification of Disease Revision 9 Clinical Modification (ICD-9) [ICD-9-CM] coding scheme includes external codes or “E” codes that indicate the source of injury (for example, motor vehicle, machinery, fire, etc.) for injury related diagnosis. Some of these E codes can be used to specify the work relatedness of an injury. Additionally, starting in April 1989, hospitals in the Canadian province of British Columbia (BC) began to code a fifth digit indicating whether or not the injury occurred at a workplace for certain E Codes. The hospital discharge records in BC also contain a responsibility for payment schedule, which includes the option of selecting the provincial workers’ compensation agency - the Worker’s Compensation Board of BC (WCB). The
availability of two indicators also provide the opportunity of estimating the hospitalized cases that would remain unascertained through an appropriate statistical method, such as the capture-recapture method [Morse et al., 2001].

The sawmill industry in British Columbia represents an important workplace setting to investigate the use of hospital discharge records for work related injury surveillance because of both its hazardous work environments and importance to the local economy. In the province of British Columbia, about 2% of the workforce was working in the logging and forestry industry during 1993-1998 [BC Statistics, 2004]. Sawmills and other lumber mills are hazardous work environments due to the nature of the work processes, the types of equipment used, and materials handled [Demers and Teschke, 1998]. From 1993 to 1997, the average accepted, time-loss claim rate was 7 injuries per 100 full-time equivalent workers in BC sawmills compared to the overall provincial average of 5.4 injuries [WCB, 1999].

A large cohort study on sawmill workers in BC, initially started in the 1980s to investigate the risk of cancer associated with the use of Chlorophenol fungicides [Hertzman et al., 1997], was expanded to investigate a wide variety of occupational health issues in the forest industry [Teschke et al., 1998]. This study used two study populations: a) the full cohort, which included members who might not be working in sawmills at the time of hospital admission (moved out of the study sawmills at some point during the follow up period); and b) a sub-set of the cohort members who were working in the study sawmills at the time of hospital admission. This investigation captured and described work-related serious injuries using the indicators available in hospital discharge records from 1989 to 1998. It compared the agreement and capturing patterns of the work related indicators (E codes and responsibility for payment), and investigated whether the agreement between the two indicators in this surveillance system varied
by causes of injuries or types of populations. It also attempted to estimate the number of hospitalized injuries that were undetected by both sets of indicators.

2.2 METHODS

2.2.1 THE SAWMILL COHORT

The BC sawmill cohort originally includes 28,827 workers employed for at least one year between 1950 and 1998 by one of 14 large BC sawmills. There were 7,496 cohort members who died or were lost to follow-up, or left the province prior to April 1989. Thus, for this study, the population base was the rest of the cohort members (21,301). From the work history records, 6,512 cohort members were selected for the second set of analysis, all of who were working in sawmills on or after April 1989. The study populations were followed up from April 1989 for health outcomes to study end date (December 1998), date of death, or date of last observation, whichever occurred earlier. Hospital discharge records were extracted for an injury diagnosis between April 1989 and December 1998. Injuries among the cohort members captured hospitalization incidents that occurred while the cohort members were employed in study sawmills, in other sawmills, in another industry, or were out of work.

2.2.2 BRITISH COLUMBIA LINKED HEALTH DATABASE

The British Columbia Linked Health Database (BCLHD) is a health data resource created and maintained by the University of British Columbia Centre for Health Services and Policy Research [CHSPR, 2004]. It contains datasets recording physician visits, hospital discharges, deaths, and births, as well as extended care, drug usage, and workers' compensation claims from 1985 [CHSPR, 2004]. The data sets are all linked to a central registry file of all persons in the province covered by the BC Medical Services Plan (MSP) [Chamberlayne et al., 1998]. Almost
all eligible residents of BC (over 4.1 million people) are enrolled with MSP [BC Ministry of Health, 2004]. The MSP processes claims for insured services submitted by physicians, supplementary health care practitioners, hospitals, laboratory services and diagnostic procedures [BC Ministry of Health, 2004]. The hospital discharge dataset used in this study came from the BCLHD. As part of previous studies, 19, 972 members of the BC Sawmill Cohort Study were linked with hospitalization records using the BCLHD by April 1989. They were linked to the BCLHD by probabilistic linkage using names, birth dates, and where available, Social Insurance Numbers as identifiers [Hertzman et al., 1997]. Among the 6,512 cohort members actively employed on or after April 1, 1989, a total of 5,876 members were linked with their hospitalization records.

2.2.3 HOSPITAL DISCHARGE DATA

The hospital discharge dataset consists of all separations (discharges, transfers, and deaths) for inpatients or day surgery patients admitted to acute care hospitals in British Columbia [CHSPR, 2005]. An injury related hospital admission is described by cause of injury (E codes) and nature of injury (ICD-9 N codes). External causes of Injury and Poisoning (E800-E998) codes are applicable to describe the accident, circumstance, event, or specific agent, which caused the injury or other adverse effect [ICD-9]. These E codes are used in addition to the nature of injury or poisoning codes (ICD-9 N codes), which range between 800 and 999 [ICD-9]. Up to 16 diagnoses are available using the ICD-9 codes to describe the nature and cause of a hospital admission. The principal diagnosis for the patient's stay in a hospital was used to designate the nature of an injury for this analysis. This diagnosis code was accompanied by E
codes present in one or more of the 15 other fields; the first E code in order of presence was used to identify the cause of an injury.

Of the 40,806 hospital discharge records extracted among the full study cohort, there were 3,317 cases (8.13%) where the principal diagnoses were injury (ICD-9 N codes ranged between 800 and 999), and of these, 3,305 (99.6%) were E Coded (Figure 2.1). From the E Coded segment of the total hospitalization records (3,305), a subset of hospitalization records with cause of injury codes that have a minimal probability of being occupational in nature were excluded from our analysis (Figure 2.1).

In this study, work-related injuries were identified by two indicators. The first indicator relied solely on the ICD-9 E-codes. Table 2.1 lists the indicators of work-relatedness available in the digits of the E codes [ICD-9]. The second indicator used to describe work-related injuries in the hospital discharge records was the field indicating the agency responsible for payment of the patient's hospitalisation. The second indicator was considered as a surrogate of workers' compensation claim filed for that injury, as at that point, no further information was available to know whether an injury related claim was essentially filed or compensated subsequently.

2.2.4 ANALYSIS

Each injury was classified as work related using E-codes and then again using payment schedules. Next, the relationship of work-relatedness with the demographic and hospital characteristics was explored for both study populations. Demographic characteristics included age, sex, and race; and hospitalization characteristics included type of admission (for example, elective, urgent, emergency), level of care (for example, acute care, day care surgery), and length of stay. The concordance of the two work-relatedness identifiers (E code versus payment
schedule) was examined by cause of injury. The Kappa statistic was calculated to measure the agreement between the two work-related indicators [Maclure and Willett, 1997].

Capture-recapture methods were used to estimate the number of injuries that were unreported in both the study populations. The capture-recapture method estimates the extent of incomplete ascertainment using population-based data from two independent and overlapping sources. This methodology originated in wildlife biology and demography, and has been tailored into epidemiology to determine population parameter estimates derived from two or more imperfect sources [Morse et al., 2001]. This method was described by Hook and Regal [1995]. It attempted to estimate the number of hospitalized work related injuries that were undetected by both sets of indicators.

The study was approved by the behavioural research ethics board of the University of British Columbia.

2.3 RESULTS

Of the 1,885 hospital records selected for the first set of analysis, 547 (29%) were identified as work-related by either the E codes or the payment fields. For the active sawmill workers, 173 (47%) out of the 370 hospitalizations were identified as work related (Table 2.2). Table 2.2 shows important demographic and hospital characteristics of the work related and total injury related hospitalization records for both study populations. The active sawmill workers were significantly younger and the proportion of Asians among this group was higher than that in the full study cohort.

In the full study population, there were no significant differences in the distribution of hospitalizations by sex, race, admission category, level of care, or length of stay for any hospitalization compared to work related hospitalizations. There were no major differences in
the distribution of hospitalizations by sex, age, admission category, or level of care for any hospitalization compared to work related hospitalizations in active sawmill workers.

Among the cohort members who were not working in the study sawmills any longer, almost half of all injury hospitalizations among people aged 30-34 years, and one third among aged 25-29 and 35-59 years were found to be work-related (Figure 2.2). The work-related injury hospitalizations were notably greater for the active sawmill workers who were <20 years or 45-64 years compared to other cohort members. More than half of all hospitalizations among workers <20 years, 45-54 years, and 60-64 years were work-related among the active sawmill workers (Figure 2.2).

Table 2.3 compares the two sources of work-related injury identification by the cause of injury categories for the full cohort. The payment field identified 83.9% (n=459) of the total work-related cases (n=547), and E codes identified 84.4% (n=462) of the work-related cases (Figure 2.3). The indicators provided the same assessment in 68.3% (374) of the total cases. For some causes of injury, such as struck by a falling object; other & unspecified; and railway, water, air & powered vehicles, the payment field picked up more work-related cases, and for others, such as struck against, machinery related, and cutting & piercing, the E Code field was able to identify more work related cases. The two sources had relatively poor concordance for injuries, such as machinery-related, struck by falling object, overexertion, and caught in or between, as measured by kappa statistic. There was better agreement for injuries, such as, struck against; drowning, suffocation, foreign body in eye, other foreign body; fire, flame, natural & environmental; and explosions, firearms, hot substance, electric current & radiation. For the full study population, there were 324 records for which E Codes did not have information on work-relatedness; thus the agreement between the two sources in determining work-relatedness of
injuries was calculated for the rest of the 1,561 records. The agreement between them was found to be good (kappa= 0.75; p<0.01).

Table 2.4 compares the two indicators of work related injury identification by the cause of injury categories for the active sawmill workers. The payment field identified 86.7% (150) of the total work-related cases (n=370), and E codes identified 91.3% (158) of the cases as work related injuries (Figure 2.3). Both of them agreed on 78% (135) of the total cases. By either of the two sources, almost half (47%) of all hospital visits for injuries were identified as work related. Both fields were able to capture proportionately more work related events among actively employed people. In these active sawmill workers, for all causes of injury, except other & unspecified, E Codes were able to identify equal or more numbers of work related cases. There was relatively poor concordance for injuries, such as machinery related; struck by falling object; caught in or between; and railway, water, air & powered vehicle. For the active sawmill workers, there were 44 records for which E Codes information was not available; thus the agreement between the two sources in respect to identifying work-relatedness was calculated for the rest of the 326 records. The agreement was also good (kappa= 0.77; p<0.01).

To obtain an unbiased estimate for the number of unascertained cases for the full cohort population by these two sources, a capture-recapture method was applied. The results of the capture-recapture method suggested that there were 16 (1%) more work-related cases that went undetected by either of these two indicators. Therefore, adding these 16 to our already identified cases resulted in an estimated 563 hospitalizations for work-related injuries in our full study population. Application of the capture-recapture method also suggested that there were 2 (0.6%) more work-related cases that were undetected by the two sources, increasing the total work-related injury admissions to 175 among those actively employed in the sawmill industry.
2.4 DISCUSSION

Both E codes and payment schedules available in hospital discharge records were useful in capturing work related severe injury incidents in the active sawmill workers and full cohort populations. Interestingly, the E Codes in hospital records picked more work related injury cases than the responsibility of payment field for the active sawmill workers. However, identification by payment field picked up equal or more cases for several injury categories in the full study group. The E codes and payment fields have been examined in other studies as a tool for injury surveillance. Sorock and colleagues [1993] found 11% of hospital discharge records with external cause of injury codes. Smith and colleagues [Smith et al., 1990] found 13.9% hospital discharge records with at least one injury-related diagnosis or health service code, and 99.3% of them were E Coded. These findings are consistent with what we have found in this study. Sniezek and colleagues [1999] suggested that E Coded hospital discharge data systems were potentially one of the most effective and feasible means available to collect data needed for injury surveillance. Smith and colleagues [1990] recommended that with uniform guidelines and better training of coders, the E coding system could provide a valuable, cost-effective method of identifying non-fatal injuries. Baker and colleagues [1999] used California hospital discharge database to identify hospitalized ocular injury, and used workers' compensation as principal payer to identify work-relatedness. Sorock and colleagues [1993] suggested that the payment field in hospital data might be a good to excellent indicator of work-relatedness of hospitalized injuries.

The most frequent causes of hospitalizations in our study populations were falls, motor, road vehicle, overexertion, machinery related, struck against, and cutting & piercing. The most
frequent causes of work related hospitalizations were *falls, machinery related, overexertion, struck against, cutting & piercing, and struck by falling objects*. Among the workforce employed in sawmills, the two indicators identified almost all cases of *machinery related, struck by falling object* and *caught in or between* injuries as work-related.

From 1993 to 1997, the Workers’ Compensation Board of BC accepted a total of 11,685 time-loss claims from sawmills, with most being for overexertion, struck by, caught in, and falls [WCB, 1999]. There are two main reasons why injuries captured by hospital discharge records and workers compensation authority might be different in terms of severity and nature. First, the WCB has its own way of coding injury information. Second, there are injuries, which might result in time-loss without requiring a hospital visit.

People with work-related injuries were younger compared to those with any hospitalization in the full study population. Younger people are more likely to be active sawmill workers. An international literature review of 63 nonfatal studies by Salminen [2004] found that younger workers had a higher injury rate than older workers. The injury rate for young male workers (the number of short-term disability claims per 100 person-years of employment) was higher than the overall provincial average during 1976 to 1997 also in the province of British Columbia [WCB, 2004]. This study captured work-related injury among workers who were less than 20 years of age. There were 17 workers who were below 18 years during their injury admission in the full study population; two of them had work related injury. In our study, the work-related indicators failed to identify any work related injuries among the individuals of 65 years or older. This adds validity to our case definition of a work related hospitalization in this study as the province of BC has a mandatory retirement age of 65 years.
The findings of this study should be interpreted carefully due to the following limitations. It excluded from analysis certain injuries that had a small likelihood of being work-related. For example, we could have missed some work-related injuries coded as medical adverse events, violence, and medical misadventure. The records with the workers’ compensation in payment field were used in this study as a proxy for claims actually compensated by the workers’ compensation agency. It was not possible to verify this as we did not have the real compensation claims data for the study populations. Given the prevailing external cause of injury coding patterns, work-related injury identification would more be feasible for manufacturing industries. For capture-recapture analysis, source dependency should be avoided [Morse et al., 2001]. Provided that different coders coded the ICD-9 codes and payment field on the same dataset, some independency was ensured, though there were chances of cross-contamination. Also, about 10% of the active sawmill workers were not linked to the BCLHD, and the linkage rate was found lower for young people, female, and South Asians.

The principal diagnosis for the patient's stay in a hospital was used to designate the nature of an injury for this analysis. Whereas, this might create some measures of misclassification for cases which had more than one equally significant diagnosis, we decided to depend on the judgment of the attending physician who determined which code should be the principal diagnosis. For acute and severe injury requiring hospitalisation, the first diagnosis should ideally represent the more immediate and real nature of an injury.

Our study depended heavily on the accuracy of the codes available in hospital data. Studies outside Canada [Sorock et al., 1993; Baker et al., 1999, Smith et al., 1990] and inside Canada [Dimich-Ward et al., 2004; Locker et al., 2002; Liss et al., 2000] used hospital discharge datasets. The reliability and validity of hospital records were examined by some studies.
[Vestberg et al., 1997; Rawson and Malcolm, 1995; Kashner, 1998; Beghi et al., 2001]. Also, a review by Virnig and McBean [2001] recommended the use of electronically available administrative data for surveillance purposes. However, since some of the hospital discharge codes, especially the fifth digit E codes were introduced only in 1989 in British Columbia, it might somewhat under-report the work related cases for the first few years.

Provided the responsibility of payment field worked well as a surrogate for workers’ compensation claims, the hospital discharge records support some degree of under-reporting of work-related injuries by the official workers’ compensation agency statistics. There is no gold standard for work-related injury surveillance tools as the workers’ compensation agency does not capture, accept, or report on all injuries. While there are complaints of underreporting against the workers’ compensation authority, it should be sensitive enough to capture information on injuries severe enough to reach a hospital. Matching of a work related hospital record with actual WCB claim can help validate hospital records as a potential surveillance tool.

Hospital discharge data are collected for administrative reasons, and thus are readily available. They are especially suitable for retrospective studies covering longer periods of observation. Depending on the coding reliability and validity of specific databases, hospital data represent an alternative source of information for compensation related statistics for serious work related injuries.

Knowing the causes and nature of injuries that remain unreported will be helpful to employers, compensation officials, and other stakeholders to identify vulnerable groups, and subsequently target preventive measures within an industry. Accurate reporting of work-related injuries could impact regulatory processes and prevention strategies by estimating the actual size of the problem faced by both employers and the workforce. If injuries among employed persons
are not documented as work-related, policy and prevention decisions may not be based on accurate or complete evidence; employees may not receive needed compensation and rehabilitation services, and the cost of some work-related injuries may end up being paid by other parts of the social safety net (for example, the publicly funded health care system).
### TABLE 2.1: E-CODES, INJURY CATEGORIES, AND MEANS OF IDENTIFYING WORK-RELATEDNESS*

<table>
<thead>
<tr>
<th>Category Description</th>
<th>E-code</th>
<th>Indicator of Work-Relatedness [ICD-9]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway</td>
<td>E800-E807,</td>
<td>4(^{th}) digit: 0 = railway employee</td>
</tr>
<tr>
<td>Water transport</td>
<td>E930-E938</td>
<td>4(^{th}) digit: 2 = crew, 6 = dockers &amp; stevedores</td>
</tr>
<tr>
<td>Air &amp; space transport</td>
<td>E840-E845,</td>
<td>4(^{th}) digit: 2 = crew, 8 = ground crew</td>
</tr>
<tr>
<td>Powered vehicles used solely within industrial &amp; commercial buildings</td>
<td>E846</td>
<td>Primarily occupational by definition</td>
</tr>
<tr>
<td><strong>Motor vehicle traffic, non-traffic &amp; other road vehicle</strong></td>
<td>E810-E829</td>
<td>No work-related E Codes indicating work-relatedness (only payment field used for these records)</td>
</tr>
<tr>
<td>Vehicle accidents not elsewhere classifiable</td>
<td>E847-E848</td>
<td></td>
</tr>
<tr>
<td><strong>Other poisonings</strong></td>
<td>E860-E869</td>
<td>5(^{th}) digit, available April 1989 or later</td>
</tr>
<tr>
<td>1. Farm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buildings, Land under cultivation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excludes: farm house and home premises of farm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Mine and quarry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mine, quarry, gravel pit, sand pit, tunnel under construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Industrial place and premises</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building under construction, industrial yard, loading platform (factory) (store), dockyard, dry dock, industrial plant, factory, railway yard, factory -building, premises, shop – place of work, warehouse, garage – place of work, workhouse</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Falls</strong></td>
<td>E880-E888</td>
<td></td>
</tr>
<tr>
<td>Fire &amp; flame</td>
<td>E890-E899</td>
<td></td>
</tr>
<tr>
<td>Natural &amp; environmental (e.g. cold, heat, pressure)</td>
<td>E900-E909</td>
<td></td>
</tr>
<tr>
<td><strong>Drowning &amp; suffocation</strong></td>
<td>E910-913</td>
<td></td>
</tr>
<tr>
<td>Foreign body in eye</td>
<td>E914</td>
<td></td>
</tr>
<tr>
<td>Foreign body in other orifice</td>
<td>E915</td>
<td></td>
</tr>
<tr>
<td><strong>Struck by falling object</strong></td>
<td>E916</td>
<td></td>
</tr>
<tr>
<td>Struck against</td>
<td>E917</td>
<td></td>
</tr>
<tr>
<td>Caught in or between</td>
<td>E918</td>
<td></td>
</tr>
<tr>
<td>Machinery-related</td>
<td>E919</td>
<td></td>
</tr>
<tr>
<td>Cutting &amp; piercing</td>
<td>E920</td>
<td></td>
</tr>
<tr>
<td><strong>Explosions, firearms, explosive, hot substance, corrosive, caustic, steam, electric current &amp; radiation</strong></td>
<td>E921-926</td>
<td></td>
</tr>
<tr>
<td>Overexertion</td>
<td>E927</td>
<td></td>
</tr>
<tr>
<td>Other &amp; unspecified (noise &amp; vibration)</td>
<td>E928</td>
<td></td>
</tr>
</tbody>
</table>

* Responsibility of payment field was available for all categories
### TABLE 2.2: DEMOGRAPHIC AND HOSPITAL CHARACTERISTICS OF STUDY POPULATIONS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Full Study Population (n=19,972)</th>
<th></th>
<th>Active Sawmill Workers (n=5,876)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total hospitalizations (%)</td>
<td>Work-related hospitalizations* (%)</td>
<td>Total hospitalizations (%)</td>
<td>Work-related hospitalizations* (%)</td>
</tr>
<tr>
<td>N</td>
<td>1,885</td>
<td>547</td>
<td>370</td>
<td>173</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>1,868 (99%)</td>
<td>541 (99%)</td>
<td>363 (98%)</td>
</tr>
<tr>
<td>Age (Years)</td>
<td>Mean (95% CI)</td>
<td>50 [50-51]</td>
<td>43 [42-44]</td>
<td>41 [40-42]</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>47</td>
<td>43</td>
<td>40</td>
</tr>
<tr>
<td>Race</td>
<td>White</td>
<td>1,795 (95.2%)</td>
<td>520 (95.1%)</td>
<td>330 (89.2%)</td>
</tr>
<tr>
<td></td>
<td>South Asian</td>
<td>82 (4.4%)</td>
<td>24 (4.4%)</td>
<td>37 (10%)</td>
</tr>
<tr>
<td></td>
<td>East Asian</td>
<td>8 (0.4%)</td>
<td>3 (0.5%)</td>
<td>3 (0.8%)</td>
</tr>
<tr>
<td>Length of Stay (Median)</td>
<td>3 days</td>
<td>3 days</td>
<td>2 days</td>
<td>3 days</td>
</tr>
<tr>
<td>Admission Category</td>
<td>Elective</td>
<td>290 (15%)</td>
<td>89 (16%)</td>
<td>72 (20%)</td>
</tr>
<tr>
<td></td>
<td>Urgent</td>
<td>949 (50%)</td>
<td>279 (51%)</td>
<td>181 (49%)</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>646 (34.5%)</td>
<td>179 (33%)</td>
<td>117 (32%)</td>
</tr>
<tr>
<td>Level of Care</td>
<td>Day care Surgery</td>
<td>346 (18%)</td>
<td>115 (21%)</td>
<td>82 (22%)</td>
</tr>
<tr>
<td></td>
<td>Fatal Cases</td>
<td>46</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

* Work-related hospitalizations were identified by either the E codes or the payment schedule.
<table>
<thead>
<tr>
<th>Injury Category</th>
<th>Frequency of hospital admissions</th>
<th>Payment indicates Work-relatedness (%)</th>
<th>E Codes indicate work-relatedness (%)</th>
<th>Kappa Statistic (p value)</th>
<th>Either payment or E Codes indicate Work-relatedness (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls</td>
<td>663</td>
<td>117 (18)</td>
<td>116 (18)</td>
<td>0.77 (&lt;0.01)</td>
<td>139 (21)</td>
</tr>
<tr>
<td>Motor &amp; road vehicle</td>
<td>324</td>
<td>15 (5)</td>
<td>NA</td>
<td>NA</td>
<td>15 (5)</td>
</tr>
<tr>
<td>Overexertion</td>
<td>188</td>
<td>47 (25)</td>
<td>46 (24)</td>
<td>0.59 (&lt;0.01)</td>
<td>61 (32)</td>
</tr>
<tr>
<td>Machinery related</td>
<td>154</td>
<td>102 (66)</td>
<td>114(74)</td>
<td>0.54 (&lt;0.01)</td>
<td>123 (80)</td>
</tr>
<tr>
<td>Struck against</td>
<td>137</td>
<td>40 (29)</td>
<td>44 (32)</td>
<td>0.86 (&lt;0.01)</td>
<td>46 (34)</td>
</tr>
<tr>
<td>Cutting &amp; piercing</td>
<td>108</td>
<td>29 (27)</td>
<td>39 (36)</td>
<td>0.70 (&lt;0.01)</td>
<td>41 (38)</td>
</tr>
<tr>
<td>Drowning, suffocation, foreign body in eye, other foreign body</td>
<td>45</td>
<td>4 (9)</td>
<td>4 (9)</td>
<td>1.00 (&lt;0.01)</td>
<td>4 (9)</td>
</tr>
<tr>
<td>Struck by falling object</td>
<td>44</td>
<td>27 (61)</td>
<td>23 (52)</td>
<td>0.45 (&lt;0.01)</td>
<td>31 (70)</td>
</tr>
<tr>
<td>Fire, flame, natural &amp; environmental</td>
<td>42</td>
<td>13 (31)</td>
<td>16 (38)</td>
<td>0.84 (&lt;0.01)</td>
<td>16 (38)</td>
</tr>
<tr>
<td>Caught in or between</td>
<td>39</td>
<td>27 (69)</td>
<td>28 (72)</td>
<td>0.57 (&lt;0.01)</td>
<td>31 (79)</td>
</tr>
<tr>
<td>Explosions, firearms, hot substance, electric current, radiation</td>
<td>34</td>
<td>18 (53)</td>
<td>19 (56)</td>
<td>0.94 (&lt;0.01)</td>
<td>19 (56)</td>
</tr>
<tr>
<td>Railway, water, air &amp; Powered vehicle</td>
<td>27</td>
<td>8 (30)</td>
<td>6 (22)</td>
<td>0.81 (&lt;0.01)</td>
<td>8 (30)</td>
</tr>
<tr>
<td>Other poisonings</td>
<td>17</td>
<td>4 (24)</td>
<td>5 (29)</td>
<td>0.85 (&lt;0.01)</td>
<td>5 (29)</td>
</tr>
<tr>
<td>Other &amp; unspecified</td>
<td>63</td>
<td>8 (13)</td>
<td>2 (3)</td>
<td>0.37 (&lt;0.01)</td>
<td>8 (13)</td>
</tr>
<tr>
<td>Total</td>
<td>1,885</td>
<td>459 (24)</td>
<td>462 (25)</td>
<td>0.75 (&lt;0.01)</td>
<td>547 (29)</td>
</tr>
</tbody>
</table>
TABLE 2.4: IDENTIFICATION OF WORK-RELATED INJURY HOSPITALIZATION AMONG ACTIVE SAWMILL WORKERS BY CAUSE OF INJURY

<table>
<thead>
<tr>
<th>Injury Category</th>
<th>Frequency of hospital admissions</th>
<th>Payment indicates Work-relatedness (%)</th>
<th>E Codes indicate work-relatedness (%)</th>
<th>Kappa Statistic (P value)</th>
<th>Either payment or E Codes indicate Work-relatedness (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls</td>
<td>84</td>
<td>25 (30)</td>
<td>29 (35)</td>
<td>0.84 (&lt;0.01)</td>
<td>30 (36)</td>
</tr>
<tr>
<td>Struck against</td>
<td>53</td>
<td>21 (40)</td>
<td>23 (43)</td>
<td>0.85 (&lt;0.01)</td>
<td>24 (45)</td>
</tr>
<tr>
<td>Machinery related</td>
<td>52</td>
<td>44 (85)</td>
<td>45 (87)</td>
<td>0.30 (&lt;0.01)</td>
<td>49 (94)</td>
</tr>
<tr>
<td>Motor &amp; road vehicle</td>
<td>44</td>
<td>1 (2)</td>
<td>NA</td>
<td>NA</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Overexertion</td>
<td>40</td>
<td>13 (33)</td>
<td>15 (38)</td>
<td>0.78 (&lt;0.01)</td>
<td>16 (40)</td>
</tr>
<tr>
<td>Cutting &amp; piercing</td>
<td>25</td>
<td>7 (28)</td>
<td>9 (36)</td>
<td>0.82 (&lt;0.01)</td>
<td>9 (36)</td>
</tr>
<tr>
<td>Other &amp; unspecified</td>
<td>17</td>
<td>5 (29)</td>
<td>2 (12)</td>
<td>0.49 (0.02)</td>
<td>5 (29)</td>
</tr>
<tr>
<td>Struck by falling object</td>
<td>14</td>
<td>11 (79)</td>
<td>11 (79)</td>
<td>0.15 (0.57)</td>
<td>13 (93)</td>
</tr>
<tr>
<td>Caught in or between</td>
<td>11</td>
<td>8 (73)</td>
<td>8 (73)</td>
<td>0.54 (0.07)</td>
<td>9 (82)</td>
</tr>
<tr>
<td>Fire, flame, natural, environmental</td>
<td>10</td>
<td>6 (60)</td>
<td>7 (70)</td>
<td>0.78 (0.01)</td>
<td>7 (70)</td>
</tr>
<tr>
<td>Railway, water, air, powered vehicle</td>
<td>6</td>
<td>2 (33)</td>
<td>1 (17)</td>
<td>0.57 (0.12)</td>
<td>2 (33)</td>
</tr>
<tr>
<td>Drowning, suffocation, foreign body in eye, other foreign body</td>
<td>6</td>
<td>3 (50)</td>
<td>3 (50)</td>
<td>1.00 (0.01)</td>
<td>3 (50)</td>
</tr>
<tr>
<td>Explosions, firearms, hot substance, electric current, radiation</td>
<td>6</td>
<td>3 (50)</td>
<td>4 (67)</td>
<td>0.67 (0.08)</td>
<td>4 (67)</td>
</tr>
<tr>
<td>Other poisonings</td>
<td>2</td>
<td>1 (50)</td>
<td>1 (50)</td>
<td>1.00 (0.16)</td>
<td>1 (50)</td>
</tr>
<tr>
<td>Total</td>
<td>370</td>
<td>150 (41)</td>
<td>158 (43)</td>
<td>0.77 (&lt;0.01)</td>
<td>173 (47)</td>
</tr>
</tbody>
</table>
FIGURE 2.1: STUDY POPULATIONS FOR ANALYSIS OF WORK-RELATED HOSPITALISATIONS

40,806 hospitalisation records

3,305 hospitalisation records had principal diagnosis injury and had E codes

1,420 records excluded for being primary non-occupational in nature

Analysis of 1,885 hospitalisation records

1,515 records excluded, as people were not working in sawmills during injury admission

Sub-analysis of 370 hospitalisation records
FIGURE 2.2: AGE AND WORK-RELATED INJURY*

* Other sawmill workers are cohort members who were not working in study sawmills during injury
FIGURE 2.3: AGREEMENT BETWEEN TWO INDICATORS OF THE HOSPITAL DISCHARGE RECORDS TO IDENTIFY WORK-RELATED CASES

Full study population (total=547)  Active sawmill workers (total=173)
2.5 REFERENCES


CHAPTER 3

HOW MANY WORK-RELATED INJURIES REQUIRING HOSPITALIZATION IN BRITISH COLUMBIA ARE CLAIMED FOR WORKERS’ COMPENSATION?2

3.1 INTRODUCTION

The collection, analysis, and dissemination of work-related injury data can provide useful and often essential information for the development of injury prevention strategies. For example, injury surveillance mechanisms can be used to interpret and understand the incidence and patterns of injury, as well as facilitate the design and evaluation of intervention programs at an industrial and government level. However, the validity of many work-related injury surveillance tools has not often been evaluated in terms of capturing pattern and information accuracy.

Workplace compensation claims datasets represent an important source of information on work-related injuries. However, a key concern about the compensation statistics is that they are based on reported and accepted claims only. Several recent studies in the USA [Waller et al., 1989; Frumkin et al., 1995; Stanbury et al., 1995; Biddle et al., 1998; Rosenman et al., 2000] and Canada [Shannon and Lowe, 2002] have identified underreporting of work-related injuries to the compensation systems. Work-related injuries are not always reported to workers’ compensation systems for several reasons, such as discouraging supervisors and coworkers, legal status, job insecurity, high odds of having a claim rejected, procedural complications, unawareness about

2 The chapter has been published under the same title in American Journal of Industrial Medicine 2006; 49(6):443-451. This article is Reprinted with permission of Wiley-Liss, Inc. a subsidiary of John Wiley & Sons, Inc
the system, injury not considered serious enough, and social stigma [Herbert et al., 1999; Rosenman et al., 2000; Azaroff et al., 2002; Shannon and Lowe, 2002]. As well, the workers' compensation system does not compensate every claim that is filed [Stanbury et al., 1995; Herbert et al., 1999].

In addition to workers' compensation claims data, some other surveillance tools for non-fatal work-related injuries have been explored [McCurdy et al., 1991; Hayden et al., 1995; Murphy et al., 1996; van Charante and Mulder, 1998; Morse et al., 2001; Tercero and Andersson, 2004]. Hospital discharge data are a potential source of information on more severe injuries. Work-related injuries reported in a hospital should overcome barriers within organizations that might prevent reporting of such events [Azaroff et al., 2002]. External cause of injury codes and source of payment information are available in hospital discharge records to potentially identify work-relatedness of an injury in British Columbia (BC), Canada [Alamgir et al., 2006]. Since April 1989, the hospitals in BC started coding an additional digit the International Classifications of Disease diagnosis schedule to indicate whether or not the injury was work-related, which enhanced its utility as a work-related injury surveillance system [Alamgir et al., 2006]. Hospital discharge records can be used to efficiently evaluate the pattern and extent of reporting by other surveillance systems, such as workers' compensation, because this data is routinely collected for administrative reasons and is readily available in electronic databases.

The workers' compensation system covers about 90% of workforce in the province of BC [WCB, 1998; British Columbia Statistics, 2005]. Employers are required by law to register their business/firm with the compensation authority and pay premiums. Coverage is usually higher for large, high-risk, and unionized industries and lower for small employers (>3
employees), self-employed individuals, and federal worksites. If a worker is injured while on the job during the course of employment, the compensation authority usually pays for the worker’s medical and wage-loss costs.

This study attempted to determine work-related injury capturing patterns of the workers’ compensation system by investigating the agreement of compensation records and hospital discharge records for a cohort of sawmill industry workers in BC. The injuries admitted to hospitals through urgent and emergency departments are usually acute and severe in nature. Emergency admission is considered to be life/limb threatening and urgent is also serious admission but not life/limb threatening in BC hospitals. It is hypothesized that the compensation system should be sensitive enough to capture most of these work-related injuries. In addition to testing the aforementioned hypothesis, this study examined the extent to which workers’ compensation capturing patterns varied by cause, severity of injuries, and demographic characteristics of workers.

The sawmill industry in BC represents an important workplace setting to investigate the use of hospital discharge records and compensation records for work-related injury surveillance both because of its hazardous work environments and importance to the local economy. A large cohort study on sawmill workers in BC was started in the 1980s to investigate the risk of cancer associated with the use of chlorophenol fungicides and later expanded to examine other health issues in the industry [Hertzman et al., 1997; Teschke et al., 1998]. This study used two study populations: (a) the full study population, which included members who might not be working in sawmills at the time of hospital admission (moved out of the study sawmills at some point during the follow-up period) and (b) active sawmill workers—a sub-set of the cohort members who were working in the study sawmills at the time of hospital admission. This examination of both
populations will be used to determine whether the agreement between the two surveillance systems (i.e., workers' compensation files and hospital discharge records) differed for the active sawmill workers versus the full study population.

3.2 METHODS AND DATA SOURCES

3.2.1 THE SAWMILL COHORT

The BC sawmill full cohort includes 21,301 workers employed for at least 1 year by one of 14 large BC sawmills between 1950 and 1998, who were being followed on or after April of 1989. Demographic records on the cohort members include information on sex, race, and birth date; and work history records includes information on mill, department, start and end of employment, start and end dates of all unique jobs held at the mill, and job descriptions. The study population was followed from April 1989 for health outcomes to the study end date (December 1998), date of death, or date of last observation, which ever occurred earlier.

Hospitalizations from injuries among the full study population (21,301) that occurred while the cohort members were employed in study sawmills, in other sawmills, in another industry, or were out of work were captured. From the work history records, 6,512 cohort members were selected, all of them were working in study sawmills on or after April 1989. Work-related injuries were identified among this group of people who were known to be working in sawmills during the time of injury-related hospital admissions. Hospital discharge records and workers' compensation records from April 1989 to December 1998 were extracted for both study populations [Alamgir et al., 2006].
3.2.2 BRITISH COLUMBIA LINKED HEALTH DATABASE

The British Columbia Linked Health Database (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 physician visits, hospital discharges, deaths, births, as well as extended care, drug usage, and workers’ compensation claims since 1985 [CHSPR, 2004-A]. Use of the data for research purposes is governed by an access policy to protect privacy [CHSPR, 2004-A]. The datasets are linked to a central registry file of all persons in the province covered by the BC Medical Services Plan (MSP) [Chamberlayne et al., 1998]. Almost all eligible residents of BC (over 4.1 million people) are enrolled with MSP [BC Ministry of Health, 2004]. The MSP claims cover insured services submitted by physicians, hospitals, supplementary health care practitioners, and laboratory and diagnostic procedures. As part of previous cohort studies, 19,972 members of the BC Sawmill Cohort Study were linked with their health records using the BCLHD as of April 1989. Among the 6,512 cohort members actively employed on or after April 1, 1989, a total of 5,876 members were linked.

3.2.3 HOSPITAL SEPARATIONS DATA

Work-related injuries using hospital discharge data among this cohort of sawmill workers were captured as part of a prior investigation [Alamgir et al., 2006]. Work-related injury was identified using two indicator variables available. The International Classification of Disease Revision 9 Clinical Modification (ICD-9) scheme includes external codes ("E" codes) that indicate the cause of an injury (e.g., motor vehicle, machinery, fire, etc.) [ICD-9-CM]. Starting in April 1989, hospitals in the Canadian province of BC began to code a fifth digit indicating
whether or not the injury was work-related for certain E Codes (e.g., a fifth digit of 2 indicate mine and quarry as the workplace for an injury). Other provinces in Canada have also been using these codes [CIHI, 1999]. The hospital discharge records also contain a second indicator variable that can be used to capture work-related events. Each injury record has a responsibility for payment schedule, which includes the option of selecting the provincial compensation agency, which is the Worker’s Compensation Board (WCB) in BC. The methods are described by Alamgir et al. [2006].

From prior investigation, a total of 1,885 hospitalization records were extracted for injury diagnosis between April 1989 and December 1998 for the full study population. By using one or the other work-related indicators 547 hospitalizations (29%) were considered work-related. During the same period, there were 370 admission records for active sawmill workers. By either of the two sources, 173 (47%) records were identified as work-related among this group. This analysis excluded work-related hospital admissions which were coded as elective admissions (i.e., only urgent and emergent cases were kept) for both sets of study populations.

The principal diagnosis for the patient’s stay in a hospital was used to designate the nature of an injury. Each hospitalization record was categorized into meaningful broad injury categories (Table 3.1).

3.2.4 WORKERS’ COMPENSATION DATA

The BCLHD has information on all claims reported and compensated by the WCB of BC from the year 1987 onwards [CHSPR, 2004-B]. The claims are classified in terms of level of compensation awarded: health care only, short-term disability, long-term disability or fatality. There were 28,199 claims identified for the sawmill cohort between 1989 and 1998. Injury dates
were available for each claim. Claims with health care only outcomes did not have detailed
injury information. There was detailed information on the injury for the rest of the 8,103 claim
records. This detailed information included ICD-9 codes, source of injury, nature of injury, and
body parts involved. The ICD-9 codes of the WCB records were used to identify claims and
categorize each record into the broad groups of injury (as described in Table 3.1).

3.2.5 LINKING AND MATCHING COMPENSATION CLAIMS DATA AND HOSPITAL
DISCHARGE DATA

For linking the hospital and claim records, injury date, hospital admission and separation
dates, and diagnoses codes in both datasets were reviewed and qualitative assessment rules were
applied. The date of injury recorded in the claim record for an injured individual and the dates of
admission and separation in the hospital record for the same individual was used to link the two
datasets. All linked records for which the date of injury on the compensation claim for an
individual was within the range of 1 month prior to hospital admission date to 1 month after the
hospital separation date were retained. A total of 399 hospital records were linked to claim
records following this strategy. After linking the two datasets, the following decision criteria
were used to consider a claim in the WCB data file as a proper match for an injury record in the
hospital data file. Meeting any of these criteria qualified a record to be a proper match:

* When the injury date reported for a claim was within 1 day of admission date recorded in
  hospital discharge records.
* When the injury diagnosis of both datasets fell under same injury category (as described
  in Table 3.1).
For the records that did not exactly match by injury diagnosis category between the two datasets, the principal ICD-9 diagnosis codes of both files were checked further to resolve minor disagreements. For example, an ICD-9 code of 9223 (contusion of back) in a hospital record and a code of 7245 (backache unspecified) in a compensation claim were considered to be the same injury event.

In addition to the principal diagnosis, the second diagnosis field of the hospital records described another important pre-admission condition of the patient, which usually had a significant influence on the patient's length of stay. For records unmatched by the first three rules, these secondary diagnosis codes of hospital records were checked against compensation records to find additional matches.

Out of the 399 linked records, 391 hospital records were matched as the same event using these decision criteria; 315 records (81%) were matched by decision criterion of 1 day, 23 records (6%) were matched by injury category, and an additional 53 records (13%) claims were matched by the other two criteria.

3.2.6 ANALYSIS PLANS

Each injury record in the hospital discharge records was first identified as work-related or not using the two available indicators, and then was checked as either claimed or not claimed for workers' compensation. The relationship of claim status with demographic characteristics including age, gender, and race of workers, and hospital characteristics including type of admission, e.g., urgent, emergency; level of care, e.g., day care surgery; and length of stay was explored. Chi-square test was performed for statistical significance of categorical variables and a two sample t-tests were performed for comparing means of continuous variables. The agreement
between the hospital and compensation data was also examined for different causes of injury. A Kappa statistic was used to measure the agreement between the two data sources [Maclure and Willett, 1987].

### 3.3 RESULTS

Alamgir et al. [2006] identified a total of 547 hospital records among the full study population as being work-related using the two indicator variables—E codes and responsibility for payment schedule. A total of 458 records were acute events—identified by urgency or emergency nature of admission, and 391 (85%) of these were found to have matched compensation claims (Figure 3.1). The overall agreement on identifying injury events between the hospital discharge records (two indicators combined) and compensation records was good (k=0.84, P<0.01). Among the active sawmill workers, 144 injuries out of 173 hospitalizations were acute in nature. Of these, 129 (90%) were matched to compensation claims (Figure 3.1). The overall agreement between the hospital records (two indicators combined) and compensation records was very good (k=0.87, P<0.01) in this restricted study population.

Table 3.2 illustrates how the two work-related indicators in the hospital discharge records agreed with compensation claims for both study populations. The agreement was better across all identifying categories among the active sawmill workers. Overall, the payment field had better agreement with compensation claims than the E codes for identifying work-related injuries.

Table 3.3 shows important characteristics of claimed and non-claimed work-related acute injuries requiring hospitalization. Workers employed outside of the sawmills at the time of the injury and older individuals were apparently less likely to file claims for their injury. The injuries with longer length of stay were more likely to be claimed to the workers' compensation system.
for the actively employed sawmill workers. Relatively fewer serious injuries, defined by emergency admissions, were not claimed, especially among the actively employed sawmill workers. According to the level of care, injuries requiring day care surgery were more likely to be reported to the compensation system among sawmill workers. Asians, in comparison to the Caucasian population, reported fewer work-related injuries irrespective of their working status in the sawmill industry.

To explore the relationship of admission category and claim filing patterns further, the records were stratified by admission category and their work-related identifying indicators for both populations (Table 3.4). For emergency cases identified as work-related by payment schedule, almost all cases were claimed. The records identified only by E codes but not by payment codes regardless of admission category had poor claim filing patterns. Records identified only by payment codes, but not E codes, for non-emergency admissions also had a poor claim filing pattern.

Table 3.5 presents claiming patterns by broad causes of injury category for both study populations. The most frequent work-related injuries in both populations were machinery related, falls, struck against, and overexertion. In the full study population, among the more frequent categories of injury, more than 90% of work-related hospitalizations for caught in or between, struck by falling object, and machinery related were claimed. Lower claim reporting was observed for work-related hospitalizations involving overexertion; fire, flame, natural & environmental; transportation, and falls.

Among the active sawmill workers, close to 100% work related hospitalization cases for cutting & piercing, caught in or between, machinery-related, struck by falling object had claims filed. Lower claim reporting was observed for overexertion and falls. Relatively higher claiming
patterns were observed for all major injury categories among the population employed in sawmills at the time of injury.

3.4 DISCUSSION

Overall, the agreement on work-related injuries identified by hospital discharge records and compensation records was found to be good in both study populations. This analysis included only injuries that were serious enough to warrant hospitalization, and thus, should have very high claim reporting patterns. However, the study findings suggest that compensation data underreport serious and acute injuries by about 10% even in a population actively working in a large unionized industry in the Canadian province of BC. Claiming patterns of hospitalized work-related injury varied by age, race, admission category, level of care, length of stay, and causes of injury. There were very few women in the study populations; thus, it was not possible to examine differences in claiming patterns by sex.

The reporting patterns across the two available work related indicators in hospital discharge records were investigated, and the underreporting pattern existed for both. For serious and acute injuries, the responsibility of payment, when coded as workers’ compensation, closely represented compensation reporting. Under claiming was more apparent for injuries that were identified only by the external cause of injury codes. All work-related injuries identified only by E codes might not necessarily be work-related injuries as they identified work places; there might be non-work-related injuries in work places. However, the agreement between the two indicators (E codes and payment fields) of hospital records in identifying work-relatedness was found to be good (k=0.75, P<0.01) by the earlier study [Alamgir et al., 2006].
Lower reporting was also found among the non-whites and older people, which might be explained by a lack of their awareness about the compensation system, prior unpleasant experience, higher job insecurity, and greater peer/employer or social pressure. In this study, the more serious injuries, when defined by emergency admission and longer length of stay, had higher claiming patterns.

Underreporting of work-related injuries by the compensation agencies have been widely studied. Herbert et al. [1999] studied patients diagnosed with work-related carpal tunnel syndrome. Of these patients', only 21% were initially not challenged or received responses from insurers. Insurers were more likely to challenge claims filed by non-white, low wage workers, and union members. Rosenman et al. [2000] interviewed mostly unionized automobile workers, diagnosed with known or suspected occupational repetitive trauma and found only 25.1% of them filed compensation claims. Workers who consulted a specialist were eight times more likely to file for claims than those who only visited the company doctor. Morse et al. [2001] interviewed 292 Connecticut residents with work-related musculoskeletal disorder among whom, 20.7% were reportedly covered by workers compensation. Of respondents seen by a general practitioner or a family doctor, 11–12% reported coverage by workers compensation. Waller et al. [1989] studied carpenters with work-related injuries at a Vermont hospital in 1986 and 1987. Of 168 non-self-employed subjects, 37% had their hospital bills covered by workers compensation. Sorock et al. [1993] interviewed 134 former New Jersey hospital patients treated for finger or thumb amputations described as work-related. Of these, 19% were not coded as workers compensation in the payment field of discharge database. A study by Shannon and Lowe [2002], in Canada also found that lower severity of injury was the strongest predictor of not claiming for a work-related injury.
The claim patterns also varied by injury categories. *Falls, struck against,* and especially, *overexertion* had poor reporting patterns. Injuries that are usually more serious in nature, such as *machinery-related, cutting & piercing, caught in or between* were found to have more matching claims in the compensation records.

This study had a number of limitations in its methodology. A 1-month window beyond admission and separation dates was used for the initial linkage strategy. While this captured primarily acute events needing immediate attention, it relied on the accuracy of dates in both the hospital and compensation records. As well, injuries that were admitted to hospital after a long latent period were excluded from our linking strategy. Using date criterion of 1-day difference for final matching between hospitalization and claim records should have captured the same event in both files, as it is highly unlikely for an individual to sustain two different injuries consecutively with a 1-day difference.

A broad injury category rather than exact ICD-9 code was used to match injuries that occurred during the 1-month window between the two data files. This was allowed because the injuries were coded by two different organizations, which should be able to match on broad injury categories but not necessarily on the specifics of the injury. However, an individual might sustain two injuries within the time window, which were of same broad category injury, but were indeed different events. There might be differences in coding accuracy and techniques by the two surveillance systems studied. The hospital records and WCB records had different ways of describing injuries. The WCB provides only one set of ICD-9 codes to describe an injury event; the other injury information they provide including injured body parts and nature of injury, are difficult to verify against other common and standard coding schemes.
The WCB file does not provide information on reported claims that are rejected and not compensated. The WCB does not compensate all claims submitted by injured workers. According to annual statistics, 207,019 new injuries were reported in 1989 and the numbers of claims first paid in that year were 153,545 (74%), and in 1998, 179,582 new injuries were reported in 1989 and the numbers of claims first paid in that year were 144,380 (80%) [WCB,1998]. It was expected that injuries requiring hospitalization should have a higher acceptance rates, and claim filing should have more closely represented compensated claims.

The WCB file does not have detailed information on injuries for health care-only claims; thus, alternative variable, such as dates were used to match for claims. The large study population, who were not necessarily working in sawmills at one time, was different from the second population, who were actively working in sawmills at the time of injury. The latter group, was working full-time in large, unionized organizations, and should have been comprehensively covered by the workers’ compensation system. Higher claim patterns were expected among this group, which the study findings corroborated.

According to these findings, the provincial compensation board underreported serious and acute work-related injuries. Several vulnerable groups of workers and specific injury categories that were associated with greater underreporting were identified. Education and training of the susceptible group of workers on the compensation system and claim filing method might help improve reporting patterns. Also, compensation claims managers should take precautions to handle claims for the specific injury types that are commonly underreported. This study also suggested that the WCB data collection systems should be upgraded with detailed information on all types of injuries irrespective of their severity, and they should follow a more standardized approach of injury coding as recommended by ICD-9, so that, their data can be
effectively used for surveillance. Paying for the costs of hospitalizations for work-related injuries is the financial responsibility of the compensation system and nonpayment by them shifts the burden to other parts of the social safety net (e.g., the publicly funded health care system).

The hospital discharge dataset has more detailed information on the type and severity of injuries than what is traditionally reported and found in WCB datasets. Moreover, this data is gathered outside of the contentious arena of attribution. Depending on coding reliability and validity, hospital discharge data can be a readily available and efficient alternative to provincial compensation body reports for examining serious injury trends and has the potential to be integrated into a comprehensive work-related injury surveillance system in BC. Although BC is unique in terms of comprehensiveness and access to such datasets, it would be feasible to investigate reporting of work-related injuries in other jurisdictions for other types of cohorts or other types of study populations as long as claim and hospitalization datasets have similar coding scheme and are accessible.
TABLE 3.1: INJURY CATEGORY CREATED FROM ICD-9 CODES FOR HOSPITAL DISCHARGE RECORDS AND WORKERS' COMPENSATION CLAIMS

<table>
<thead>
<tr>
<th>Injury Category</th>
<th>Corresponding ICD-9 Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture of skull &amp; intracranium</td>
<td>800-804, 850-854</td>
</tr>
<tr>
<td>Fracture-spine &amp; trunk</td>
<td>805-809</td>
</tr>
<tr>
<td>Fracture-upper limb</td>
<td>810-819</td>
</tr>
<tr>
<td>Fracture-femur</td>
<td>820, 821</td>
</tr>
<tr>
<td>Other fractures-lower limb</td>
<td>822-829</td>
</tr>
<tr>
<td>Dislocation, sprains, strains</td>
<td>830-848</td>
</tr>
<tr>
<td>Internal injury-chest, abdomen, pelvis</td>
<td>860-869</td>
</tr>
<tr>
<td>Open wounds, injuries to blood vessels</td>
<td>870-904</td>
</tr>
<tr>
<td>Superficial injury, contusion with intact skin surface, crushing</td>
<td>910-919, 920-924, 925-929</td>
</tr>
<tr>
<td>Effects of Foreign body entering thru orifice</td>
<td>930-939</td>
</tr>
<tr>
<td>Burns</td>
<td>940-949</td>
</tr>
<tr>
<td>Nerves and spinal cord</td>
<td>950-957</td>
</tr>
<tr>
<td>Traumatic complications, unspecified, others</td>
<td>958, 959, 990-995</td>
</tr>
<tr>
<td>Toxic effects of non-medicinal subs</td>
<td>980-989</td>
</tr>
</tbody>
</table>
TABLE 3.2: AGREEMENT* BETWEEN WORK-RELATED INDICATORS IN THE HOSPITAL RECORDS WITH COMPENSATION CLAIM RECORDS FOR FULL STUDY POPULATION AND ACTIVE SAWMILL WORKERS

<table>
<thead>
<tr>
<th>Hospitalizations identified as work-related by</th>
<th>Full Study population Work-related Hospitalizations (458)</th>
<th>Active Sawmill Workers Work-related Hospitalizations (144)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Matched with WCB claims</td>
<td>Not Matched with WCB claims</td>
</tr>
<tr>
<td>Either E Codes or payment</td>
<td>391 (85%)</td>
<td>67</td>
</tr>
<tr>
<td>E Codes</td>
<td>340 (87%)</td>
<td>53</td>
</tr>
<tr>
<td>Payment</td>
<td>349 (91%)</td>
<td>36</td>
</tr>
<tr>
<td>Both E Codes and payment</td>
<td>298 (93%)</td>
<td>22</td>
</tr>
</tbody>
</table>

Kappa* =0.84, P<0.01

Kappa* =0.87, P<0.01

* Agreement between hospital records (two indicators combined) and WCB claims
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Full Study population</th>
<th>Active Sawmill Workers</th>
<th>P Value</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Work related hospitalization-with matched claims (%)</td>
<td>Work-related hospitalization-without matched claims (%)</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>458</td>
<td>391 (85%)</td>
<td>67 (15%)</td>
</tr>
<tr>
<td></td>
<td>Sex (M/F)</td>
<td>454/4</td>
<td>388/3</td>
<td>66/1</td>
</tr>
<tr>
<td></td>
<td>Race</td>
<td>White</td>
<td>437</td>
<td>375 (86%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asian</td>
<td>21</td>
<td>16 (76%)</td>
</tr>
<tr>
<td></td>
<td>Length of Stay (Median)</td>
<td>3 days</td>
<td>3 days</td>
<td>3 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>41</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Admission Category</td>
<td>Urgent</td>
<td>279</td>
<td>233 (84%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Emergency</td>
<td>179</td>
<td>158 (88%)</td>
</tr>
<tr>
<td></td>
<td>Level of Care</td>
<td>Day Care</td>
<td>56</td>
<td>46 (82%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Surgery</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE 3.4: ADMISSION CATEGORY AND CLAIM FILING OF HOSPITALIZED INJURY RECORDS BY WORK-RELATED IDENTIFYING INDICATORS FOR FULL STUDY POPULATION AND ACTIVE SAWMILL WORKERS

<table>
<thead>
<tr>
<th>Hospitalizations identified as work-related by</th>
<th>Full Study population Work-related Hospitalizations (458)</th>
<th></th>
<th>Active Sawmill Workers Work-related Hospitalizations (144)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Admission Category</td>
<td>With matched claims (%)</td>
<td>Without matched claims</td>
<td>Total</td>
</tr>
<tr>
<td><strong>E Codes</strong></td>
<td>Urgency</td>
<td>201 (86%)</td>
<td>33</td>
<td>234</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>139 (87%)</td>
<td>22</td>
<td>161</td>
</tr>
<tr>
<td><strong>Payment</strong></td>
<td>Urgency</td>
<td>206 (88%)</td>
<td>28</td>
<td>234</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>143 (95%)</td>
<td>8</td>
<td>151</td>
</tr>
<tr>
<td><strong>Payment but not by E Codes</strong></td>
<td>Urgency</td>
<td>32 (71%)</td>
<td>13</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>19 (95%)</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td><strong>E Codes but not by payment</strong></td>
<td>Urgency</td>
<td>27 (60%)</td>
<td>18</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>15 (54%)</td>
<td>13</td>
<td>28</td>
</tr>
<tr>
<td>Cause of Injury (ICD-9 E Codes)</td>
<td>Full Study population Work-related Hospitalizations (458)</td>
<td>Active Sawmill Workers Work-related Hospitalizations (144)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>With matched claims (%)</td>
<td>Without matched claims</td>
<td>Total</td>
<td>With matched claims (%)</td>
</tr>
<tr>
<td>Machinery related (E919)</td>
<td>101 (93%)</td>
<td>8</td>
<td>109</td>
<td>43 (100%)</td>
</tr>
<tr>
<td>Falls (E880-E888)</td>
<td>99 (83%)</td>
<td>20</td>
<td>119</td>
<td>21 (84%)</td>
</tr>
<tr>
<td>Struck against (E917)</td>
<td>34 (87%)</td>
<td>5</td>
<td>39</td>
<td>18 (90%)</td>
</tr>
<tr>
<td>Cutting &amp; piercing (E920)</td>
<td>31 (86%)</td>
<td>5</td>
<td>36</td>
<td>8 (100%)</td>
</tr>
<tr>
<td>Caught in or between (E918)</td>
<td>28 (97%)</td>
<td>1</td>
<td>29</td>
<td>9 (100%)</td>
</tr>
<tr>
<td>Struck by falling object (E916)</td>
<td>26 (93%)</td>
<td>2</td>
<td>28</td>
<td>10 (100%)</td>
</tr>
<tr>
<td>Overexertion (E927)</td>
<td>23 (66%)</td>
<td>12</td>
<td>35</td>
<td>7 (70%)</td>
</tr>
<tr>
<td>Transportation Injury (E800-E807, E810-E838, E840-E848)</td>
<td>17 (81%)</td>
<td>4</td>
<td>21</td>
<td>3 (100%)</td>
</tr>
<tr>
<td>Explosion, firearms, hot substance, electricity (E921-926)</td>
<td>14 (88%)</td>
<td>2</td>
<td>16</td>
<td>2 (67%)</td>
</tr>
<tr>
<td>Fire, Flame, Natural &amp; Environmental (E890-E909)</td>
<td>10 (63%)</td>
<td>6</td>
<td>16</td>
<td>4 (57%)</td>
</tr>
<tr>
<td>Other Poisonings (E860-E869)</td>
<td>4 (100%)</td>
<td>0</td>
<td>4</td>
<td>1 (100%)</td>
</tr>
<tr>
<td>Drowning, suffocation, foreign body (E910-915)</td>
<td>4 (100%)</td>
<td>0</td>
<td>4</td>
<td>3 (100%)</td>
</tr>
<tr>
<td>Other &amp; unspecified (E928)</td>
<td>0 (0%)</td>
<td>2</td>
<td>2</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Total</td>
<td>391 (85%)</td>
<td>67</td>
<td>458</td>
<td>129 (90%)</td>
</tr>
</tbody>
</table>
FIGURE 3.1: CASE IDENTIFICATION OF WORK-RELATED HOSPITALIZATION IN SAWMILL WORKERS

Full Study Population

1,885 injury hospitalizations

547 identified as work-related hospitalizations

458 work-related acute hospitalizations

399 hospitalizations linked to compensation claims within 1 month of admission or separation date

391 hospitalizations matched within 1 day of admission date and/or type of injury

Active Sawmill Workers

370 injury hospitalizations

173 identified as work-related

144 work-related acute hospitalizations

141 hospitalizations linked to compensation claims within 1 month of admission or separation date

129 hospitalizations matched within 1 day of admission date and/or type of injury
3.6 REFERENCES


CHAPTER 4

ACCURACY OF INJURY CODING IN A CANADIAN WORKERS' COMPENSATION SYSTEM

4.1 INTRODUCTION

Information on work-related injuries filed for compensation are routinely collected and coded by the workers' compensation systems. Workers' compensation data have been used by health services and population health researchers to study the incidence, epidemiology, outcomes and costs of work-related injury, and also to investigate the effectiveness, appropriateness, and utilization of the services provided by compensation systems [McCall et al., 2006; Horwitz et al., 2005; Scherzer et al., 2005; Boufous et al., 2003; Islam et al., 2001]. The use of workers' compensation data for research purposes is based, however, on the assumption that it provides reasonably valid information on injury related diagnoses. Evaluation of the validity of the workers' compensation system dataset is imperative because this data source provides the most comprehensive source of information on work-related injuries to date.

Hospital discharge records in the Canadian province of British Columbia (BC) have the potential to be a useful data resource for injury surveillance because of the public health care system in Canada and the comprehensive coverage of hospitalizations at the population level. Hospital discharge data is also a potential source of information on serious work-related injuries. External cause of injury codes (E-codes) of the International Classifications of Disease and source of payment information are available in hospital discharge records to identify the work-

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3 The chapter is currently under review for publication in Journal of Occupational Health & Safety Australia and New Zealand under the same title.
relatedness of an injury hospitalization in British Columbia (BC), Canada [ICD-9; Alamgir et al., 2006]. Since April 1989, the hospitals in BC started coding an additional digit to the ICD-9 schedule that enhanced its utility as a work-related injury surveillance system [Alamgir et al, 2006]. It is expected that most of the work-related injury cases that are hospitalized should have been compensated and have matching claims in the workers’ compensation datasets. Thus, hospital discharge records provide an opportunity to evaluate the injury coding patterns of the workers’ compensation system for serious injuries reaching hospitals.

The validity of the injury related diagnostic codes of the workers’ compensation dataset was assessed in this study using the hospital discharge dataset as the comparative standard. The injuries admitted to hospitals through urgent and emergency departments are usually more acute in nature. We, therefore, hypothesized that the compensation system codes should agree with the hospital diagnosis codes for these work-related injuries. This study also examined the agreement of the injuries by body parts involved between these two data sources.

The study population for this study was a large cohort study of BC sawmill workers that was started in the 1980’s to investigate the risk of cancer associated with the use of Chlorophenol fungicides and later expanded to examine other health issues in the industry [Hertzman et al., 1997; Teschke et al., 1998].

4.2 METHODS AND DATA SOURCES

Hospital discharge records and workers’ compensation records for this study 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 (CHSPR). It contains datasets recording physician visits, hospital discharges, deaths, births, as well as extended care, drug usage, and workers’
compensation claims since 1985 [CHSPR, 2005]. The datasets are linked to a central registry file of all persons in the province covered by the BC Medical Services Plan (MSP) [CHSPR, 2005]. Almost all eligible residents of BC (over 4.1 million people) are enrolled with the provincial Medical Services Plan (MSP) [BC Ministry of Health, 2005]. The MSP processes claims for insured services submitted by physicians, supplementary health care practitioners, hospitals, laboratory services and diagnostic procedures [BC Ministry of Health, 2005].

As part of previous investigations, among the 6,512 cohort members actively employed on or after April 01, 1989, a total of 5,876 members were linked with their health records using the BCLHD as of April 01, 1989. Hospitalization records were extracted for this study population and identified as work-related or not. These were identified as work-related using ICD-9 external cause of injury codes that indicate place of occurrence, and the responsibility of payment schedule, which identifies workers' compensation as being responsible for payment. The methods are described by Alamgir and colleagues [2006].

The principal ICD-9 diagnosis for the patient's stay in a hospital was used to designate the nature of the injury, and each hospitalization record was then categorized into meaningful broad nature of injury categories. The principal ICD-9 codes were also used to identify the exact body parts involved in an injury. The body parts were also categorized into meaningful broad body part categories. For example, an ICD-9 code of 801 is a fracture of base of skull. The nature of injury is fracture of head and the body part is head.

The BCLHD has information on all claims reported and compensated by the Workers' Compensation Board of BC (WCB) from the year 1987 onwards [CHSPR, 2004]. Claim records have information on injury date, ICD-9 codes, source of injury, nature of injury, and the body
parts involved. To compare with hospital data, the reported ICD-9 codes and body parts of the WCB records were also categorized into similar broad nature of injury and body parts categories.

To identify the claim record for a particular hospitalized injury event, the claim records for this study population were extracted from 1989 to 1998. The date of injury recorded in the claim record for an injured individual and the dates of admission and separation in the hospital record for the same individual was used to link these two datasets. For an individual, if the date of injury of the claim record fell within the range of one week prior to hospital admission date to one week after the hospital separation date, it was considered the same injury event. For example, if the hospital admission and separation dates were April 8 and April 18, a claim record with an injury date recorded anywhere between April 1 and April 25 would be considered the same injury event.

The ICD-9 codes of both the hospital discharge database and compensation claims database were studied by exact ICD-9 diagnosis four digits codes, by 3 digits, then by 2 digits, and finally, by the broad nature of injury. The body sites were also investigated. Holding the hospital discharge records as the standard, sensitivity, specificity, positive and negative predictive values of the compensation records were calculated. Kappa was also calculated to measure the agreement between both data sources [Sim and Wright, 2005]

4.3 RESULTS

A total of 1,595 urgent and emergent hospitalization records were extracted for injury diagnosis between April 1989 and December 1998 for this study population. By using the two indicator variables- E codes and responsibility for payment schedule, 458 hospitalizations (29%)
were identified as work-related. A total of 333 (73%) of these were found to have matched compensation claims by 1 week window.

4.3.1 AGREEMENT BY NATURE OF INJURY

Between the compensation claims data and hospital discharge data, a total of 107 records matched on the 4 digit ICD-9 code (32%); whereas 162 matched on the 3 digit ICD-9 code (49%). Also, a total of 228 records matched on the 2 digit ICD-9 code (69%). When compared by injury characteristics, 232 injury events matched on nature of injury (70%). Table 4.1 shows the frequency of the injuries and agreement statistics by the two data sources based on the broad injury category.

The workers’ compensation claims only agreed with the hospitalization database for 1 of 9 (11%) of internal injury of thorax, abdomen & pelvis and injuries of nerves & spinal cord and 5 of 18 (28%) of the traumatic complications, non-medicinal substances, unspecified & other injuries. Also, only 78% of the cases of fracture of lower limbs were reported by the workers’ compensation database. In contrast, the compensation database detected 34 (136%) more cases of superficial injury, contusion & crushing injuries than the hospitalization database.

To determine the extent to which the hospitalization database and the compensation claims database identified the same injury cases (i.e., inter-database agreement), we computed kappa for each of the conditions. The highest level of agreement ($\kappa = 0.97$) was found for burns, with excellent agreement for fracture of lower limbs. The lowest level of agreement was found for internal injury of thorax, abdomen & pelvis and injuries of nerves & spinal cord; superficial injury, contusion & crushing and traumatic complications, non-medicinal substances,
unspecified & others. The levels of agreement were good (0.63-0.74) for the remaining conditions.

Assuming the hospitalization database correctly identified the conditions as being present or absent, sensitivity, specificity, and predictive values were calculated (Table 4.1). The results indicate that the compensation database was most likely to identify burns when the hospitalization database indicates they were truly present (sensitivity). Conversely, the compensation database was least likely to identify traumatic complications, non-medicinal substances, unspecified & other injuries and failed to identify internal injury of thorax, abdomen & pelvis; and injuries of nerves & spinal cord.

The positive predictive values for fracture of lower limbs and burns were more than 90%, indicating good evidence of these conditions when these were coded as such in the compensation database relative to the hospitalization source of information.

4.3.2 AGREEMENT BY THE BODY PARTS OF INJURY

Table 4.2 shows the prevalence of injury categories by body parts for the two data sources. Compared to hospitalization database, the compensation database detected only 70% of shoulder & arm injuries and 80% of trunk, back & groin injuries. It captured about 90% head, face & neck and leg, knee & ankle injuries. In contrast, the compensation database detected 11 more hand & finger injuries (10%) and 11 more other body parts injuries (30%) than the hospitalization database.

The highest level of agreement ($\kappa = 0.86$) was found for leg, knee & ankle injuries, with very good agreement for hand & finger and head, face & neck injuries. The lowest level of agreement was found for shoulder & arm and other body parts injuries.
Assuming the hospitalization database correctly identified the conditions as being present or absent, sensitivity, specificity, and predictive values were calculated (Table 4.2). The results indicate that the compensation database were most likely to identify hand/finger injuries when the hospitalization database indicates they were truly present (sensitivity). Conversely, the compensation database was least likely to identify shoulder/arm injuries.

The positive predictive value for leg, knee & ankle; head, face & neck, hand & finger and trunk, back & groin were more than 80%, indicating good evidence of these conditions when these were coded in the compensation database relative to the hospitalization source of data.

4.4 DISCUSSION

This study, to our knowledge, is the first to evaluate the accuracy of injury coding in the compensation data among a population of injured workers admitted to hospitals. The results indicate that the overall agreement of injury coding between the compensation dataset and hospitalization dataset was good; Kappa was 0.63 for nature of injury and 0.71 for body parts. Kappa measured the amount of agreement beyond what is expected due to chance alone [Sim and Wright, 2005]. This study encourages the use of compensation datasets for occupational epidemiology and injury surveillance investigations. This support is stronger for more acute and sharp injuries such as burns and fracture of lower limbs and weaker for injuries such as superficial injury, contusion & crushing; internal injury of thorax, abdomen & pelvis and injuries of nerves & spinal cord and traumatic complications, non-medicinal substances, unspecified & others. For body parts, high level of agreement was found for leg, knee & ankle, hand & finger and head, face & neck and low level of agreement was found for shoulder & arm and other body parts injuries.
The hospitalization database was used as the standard to compare the claim database in our study as the reliability and validity of hospital records were favorably examined previously by some studies [Vestberg et al., 1997; Rawson and Malcolm, 1995; Kashner, 1998; Beghi et al., 2001]. Claim records are usually more concerned about cost information and industry of employment fields because these are used to determine employer payments/premiums and the other fields are secondary for statistics and report generation, and as a result, there is less incentive to be exact compared to hospitalizations in injury diagnosis.

Like any other administrative dataset, errors could occur in the process of creating the workers' compensation dataset as a result of physicians' misdiagnoses, incomplete documentation of clinical information, or coders' incomplete or miscoding of diagnoses [Johantgen et al., 2004; MacIntyre et al., 1997; Hawker et al., 1997; Tamblyn et al., 2000; Quan et al., 2004]. Also, there could be multiple organs affected in some injury events making the coding of one primary reason or site very difficult.

This study had a number of limitations in its methodology. A one-week window beyond admission and separation dates was used for the linkage strategy. While this captured primarily acute events needing immediate attention, it relied on the accuracy of dates in both the hospital and compensation records. As well, injuries that were admitted to hospital after a long latent period were excluded from our linking strategy. Using date criterion of one-week difference for matching between hospitalization and claim records should more likely capture the same event in both files as it is highly unlikely for an individual to sustain two different injuries in a row within this short period. However, if we used a narrower time window, the agreement should have improved.
This study was not also able to describe the reasons why injuries of some nature and body parts were associated with low level of agreement between the two data sources. Limited studies done in this area restricted further interpretations. Another limitation was that all injuries studied here were sawmill injuries. Using a larger study population comprising of workers from other industrial sectors would have been able to study other types of injuries, and provide more support to the findings on validity of injury coding in the claims datasets.

A broad injury category rather than exact ICD-9 code was used to match injuries between the two data files in this study. This was allowed because the injuries were coded by two different organizations; this should allow for a match on broad injury categories but not necessarily on the specifics of the injury. As was expected the agreement was the best for broad injury category, then gradually decreased for comparison of the specific ICD9 codes from 2 digits to 4 digits.

The WCB provides other injury information that is difficult to verify against sources like hospitals which use more standard coding schemes. It was not possible to match cases by causes of injury, as the causes available in the compensation databases were very different from the standard ICD-9 external cause of injury codes. The cause of injury categories created by using the ICD-9 external cause codes from hospital discharge database were *falls, struck by falling object, caught in or between, cutting & piercing, cutting and piercing*, etc., whereas, the compensation systems categorized injures based on contacts with *animals (live), boxes, containers, glass items, liquids, trees, plants, working surfaces*, etc.

It should be kept in mind that this study was undertaken independently of the workers' compensation or medical care system and without any prior agreement regarding definitions for coding information in the two data sources. Discrepancies are thus likely to occur. The ultimate
gold standard for comparison would be clinical data collected prospectively in accordance with rigorous, *a priori* definitions as occur in the setting of a clinical trial. Despite the favorable comparison between data from the hospitalization database and compensation databases, this study cannot establish the true validity of clinical data from the compensation databases because hospitalization database is not the perfect gold standard, but the agreement between these two independent sources of data lends some credence to the clinical information that can be ascertained from claim records.

The validity of injury diagnosis in administrative datasets has been studied before, and in most previous studies, the comparator group was not another set of administrative data but rather patient charts or surveys [Johantgen et al., 2004; MacIntyre et al., 1997; Hawker et al., 1997; Tamblyn et al., 2000; Quan et al., 2004].

The accuracy of diagnostic codes for workers’ compensation system has rarely been investigated before. However, workers compensation database should follow a more standardized approach of injury coding as recommended by ICD-9 or ICD-10, so that their datasets can be more effectively used for surveillance and compared with other readily available data sources.

The structure and operation of provincial hospitalization databases across Canada are similar. All provinces and territories follow guidelines from the Canadian Institute of Health Information [CIHI, 2006]. The workers’ compensation datasets of other provinces also follow similar coding scheme [AWCBC, 2006]. It is, therefore, likely that findings like these on coding accuracy have wider generalizability across Canada.
TABLE 4.1: MEASURES OF AGREEMENT BETWEEN COMPENSATION CLAIMS DATA AND HOSPITAL DISCHARGE DATA BY NATURE OF INJURY

<table>
<thead>
<tr>
<th>Nature of injury</th>
<th>Frequency in Hospital Data</th>
<th>Frequency in Compensation data</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive Predictive Value</th>
<th>Negative Predictive Value</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open wounds</td>
<td>76 (22.8)</td>
<td>73 (21.9)</td>
<td>0.76</td>
<td>0.94</td>
<td>0.79</td>
<td>0.93</td>
<td>0.72*</td>
</tr>
<tr>
<td>Fracture of lower limbs</td>
<td>64 (19.2)</td>
<td>50 (15)</td>
<td>0.75</td>
<td>0.99</td>
<td>0.96</td>
<td>0.94</td>
<td>0.81*</td>
</tr>
<tr>
<td>Fracture of upper limbs</td>
<td>53 (15.9)</td>
<td>53 (15.9)</td>
<td>0.74</td>
<td>0.95</td>
<td>0.74</td>
<td>0.95</td>
<td>0.69*</td>
</tr>
<tr>
<td>Spine &amp; trunk</td>
<td>46 (13.8)</td>
<td>48 (14.4)</td>
<td>0.70</td>
<td>0.94</td>
<td>0.67</td>
<td>0.95</td>
<td>0.63*</td>
</tr>
<tr>
<td>Dislocation, sprains &amp; strains</td>
<td>27 (8.1)</td>
<td>28 (8.4)</td>
<td>0.78</td>
<td>0.98</td>
<td>0.75</td>
<td>0.98</td>
<td>0.74*</td>
</tr>
<tr>
<td>Superficial injury, contusion &amp; crushing</td>
<td>25 (7.5)</td>
<td>59 (17.7)</td>
<td>0.60</td>
<td>0.86</td>
<td>0.25</td>
<td>0.96</td>
<td>0.28*</td>
</tr>
<tr>
<td>Burns</td>
<td>15 (4.5)</td>
<td>16 (4.8)</td>
<td>1.00</td>
<td>1.00</td>
<td>0.94</td>
<td>1.00</td>
<td>0.97*</td>
</tr>
<tr>
<td>Traumatic complications, non-medicinal substances, unspecified &amp; others</td>
<td>18 (5.4)</td>
<td>5 (1.5)</td>
<td>0.22</td>
<td>1.00</td>
<td>0.80</td>
<td>0.96</td>
<td>0.33*</td>
</tr>
<tr>
<td>Internal injury of thorax, abdomen &amp; pelvis; Injuries of nerves &amp; spinal cord</td>
<td>9 (2.7)</td>
<td>1 (0.3)</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.97</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>333</strong></td>
<td><strong>333</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.64 *</td>
</tr>
</tbody>
</table>

* Statistical significance at 95% level
### TABLE 4.2: MEASURES OF AGREEMENT BETWEEN COMPENSATION CLAIMS DATA AND HOSPITAL DISCHARGE DATA BY BODY PARTS

<table>
<thead>
<tr>
<th>Body Parts</th>
<th>Frequency in Hospital Data</th>
<th>Frequency in Compensation data</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive Predictive Value</th>
<th>Negative Predictive Value</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand &amp; Finger</td>
<td>110 (33)</td>
<td>121 (36.3)</td>
<td>0.94</td>
<td>0.92</td>
<td>0.85</td>
<td>0.97</td>
<td>0.84 *</td>
</tr>
<tr>
<td>Leg, Knee &amp; Ankle</td>
<td>82 (24.6)</td>
<td>75 (22.5)</td>
<td>0.85</td>
<td>0.98</td>
<td>0.93</td>
<td>0.95</td>
<td>0.86 *</td>
</tr>
<tr>
<td>Trunk, Back &amp; Groin</td>
<td>50 (15)</td>
<td>40 (12)</td>
<td>0.64</td>
<td>0.97</td>
<td>0.80</td>
<td>0.94</td>
<td>0.67 *</td>
</tr>
<tr>
<td>Head, Face &amp; Neck</td>
<td>44 (13.2)</td>
<td>42 (12.6)</td>
<td>0.82</td>
<td>0.98</td>
<td>0.86</td>
<td>0.97</td>
<td>0.81 *</td>
</tr>
<tr>
<td>Shoulder &amp; Arm</td>
<td>10 (3)</td>
<td>7 (2.1)</td>
<td>0.30</td>
<td>0.99</td>
<td>0.43</td>
<td>0.98</td>
<td>0.34 *</td>
</tr>
<tr>
<td>Other body parts</td>
<td>37 (11.1)</td>
<td>48 (14.4)</td>
<td>0.38</td>
<td>0.89</td>
<td>0.29</td>
<td>0.92</td>
<td>0.23 *</td>
</tr>
<tr>
<td>Total</td>
<td>333</td>
<td>333</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.71 *</td>
</tr>
</tbody>
</table>

* Statistical significance at 95% level
4.6 REFERENCES


Accessed January 30, 2006


Accessed January 30, 2006


CHAPTER 5
COSTS AND COMPENSATION OF WORK-RELATED INJURIES IN BRITISH COLUMBIA SAWMILLS

5.1 INTRODUCTION

Severe and non-fatal injuries often require hospitalization. These injuries have the highest potential of resulting in both short and long-term disability, and are among the most costly of all injuries from an economic perspective. When injuries requiring hospitalizations are work-related, they typically involve substantial losses of productivity for the injured worker. Cost of injury studies 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 [Koopmanschap, 1998; Weil, 2001]. Costs of work-related injuries in the USA have been studied within states [Leigh et al., 2001], across states [Waehrer et al., 2004], across industries [Leigh et al., 2004], and within the health services sector [Waehrer et al., 2005], 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 [Shannon and Lowe, 2002; WCB, 2005-A]. Therefore, it is

4 The chapter is currently under review for publication in Occupational and Environmental Medicine under the same title.
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 reveal the magnitude of the burden shifted to other social safety systems.

Hospital discharge records from provincial health care providers can be a useful resource for serious injury surveillance because the public health care system in Canada provides comprehensive coverage of hospitalizations at the population level. We use data from British Columbia (BC) to illustrate its potential. Almost all eligible residents of BC (over 4.1 million people) are enrolled with the provincial Medical Services Plan (MSP) [BC Ministry of Health, 2005]. The MSP captures all medical services records of physicians, specialists, other health care practitioners, laboratory services, and diagnostics services and hospitalizations. 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 hospitalization [Alamgir et al., 2006-A]. Since April 1989, hospitals in BC started coding an additional digit to the International Classifications of Disease diagnosis schedule that enhanced its utility as a work related injury surveillance system [Alamgir et al., 2006-A].

Most employers in BC are required by law to register their business/firm with the workers' compensation system and pay premiums [WCB, 2005-B]. Employer coverage is usually more comprehensive for large, high-risk, and unionized 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 [WCB, 2005-A]. The compensation system also provides pension benefits to permanent disabled workers [WCB, 2005-A].

Sawmills in British Columbia provide an important work-setting to study the costs of work-related injury as this sector is large and unionized, contributes significantly to the economy of the province, 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 BC, initiated in the 1980's to investigate the risk of cancer associated with the use of Chlorophenol fungicides [Hertzman et al., 1997], and later expanded to investigate a wide variety of occupational health issues in the forest industry [Teschke et al., 1998].

The objectives of this study were to assess the costs of serious work-related injuries requiring hospitalization amongst the active sawmill workers in British Columbia during 1989-1998 from the perspective of the workers' compensation insurer. We estimated both workers' compensation costs paid by the compensation system and those costs that should have been paid but were not (i.e., the hospital discharge cases not identified in the workers' compensation records).

5.2 METHODS AND DATA SOURCES

The current investigation examined a sub-set of the full BC sawmill cohort, who were actively working in the study sawmills at the time of a 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 physician visits, hospital discharges, deaths, births, as well as extended care, drug usage, and workers' compensation claims since
1985 [CHSPR, 2004]. The datasets are linked to a central registry file of all persons in the province covered by the BC Medical Services Plan [Chamberlayne et al., 1998].

As part of previous investigations [Alamgir et al., 2006-A], we were able to link 5,876 of 6,512 cohort members (90.3%) actively employed in sawmills on or after April 01, 1989, with their medical services and hospitalization records using the BCLHD. Work-related injuries were captured among these sawmill workers using the hospital discharge dataset. Hospitalization records were identified as work-related using ICD-9 external cause of injury codes that indicate 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 [2006-A].

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

The BCLHD has information on all injuries and illnesses compensated by the workers' compensation agency of BC [CHSPR, 2004]. Claim records had information on injury date, 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 hospitalization records by worker study identifier, injury date 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 [Alamgir et al., 2006-B]. For each matched injury claim, comprehensive compensation cost data for up to 7 years was collected directly from the WCB.
The claim cost information was classified by type of compensation benefits: health care only, short-term disability (time-loss), long-term disability (permanent disability), vocational rehabilitation and fatality.

As noted, costs were calculated from the workers' compensation agency perspective. Costs incorporated in the analysis include short 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. All costs were converted into constant Canadian dollars with 1995 as the base using the provincial general consumer price index (CPI) for the non-healthcare costs and medical consumer price index for the healthcare costs [Drummond et al., 1997]. A 5% discounting rate was applied to adjust for the time value of money and all values were discounted to 1995 [Drummond et al., 1997]. 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 by cause and nature of injury. The portion of costs that the workers' compensation agency did not appear to compensate were also reported.

5.3 RESULTS

For the 5,876 active sawmill workers, there were 370 injury hospitalization events captured between 1989 and 1998. By either of the two indicators (E Codes or payment schedules), 173 (47%) of the hospitalizations were identified as work-related. Of these 173 hospitalizations, 136 (79%) were matched to a compensation claim. Thus, 37 (21%) of the work-related injuries requiring hospitalization were not matched to a workers' compensation claim.
Approximately 95% of the work-related injuries requiring hospitalization resulted in a short-term-disability claim and about one-half of the injuries also resulted in a long-term disability claim (calculations excludes the 37 that were not in the WCB records). However, only 13% of the 136 hospitalized injuries required vocational rehabilitation. Figure 5.1 shows claim outcome categories by cause and nature of work-related injury. About 89% of caught in or between, 75% of fire, flame, natural & 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 5.1 lists the median and total costs for all 173 work-related injuries requiring hospitalization among this study population stratified by compensation benefit category. 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); they were also associated with the highest median costs.

Table 5.2 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 & 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 health care 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 remained the most costly category for nature of injury for both non-health care and health care costs.

Figure 5.2 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-health care costs and $200,588 (11.4%) of healthcare costs. In total $1,075,459 (9%) was not compensated by the workers’ compensation system.

5.4 DISCUSSIONS

This study described costs and compensation patterns of work-related serious injuries requiring hospitalization among the sawmill workers in British Columbia. We estimated costs using data from the provincial compensation system for healthcare (medical services) and non-health care services (vocational rehabilitation, permanent disability payments and lost-time payments). Our study found median non-health care costs of $16,559 and healthcare costs of $4,377 per injury and total non-health care costs of $10,374,115 and healthcare costs of $1,764,137. Comparison of cost statistics across studies is very difficult because of 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 and colleagues [2004] estimated occupational injury costs per worker across states in the USA. Analysis was conducted on injury data from the Bureau of Labor Statistics and costs data from workers’ compensation records. In the state of Washington, the costs of nonfatal cases with at least 1 day of work loss per employee was found to be $864. Eastridge and colleagues [2006] analyzed costs of motorcycle related injuries in Texas and estimated charges of $36,334 - $39,390 per injury. Sorensen and colleagues [2006] studied the economic consequences of nursing home falls in the USA. The most costly was fall category with multiple injuries, which accounted for $22,368.
Rautiainen and colleagues [2005] aimed to determine the cost burden from compensated injuries in Finnish agriculture using workers compensation records. The mean cost of 1996 injury cases was estimated at Euro 1,340. Small and colleagues [2006] examined the demographics, injury profile, and cost of pedestrian accidents in a central city hospital in Sydney. The average length of stay was 13.4 days costing $A 16,320 per admission. Singh and colleagues [2006] studied head injuries through a prospective 6-month study to evaluate the expenditure incurred on head injury patients in a modern neurosurgical center in India. The total expenditure in minor head injury was Rs. 7,800 per patient, in moderate head injury was Rs. 22,172 per patient, whereas in severe head injury, it was found to be Rs. 32,852 per patient. Patients who underwent surgery, the total cost incurred was Rs. 33,100 per operated patient. [1 Indian rupee = 0.02 U.S. dollars]

Nilsen and colleagues [2006] reviewed studies that calculated injury costs. Based on 12 studies that met the inclusion criteria, the average total cost per injury case was found USD $3,536, while 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 or spouse/family members; ambulance fees, retraining, recruiting, and overtime costs for the employers [Weil, 2001; Drummond et al., 1997]. While 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 [Drummond et al., 1997], there was insufficient information available for us to consider all costs in this study. The WCB covered health care costs for a compensated injury including the medical services and supplies required
to help the worker recover from a compensable injury [WCB, 2005-A]. Long-term disability costs apply to work-related injury or disease that permanently disables a worker [WCB, 2005-A]. The WCB covered vocational rehabilitation program helps disabled workers get back to work after a compensable injury [WCB, 2005-A]. Thus, the WCB covers some important cost components associated with an injury. The costs captured in this study included these 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, preventing only one burn injury could save about $54,000 for the compensation agency. As well, our findings suggest a prevention focus on open wounds, machinery related and fire & environmental causes are a key area to focus on if a significant reduction in work-related injury burden is being sought.

According to the workers' compensation board statistics, there were 28,950 full-time equivalent sawmill workers with insurance coverage in BC in 1997 who sustained a total of 1,737 time-loss injuries at work [WCB, 2005-C]. If we assume that all time-loss injuries resulted in hospitalization and were similar in costs, according to our findings, based on 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 very close to the official costs.

The strength of this study was the use of a readily available and large administrative datasets. Our study also captured actual compensated costs for each claim rather than estimating these from secondary sources or using average claim costs. This study used distinct CPI indexes for healthcare costs and non-healthcare costs for BC province 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% through 7% would also result in substantial cost burdens.

This study had a number of limitations in its methodology. It captured only serious injuries resulting in hospitals; less serious injuries amongst the study population were not captured. Thus, the costs were not comprehensive for all 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 hospitalization. We acknowledge that there might be some inaccuracies in the linking methodology to extract the right claims for the hospitalization cases resulting in mismatches. Cost information 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, it is likely that major costs were developed within the first 7 years after an injury event.

Research on the cost of workplace injury plays an important role in many aspects of industrial hygiene initiatives. Knowing all the associated costs and the causes and nature of costly injuries will be helpful to 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 within 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 likely covered by the provincial health care system.
## TABLE 5.1: COSTS* FOR ALL (173) WORK-RELATED INJURIES REQUIRING HOSPITALIZATION AMONG ACTIVE SAWMILL WORKERS

<table>
<thead>
<tr>
<th>Claim type (number)</th>
<th>Median cost (Range)</th>
<th>Total cost (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare</td>
<td>4,377 [493-96,920]</td>
<td>1,764,137 (15%)</td>
</tr>
<tr>
<td>Short-term Disability</td>
<td>13,254 [204-142,380]</td>
<td>3,490,051 (29%)</td>
</tr>
<tr>
<td>Long-term Disability</td>
<td>34,203 [1,754-721,790]</td>
<td>6,506,373 (54%)</td>
</tr>
<tr>
<td>Vocational rehabilitation</td>
<td>10,732 [39-83,357]</td>
<td>377,690 (3%)</td>
</tr>
<tr>
<td>Total</td>
<td>19,506 [493-919,726]</td>
<td>12,138,252</td>
</tr>
</tbody>
</table>

*All costs in 1995 constant Canadian dollar and costs imputed for 37 hospitalizations not linked to a claim.
### TABLE 5.2: COSTS* BY CAUSE AND NATURE OF INJURY FOR 173 WORK-RELATED INJURIES AMONG ACTIVE SAWMILL WORKERS

<table>
<thead>
<tr>
<th>Cause of Injury (Number)</th>
<th>Median Non-healthcare costs [range]</th>
<th>Median healthcare costs [range]</th>
<th>Total Non-healthcare costs (%)</th>
<th>Total healthcare costs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire, Flame, Natural &amp; Environmental (7)</td>
<td>189,768 [2,332-458,024]</td>
<td>33,276 [1,819-77,737]</td>
<td>1,205,313</td>
<td>222,439</td>
</tr>
<tr>
<td>Machinery related (49)</td>
<td>26,480 [0-372,567]</td>
<td>6,643 [493-60,923]</td>
<td>2,667,333</td>
<td>494,666</td>
</tr>
<tr>
<td>Cutting &amp; piercing (9)</td>
<td>24,706 [5,116-354,008]</td>
<td>9,450 [1,024-69,405]</td>
<td>797,005</td>
<td>151,655</td>
</tr>
<tr>
<td>Caught in or between (9)</td>
<td>24,130 [6,793-667,183]</td>
<td>4,389 [538-26,163]</td>
<td>1,015,909</td>
<td>78,421</td>
</tr>
<tr>
<td>Struck against (24)</td>
<td>12,667 [0-352,351]</td>
<td>5,741 [527-33,276]</td>
<td>1,066,883</td>
<td>208,781</td>
</tr>
<tr>
<td>Overexertion (16)</td>
<td>7,801 [0-68,770]</td>
<td>2,710 [1,031-28,145]</td>
<td>167,791</td>
<td>65,746</td>
</tr>
<tr>
<td>Other cause of injury** (16)</td>
<td>7,801 [487-204,925]</td>
<td>2,710 [569-44,208]</td>
<td>520,876</td>
<td>100,234</td>
</tr>
<tr>
<td>Total (173)</td>
<td>16,559</td>
<td>4,377</td>
<td>10,374,115</td>
<td>1,764,137</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nature of Injury (Number)</th>
<th>Median Non-healthcare costs [range]</th>
<th>Median healthcare costs [range]</th>
<th>Total Non-healthcare costs (%)</th>
<th>Total healthcare costs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open wounds (35)</td>
<td>51,517 [0-354,008]</td>
<td>9,967 [849-60,923]</td>
<td>2,713,382</td>
<td>399,815</td>
</tr>
<tr>
<td>Burns (9)</td>
<td>48,023 [2,332-458,024]</td>
<td>5,954 [1,819-77,737]</td>
<td>1,270,825</td>
<td>241,144</td>
</tr>
<tr>
<td>Fracture - lower limb (23)</td>
<td>22,439 [8,682-208,266]</td>
<td>5,794 [1,617-29,644]</td>
<td>1,198,338</td>
<td>207,397</td>
</tr>
<tr>
<td>Fracture of Head &amp; trunk (23)</td>
<td>9,200 [0-822,806]</td>
<td>5,534 [527-96,920]</td>
<td>2,365,076</td>
<td>332,780</td>
</tr>
<tr>
<td>Dislocation, sprains, strains (35)</td>
<td>7,801 [0-166,564]</td>
<td>2,710 [686-28,145]</td>
<td>464,752</td>
<td>120,957</td>
</tr>
<tr>
<td>Other nature of Injury*** (9)</td>
<td>4,790 [0-189,768]</td>
<td>2,270 [493-33,276]</td>
<td>403,670</td>
<td>77,003</td>
</tr>
<tr>
<td>Total (173)</td>
<td>16,559</td>
<td>4,377</td>
<td>10,374,115</td>
<td>1,764,137</td>
</tr>
</tbody>
</table>

*All costs in 1995 constant Canadian dollar

** Other cause of injury includes transportation, drowning, suffocation, foreign body; explosion, firearms, hot substances, electricity; other and unspecified

*** Other nature of Injury includes Internal injury-chest, abdomen, pelvis, injuries to nerves & spinal cord; traumatic complications, non-medicinal substances, unspecified, others
FIGURE 5.1: CLAIM OUTCOME* CATEGORIES BY CAUSE AND NATURE OF WORK-RELATED INJURY

*For 136 work-related injuries requiring hospitalization
FIGURE 5.2 COSTS* AND COMPENSATION BY THE WORKERS’ COMPENSATION SYSTEM

- Compensation costs covered
- Estimated compensation costs not covered

<table>
<thead>
<tr>
<th>Category</th>
<th>Covered Costs</th>
<th>Not Covered Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Care</td>
<td>$0.20</td>
<td>$1.56</td>
</tr>
<tr>
<td>Short-term Disability</td>
<td>$3.07</td>
<td>$0.42</td>
</tr>
<tr>
<td>Long-term Disability</td>
<td>$6.06</td>
<td>$0.45</td>
</tr>
<tr>
<td>Vocational rehabilitation</td>
<td>$0.38</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$11.06</td>
<td>$1.08</td>
</tr>
</tbody>
</table>
5.5 REFERENCES


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CHAPTER 6

HOSPITAL COSTS AND COMPENSATION OF TREATING WORK-RELATED
SAW MILL INJURIES IN BRITISH COLUMBIA

6.1 INTRODUCTION

An average of 164,404 work-related injuries occurred each year in the Canadian province of British Columbia over the five-year period from 1997 to 2001 [AWCBC, 2005]. Current predictions indicate that the incidence of work-related injuries will not decline notably over the next few years. In fact, the number of reported injuries remained unchanged from 2002 to 2004 at 156,000 [AWCBC, 2005]. Patients with serious work-related injury often experience long hospital stays and consume substantial amount of medical and hospital services.

The principal component of Canada's health care system is a socialized health insurance plan that covers all citizens and residents [Health Canada, 2006]. It is publicly funded and under this system, citizens receive medically necessary preventative care and medical treatments from primary care physicians, hospitals, dental surgery and other medical services [Health Canada, 2006]. In Canada, the public hospital sector serves both the public health care system and the workers' compensation system. The latter is funded entirely by employers but relies largely on the public health care infrastructure for services.

Hospital costs associated with work-related injuries are likely to escalate in Canada due to the growing size of the labour force and greater inflation in the health service sector than the general economy [CIHI, 2006-A]. For example, the total hospital expenditures in Canada

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5 The chapter is currently under review for publication in Injury under the same title.
increased from $26 billion in 1997 to $35 billion in 2002 [CIHI, 2006-A]. Though hospital costs account for a large component of total healthcare costs incurred following a work-related injury that requires hospitalization, no previous studies in Canada have estimated inpatient costs associated with work-related acute hospitalizations from the health care system's perspective. This perspective is particularly relevant because the infrastructure of the hospital sector in Canada is funded by the public sector and its primary client is the general public. Workers' compensation agencies across the country largely rely on this public infrastructure, but pay for the services directly, sometimes with a premium on the public fee schedule in order to receive expedited services. This different financing and payment scheme can create conflicting priorities for hospitals. Furthermore, in some instances the public sector may subsidize the privately funded workers' compensation system when work-related injuries and illnesses go undetected by the workers' compensation system.

The workers' compensation system is a provincial jurisdiction but is based on similar principles in the ten provinces and three territories across Canada- the liability of employers for injuries in the workplace is no fault and collective funding, with employers paying into a monopoly not-for-profit insurer that is publicly regulated [WCB-NS, 2006]. In return for guaranteed compensation, workers waive their right to sue their employer or co-workers through the tort system for any negligence that may have given rise to the workplace injury. Workers' compensation boards are entities independent of direct government involvement and usually have equal representation from labor and industry [WCB-NS, 2006]. If a worker is injured while on the job, the compensation system pays for accepted medical expenses (medical services and supplies) and wage-loss benefits, plus any necessary rehabilitation services.
Most of the hospital cost statistics on work-related injury in Canada have been based on reports from the workers’ compensation agencies, but these agencies might not capture all work-related injury [Shannon and Lowe, 2002; Alamgir et al., 2006-A]. Therefore, it is necessary to study costs using injury reports from an independent surveillance source to try 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 reveal the magnitude of the hospital cost that is shifted from the compensation agency to the provincial health care system.

Sawmills in British Columbia provide an important work-setting to study the hospital costs of work-related injury as this sector is large and unionized, contributes significantly to the economy of this province, is considered a hazardous industry, and its workers should be covered by the compensation system. A large cohort study on sawmill workers in BC, initially started in the 1980’s to investigate the risk of cancer associated with the use of Chlorophenol fungicides [Hertzman et al., 1997] was expanded to investigate a wide variety of occupational health issues in the forest industry [Teschke et al., 1998]. This study analyzes data from a sub-set of the full BC sawmill cohort, specifically, individuals who were working in the study sawmills at the time of hospital admission.

The primary objective of this study was to assess the hospital costs associated with work-related injuries of individuals in the BC sawmill cohort that were incurred by the BC hospitals during 1989-1998. Additionally, it estimated the hospital costs of the subset of work-related injury not compensated by the provincial workers’ compensation system and explore the range of costs for different types of injuries. This latter information provides insight into the most
expensive injuries and can be used to gauge where prevention efforts might have the greatest payback.

Hospital discharge records in the Canadian province of British Columbia (BC) have the potential to be a useful resource for estimating the costs associated with treating work-related injuries reaching hospitals. Almost all eligible residents of BC (over 4.1 million people) are enrolled with the provincial Medical Services Plan – MSP [BC Ministry of Health, 2005]. The MSP processes claims for insured services submitted by physicians, supplementary health care practitioners, hospitals, laboratory services and diagnostic procedures [BC Ministry of Health, 2005].

Hospital discharge data 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 to identify work-relatedness of hospitalization cases in British Columbia (BC), Canada [ICD-9; Alamgir et al., 2006-B]. Since April 1989, hospitals in BC have coded an additional digit to the International Classifications of Disease diagnosis coding schedule. This additional information enhanced the utility of discharge data as a work related injury surveillance system [Alamgir et al., 2006-B].

6.2 METHODS

There is no definitive method for calculating costs of hospital stays in Canada, as there are no provincial case-costing systems in place. One popular method has been the use of a cost per weighted case or Cost per Resource Intensity Weight (RIW) methodology utilizing financial and statistical reporting from hospitals and health authorities according to the Canadian Institute for Health Information National Management Information Systems guidelines [CIHI, 2006-B]. A
net total inpatient cost is arrived at and the total acute care RIWs are used as a denominator to determine an average cost per weighted case.

Another approach for calculating hospitalization costs is the use of the Standard Ward Rate (SWR), sometimes referred to as a Per Diem Rate. This is the daily charge for hospital stays for Inter-provincial and workers’ compensation billing purposes [BC Ministry of Health Services]. For example, when a resident from Alberta is hospitalized in a BC hospital for 3 days, an SWR for the hospital is multiplied by 3 and a bill is submitted for the stay. This rate is generally re-estimated on a yearly basis and is also site-specific. This rate has been compared to the "rack rate" of a hotel and does not take into account the cost of overhead. The same daily rate is used for all cases such that one-day for one type of patient is the same as that of another type of patient in a particular hospital. Any differences in costs between patients would be due to different lengths of stay.

Although the use of a standard ward rate is a cruder method for calculating hospital costs, hospitals in BC currently use it to calculate charges to the provincial workers’ compensation agency for work-related injuries [BC Ministry of Health Services]. Therefore, the method is more appropriate to assess costs of injury categories from the payer’s perspective. When the compensation agency is not capturing or compensating a hospital for an injury-related stay, it is at this rate that the costs to the hospital are forgone.

Hospital discharge records and workers’ compensation claims for this study population were obtained 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 with information on physician visits, hospital discharges, deaths, births, as well as extended care, drug
usage, and workers' compensation claims since 1985 [CHSPR, 2005-A]. The datasets are linked to a central registry file of all persons in the province covered by the BC Medical Services Plan (MSP) [Chamberlayne et al., 1998]. The hospitals have a year-specific standard billing schedule prepared by the provincial Ministry of Health by which they bill and collect payment from agencies such as the Workers' Compensation Board of British Columbia (WCB).

The hospital discharge dataset provided for research purposes by the BCLHD is a file of separations (discharges, transfers, and deaths) of in-patients and day surgery patients from acute care hospitals in BC [CHSPR, 2005-B]. Thus, outpatient cases such as emergency room only visit in which patients are not admitted to the hospital, are excluded from the research database. Records with the same admission and separation date are generally coded as Day Care Surgery (DCS). The DCS rate for that year from the Ministry's billing data was applied for costing purposes. For records with the same admission and separation date that were not coded as DCS, the full day's rate for that hospital for that year was applied. Some cases were transferred to other hospitals on the same day of admission. For these cases, it was assumed that they stayed more than 6 hours in the first hospital, and so a full day's rate for that hospital was included in the cost calculations.

As part of previous investigations, a total of 5,876 members were linked with their health records (using the BCLHD as of April 1989) from the original cohort of 6,512 members actively employed on or after April 01, 1989. Work-related injuries were also captured among these sawmill workers using the hospital discharge dataset [Alamgir et al., 2006-B]. Hospitalization records were identified as work-related using ICD-9 external cause of injury codes that indicate 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 [2006-B].

The principal diagnosis for the patient's stay in a hospital was used to designate the nature of injury and each hospitalization record was then categorized into meaningful broad nature of injury categories (Table 6.1). External cause of injury (ICD-9 E codes) was used to designate the cause of injury and each hospitalization record was then categorized into meaningful broad cause of injury categories (Table 6.2).

The workers' compensation claim records for this study population were extracted from 1989 to 1998, and matched with the hospitalized work-related injury records using the admission and separation dates and ICD-9 codes of the hospital discharge records with the injury date and ICD-9 codes of the compensation claim records [Alamgir et al., 2006-A].

Costs were calculated from the hospital's perspective. All costs were expressed in 1995 constant Canadian dollars using the provincial medical consumer price index [Drummond et al., 1997]. A 5% discounting rate was applied to adjust for the time value of money [Drummond et al., 1997]. Total costs and median costs were calculated by cause and nature of injury. Costs were also calculated for the subset of work-related hospitalizations that the hospital did not appear to be reimbursed for by the workers' compensation system.

6.3 RESULTS

For the 5,876 sawmill workers there were a total of 370 hospitalization events captured. By either of the two indicators (E Codes or payment schedules), 173 (47%) records were identified as work-related [Alamgir et al., 2006-B]. Of these 173 records, 136 (79%) were matched to compensation claims. Thus, 37 (21%) of the work-related injuries could not be
matched with a workers' compensation claim record. The study population for the 173 injuries was predominantly male (only 3 were females) and white (90%). The median age of the injured workers was 41 years. Nineteen percent of hospitalizations were coded as day care surgery, and 85% of records were coded as either urgent or emergency cases.

Table 6.1 describes the median length of stay by nature and cause of injury. Burns had the longest stays in hospitals and dislocation, sprains and strains had the shortest stays. In terms of cause of injury, fire, flame, natural & environmental had a median stay of 18 days, whereas, cutting and piercing had only a median stay of 1 day in hospital.

Table 6.2 presents the median, mean and total hospital costs of work-related injury requiring hospitalization among the study population. The median cost was highest for injuries involving fire, flame, natural & environmental and lowest for injuries involving cutting & piercing. In terms of nature of injury, burns were the most costly injury category and dislocation, sprains & strains were the least costly. In terms of total costs, the cause of injury category of fire, flame, natural & environmental, machinery related and falls were the most costly. For nature of injury, burns, fracture of upper limb and fracture of head & trunk were the most costly categories. The total hospital cost for the 173 studied injuries was $434,990.

Out of a total hospital cost of $434,990 for the 173 work-related injuries, the provincial compensation agency apparently did not compensate $50,663 (12%) (Figure 6.1).

6.4 DISCUSSIONS

According to the study findings, the median hospital cost for treating a work-related injury was $847 with a range of $144 to $45,409. The median stay was 3 days with the shortest being 1 day and the longest being 51 days. These figures highlight the expenses incurred by the
hospitals for the treatment of acute work-related injuries, much of which results from the length of hospital stay.

There was a large variance of median hospital costs for the injury categories studied. Injuries involving fire, flame, natural & environmental; struck against and struck by falling object were the most costly causes of injury. Injuries involving burns, fracture of lower limb and fracture of head & trunk were the most costly nature of injuries. In terms of total costs, fire, flame, natural & environmental; machinery related and falls by cause and burns, fracture of head & trunk and fracture of upper limb by nature were the most costly injuries. Targeted interventions designed to reduce these injuries will save substantial healthcare resources. For example, reducing one burn injury would save on average of $10,000 to $15,000 in hospital costs alone.

Literature on costs of injury related stays in hospitals is rare. Polinder and colleagues [2005] estimated costs of injury-related hospital admissions in 10 European countries. Highest costs were found for hip fractures [E5,530], fractures of the knee/lower leg [E3,504], burns [E4,065] and skull-brain injury [E2822]. The highest cost per patient for admitted injury patients and the corresponding mean length of stay (days) were E3,242 and 6.9 for Austria, E2,954 and 8.4 for Netherlands, E2,819 and 5 for Norway, and E2,771 and 9.3 for Spain and E2,745 and 6.1 for Denmark.

Reducing the duration of hospital stays is one potential way of minimizing expenditure to the hospitals following work-related injury. In many hospitals, patients experience delays for surgery; which leads to inefficient use of bed capacity, increased nursing dependency and longer hospital stays. The stipulation of adequate resources to minimize surgical delays would benefit patients and reduce expenditures. Moreover, the majority of hospital days are spent recuperating
after surgery and the introduction of programs to limit inpatient stay and improve rehabilitation have been shown to be cost-effective without adversely impacting health outcomes [Sanchez-Sotelo et al., 2006; Stubbs et al., 2005]. Reducing inpatient stay would also free hospital beds for other populations, and could eventually lead to reduced expenditures to the hospitals without adversely affecting the health of the BC population.

Minimizing direct hospital costs may also lessen the financial burden related to work-related injury. However, it may be more effective to tackle the root of the problem by reducing the occurrence of work-related injury. Evidence based strategies to reduce the number of work-related injury should therefore be targeted.

Our findings from this study suggest that 12% of work-related injury hospital costs do not appear to be covered by the workers’ compensation authority. These costs are attributable to approximately 20% of the work-related hospitalized injuries. These findings suggest that substantial costs are being transferred to the provincial health care system. Further research is necessary to identify the circumstances surrounding the diversion of these costs from the workers’ compensation system to the public health care sector.

The strength of this study was the use of a detailed and accurate collation of billing charts from which costs were derived. We have accounted for each patient-day and the billing rate was year and hospital specific. This study takes advantage of readily available and large administrative datasets. Other Canadian studies [Dimich-Ward et al., 2004; Locker et al., 2002] have also examined the use of administrative datasets for research purposes and the reliability and validity of such records have been established in other places [Beghi et al., 2001; Kashner, 1998; Vestberg et al., 1997; Virmig and McBean, 2001; Rawson and Malcolm, 1995]. We used
Consumer Price Index for healthcare in British Columbia to take care of the inflation. Additionally, a 5% discount rate was used to adjust for the time value of money.

Several limitations should be considered when interpreting the results of this study. First, the study depended heavily on the accuracy of the diagnosis codes and dates of both hospital and compensation databases. Second, there might have been weakness in the linking methodology to extract the right compensation claims for the hospitalization cases because the date window and injury coding might have linked different injury events. Finally, the method of using daily charge for hospital stays has its limitations. For example, it does not include overhead costs and it considered all injuries consumed similar amounts of resources per day. However, when exploring the billing relationship between the hospitals and the compensation agency, it is appropriate. The current hospital costing methods remain inaccurate and imperfect, making precise financial evaluations inherently difficult. An assumption for this study was that the bills hospitals submitted to the compensation agency were all eventually paid for by the agency.

Future cost studies could improve upon the analyses undertaken in this study by incorporating differential resource consumption patterns by injury cases within each hospital.
### TABLE 6.1: MEDIAN STAY IN HOSPITAL BY CAUSE AND NATURE OF INJURY (N=173) HOSPITALIZATIONS FOR WORK-RELATED INJURIES AMONG A SAWMILL COHORT

<table>
<thead>
<tr>
<th>Cause of Injury</th>
<th>N</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire, Flame, Natural &amp; Environmental</td>
<td>7</td>
<td>18</td>
<td>3</td>
<td>51</td>
</tr>
<tr>
<td>Falls</td>
<td>30</td>
<td>3</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Struck by falling object</td>
<td>13</td>
<td>3</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Struck against</td>
<td>24</td>
<td>3</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Overexertion</td>
<td>16</td>
<td>2.5</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Caught in or between</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Machinery related</td>
<td>49</td>
<td>2</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Cutting and piercing</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Other injuries*</td>
<td>16</td>
<td>2.5</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>173</td>
<td>3</td>
<td>1</td>
<td>51</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nature of Injury</th>
<th>N</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burns</td>
<td>9</td>
<td>13</td>
<td>2</td>
<td>51</td>
</tr>
<tr>
<td>Fracture of lower limb</td>
<td>23</td>
<td>4</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Fracture of skull, intracranium, spine &amp; trunk</td>
<td>23</td>
<td>3</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Superficial injury &amp; crushing</td>
<td>12</td>
<td>3</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Fracture of upper limb</td>
<td>27</td>
<td>2</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Open wounds</td>
<td>35</td>
<td>2</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Dislocation, Sprains &amp; Strains</td>
<td>35</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Other Injuries**</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>173</td>
<td>3</td>
<td>1</td>
<td>51</td>
</tr>
</tbody>
</table>

* Other sources of injury include transportation; drowning, suffocation, foreign body; explosion, firearms, hot substances & electricity; others and unspecified

** Other nature of injury includes internal injury of chest, abdomen, pelvis; injuries to nerves & spinal cord; traumatic complications; non-medicinal substances, unspecified, others
<table>
<thead>
<tr>
<th>Cause of Injury</th>
<th>N</th>
<th>Mean (Std. Deviation)</th>
<th>Median [Minimum-Maximum]</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls</td>
<td>30</td>
<td>2,370 (4,539)</td>
<td>857 [144-24,082]</td>
<td>71,102</td>
</tr>
<tr>
<td>Struck by falling object</td>
<td>13</td>
<td>2,130 (3,254)</td>
<td>1,093 [372-12,551]</td>
<td>27,692</td>
</tr>
<tr>
<td>Machinery related</td>
<td>49</td>
<td>2,034 (3,335)</td>
<td>813 [144-18,164]</td>
<td>99,680</td>
</tr>
<tr>
<td>Struck against</td>
<td>24</td>
<td>1,624 (1,989)</td>
<td>1,206 [262-9,630]</td>
<td>38,987</td>
</tr>
<tr>
<td>Caught in or between</td>
<td>9</td>
<td>1,287 (1,604)</td>
<td>423 [262-5,250]</td>
<td>11,587</td>
</tr>
<tr>
<td>Overexertion</td>
<td>16</td>
<td>996 (850)</td>
<td>690 [257-2,606]</td>
<td>15,945</td>
</tr>
<tr>
<td>Cutting and piercing</td>
<td>9</td>
<td>705 (1,010)</td>
<td>296 [272-3,368]</td>
<td>6,352</td>
</tr>
<tr>
<td>Other causes of injury</td>
<td>16</td>
<td>2,998 (7,186)</td>
<td>774 [239-29,584]</td>
<td>47,972</td>
</tr>
<tr>
<td>Burns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fracture of head &amp; trunk</td>
<td>23</td>
<td>2,704 (3,522)</td>
<td>991 [372-12,551]</td>
<td>62,184</td>
</tr>
<tr>
<td>Fracture of upper limb</td>
<td>27</td>
<td>2,342 (5,520)</td>
<td>684 [239-24,082]</td>
<td>63,222</td>
</tr>
<tr>
<td>Fracture of lower limb</td>
<td>23</td>
<td>2,180 (1,461)</td>
<td>1,800 [251-6,084]</td>
<td>50,149</td>
</tr>
<tr>
<td>Superficial injury &amp; crushing</td>
<td>12</td>
<td>1,999 (2,664)</td>
<td>899 [406-8,029]</td>
<td>23,989</td>
</tr>
<tr>
<td>Open wounds</td>
<td>35</td>
<td>1,453 (2,1710)</td>
<td>449 [262-11,400]</td>
<td>50,872</td>
</tr>
<tr>
<td>Dislocation, sprains &amp; strains</td>
<td>35</td>
<td>833 (850)</td>
<td>437 [144-3,675]</td>
<td>29,163</td>
</tr>
<tr>
<td>Other nature of Injury</td>
<td>9</td>
<td>1,308 (923)</td>
<td>1,447 [406-2,801]</td>
<td>11,773</td>
</tr>
<tr>
<td>Total</td>
<td>173</td>
<td>2,514 (5,489)</td>
<td>847 [144-45,409]</td>
<td>434,990</td>
</tr>
</tbody>
</table>

* In 1995 Canadian Dollar
FIGURE 6.1: COMPENSATION OF HOSPITAL COSTS* BY THE WORKERS' COMPENSATION AGENCY (N=173 HOSPITALIZATIONS) FOR WORK-RELATED INJURIES AMONG A SAWMILL COHORT

* In 1995 Canadian Dollar
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CHAPTER 7

EPIDEMIOLOGY OF WORK-RELATED INJURIES REQUIRING
HOSPITALIZATION AMONG SAWMILL WORKERS
IN BRITISH COLUMBIA, 1989-1998

7.1 INTRODUCTION

Sawmills are a major source of economic activity and employment in many countries including the United States of America (USA), Canada, China, Malaysia, Brazil, Indonesia, France, Sweden and Germany [Demers and Teschke, 1998]. About 1% of the entire global workforce is employed in a wood products industry [Demers and Teschke, 1998]. In British Columbia (BC), a province of Canada, about 2% of the workforce was working in the logging and forestry industry during 1993-1998 [BC Statistics, 2004]. Sawmills are hazardous work environments because of the nature of the work processes, the types of machines and tools used, and materials handled [Demers and Teschke, 1998]. As a result, sawmill workers are at a higher than average risk of sustaining work-related injuries. From 1993 to 1997, the average accepted, time-loss claim rate was 7 injuries per 100 full-time equivalent workers in BC sawmills compared to the overall provincial average of 5.4 injuries [WCB, 1999].

Epidemiologic study of work-related injuries has been hindered by the lack of a complete, independent, standardized, reliable, elaborate, and consistent reporting system. Among the information sources available for studying work-related injury, workers’ compensation systems are currently considered a major surveillance tool. However, some studies in USA

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6 The chapter is currently under review for publication in *The European Journal of Epidemiology* under the same title.
Waller et al., 1989; Frumkin et al., 1995; Stanbury et al., 1995; Biddle et al., 1998; Rosenman et al., 2000] and Canada [Shannon and Lowe, 2002; Alamgir et al, 2006-A] have explored underreporting of work-related injuries by the workers’ compensation systems. This has led to an interest in identifying different and independent sources of information for use in work-related injury surveillance.

In Canada, hospital discharge records represent a readily accessible and customarily collected source of data for the monitoring of severe non-fatal injuries. It has detailed information on the nature, cause, and severity of injury related admissions, and has followed the standard International Classifications of Disease diagnosis coding schedule [CIHI, 2004]. Because of the public health care system in Canada and the all-inclusive coverage of hospitalizations, hospital discharge records have the prospect to be a handy data resource for severe injury surveillance. Individual admissions can be identified as work-related using ICD-9 external cause of injury codes that can specify place of occurrence [ICD-9]; and the responsibility of payment schedule, which can identify workers’ compensation as being responsible for payment. In Canada, the potential of hospital discharge records to capture work-related injury has been recently validated [Alamgir et al., 2006-B] and a limited number of other investigations have also attempted earlier to capture work-related events using hospital discharge records [Dimich-Ward et al., 2004; Locker et al., 2002; Liss et al., 2000].

The purposes of this investigation were to describe work-related injuries requiring hospitalization from 1989 to 1998 by cause, nature, and body parts among a cohort of the sawmill workers in British Columbia and identify the job categories that were at higher risk of sustaining work-related injury.
7.2 METHODS AND DATA SOURCES

A large cohort study was composed of sawmill workers in BC in the 1980’s to investigate the risk of cancer associated with the use of Chlorophenol fungicides and it was later expanded to investigate other occupational health issues in the forest industry [Hertzman et al., 1997; Teschke et al., 1998]. As part of previous investigations, a total of 5,876 cohort members were linked with their health records using the British Columbia Linked Health Database (BCLHD) as of April 1989 from the original cohort of 6,512 members, who were employed in sawmills on or after April 1989 (90% linkage rate).

The cohort was followed from April 1989 to December 1998 for any potentially work-related hospital admission. The study populations were followed up from April 1989 for hospital admission to study end date (December 1998), date of death, or date of last employment, whichever occurred earlier.

Hospital discharge records for this study population were obtained from the BCLHD [CHSPR, 2005]. 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 (CHSPR). It contains datasets recording physician visits, hospital discharges, deaths, births, as well as extended care, drug usage, and workers’ compensation claims since 1985 [CHSPR, 2005]. The datasets are linked to a central registry file of all persons in the province covered by the BC Medical Services Plan (MSP), [Chamberlayne, 1998] representing almost all residents of British Columbia (over 4.1 million people).

Hospital discharge records were extracted for an injury diagnosis between April 1989 and December 1998, and were identified as work-related using the ICD-9 external cause of injury codes and the responsibility of payment schedule. The methods are described in more detail by
Alamgir et al [2006]. Individual admissions were identified as work-related using ICD-9 external cause of injury codes that indicate place of occurrence [ICD-9, 1989]; and the responsibility of payment schedule, which identifies workers' compensation as being responsible for payment. Since April 1989, the hospitals in BC started coding an additional digit to the ICD-9 diagnosis schedule that enhanced its utility as a work-related injury surveillance system [Aamgir et al., 2006-B; ICD-9].

Information on the cohort members include sex, race, and birth date; and work history records include information on mill, job category, and start and end of each job at sawmills. Jobs in the BC Sawmill Cohort study were categorized by skill level according to a classification system developed by others for a case-control study of sawmill injuries in Maine [Punnett, 1994]. Jobs were classified by the level of skill required as 1) foreman/supervisor, 2) skilled trades, 3) material handler/unskilled, 4) machine operator/attendant/clearer/sorter, 5) mobile equipment operator, 6) inspector/grader, 7) non-wood production and others.

Each record in the hospital discharge database was first identified as work-related or not. The injuries were described by the nature of injury using the ICD-9 primary diagnosis codes, cause of injury using the ICD-9 external cause codes, and then by body parts also identified through the ICD-9 primary diagnosis codes. For example, an ICD-9 code of 801 is a fracture of base of skull. The nature of injury is fracture of head and trunk, and the body part is head. An ICD-9 code of E888 is an unspecified fall - a cause of injury. The cause, nature and the body parts were then categorised into related, broader groups. Age of the workers was calculated at the date of hospital admission. From the start and end of employment date for each sawmill job, the total person-years and person-years at each single job that were under follow-up were
calculated. The job of a worker while injured was also identified. The hospitalization rates for injury categories and job categories were calculated per 1,000 person years.

7.3 RESULTS

Among the 5,876 sawmill workers at risk, only 131 were women and 845 were non-white. With 31,846 total person years of observation, there were 370 injury-related hospitalization events captured between 1989 and 1998. By either of the two indicators (E Codes or payment schedule), 173 injury hospitalizations were identified as work-related. Of the 173 cases, only 3 occurred among females and 17 among non-white workers. The median age at time of hospitalization was 41 years [range: 19-64]. Figure 7.1 shows the distribution of work-related injury by age category. During the ten-year follow-up period, the overall injury rate for work-related hospitalization was 5.4 per 1,000 person years.

Table 7.1 and 7.2 present cross-tabulation of the nature, cause and body parts of the injuries studied. The most frequent work-related injuries by nature of injury were dislocation, sprains & strains (20%), open wounds (20%), and fracture of upper limbs (16%) (Table 7.3). Fractures, regardless of the body part, comprised 42% of all the injuries. During the study period, the most frequent causes of injury were machinery related (28%), falls (17%) and being struck against (14%). In terms of body parts, the hand & finger was associated with a third of all work-related injuries followed by the leg, knee & ankle, which made up one fourth of all injuries. By exploring the relationship between cause of injury and body parts affected (results not shown), it was found that most of the work-related falls involved leg, knee & ankle, whereas, most struck against cases involved head, face & neck. Hands & fingers involved most of the machinery related incidents and overexertion, as anticipated, involved mainly trunk, back &
groin. Dislocation, sprains & strains primarily involved leg, knee & ankle and trunk, back & groin.

When examining work-related hospitalizations by work history, very few injuries occurred among workers in jobs such as foreman & supervisor, mobile equipment operator, or non-wood industry & non-production jobs (Table 7.4). Eighty-two percent of the cases involved machine operators, attendants, clearers & sorters; material handling & unskilled, and skilled trades (tool users). The job groups that were at high risk of sustaining serious injuries were skilled trades (6.91 work related hospitalizations per 1,000 per years), machine operators, attendants, clearers & sorters (5.96 per 1000 per years) and material handling & unskilled (5.52 per 1000 person years).

Among machine operators, attendants, clearers & sorters, the most frequent work-related cases of injury were machinery related (31%), struck by falling object (16%) and falls (16%) (Table 7.5). Among skilled trades (tool users) the most frequent causes were machinery related (27%) and struck against (23%). Among material handling & unskilled workers machinery related (30%) was also the most common cause of injury. Among machine operators/attendants/clearers/sorters, the most frequent nature of injuries were open wounds (22%) and fractures of upper limb (22%). Among skilled trades (tool users), and material handling & unskilled workers, the most frequent nature of injuries (about 20%) were open wounds and dislocation, sprains, & strains. Between 55-65% injuries among machine operators, attendants, clearers & sorters, material handling/unskilled and skilled trades (tool users) involved hand & finger and leg, knee & ankle.
7.4 DISCUSSIONS

This study identified and described work-related injuries requiring hospitalization by cause, nature and body parts among a cohort sawmill workers in British Columbia during 1989-1998, and explored the relationship of job types with injury categories. Although modern technology has greatly reduced the amount of physical work involved in operating sawmill machinery, among the sawmill workers in this study, the most common cause of injury still involved machinery. Sawmill workers operate, monitor and control various machines and tools that saw timber logs into rough lumber and then saws, splits, trims and planes the coarse lumber into dressed lumber. Following safe work practices and operating machinery when all safeguards are functioning should be helpful to prevent injuries [CDC, 2004; Trump, 1985]. Studies also show that on-the-job training for work machinery also helps to reduce the risk of injuries [CDC, 2004; Trump and Etherton, 1985].

Falls were the second most important cause of sawmill injuries. Previous studies of occupational falls have identified environmental or physical factors (surfaces, shoes, lighting, etc.), organizational deficiency (inadequate signs and indicators, inadequate maintenance schedule, etc.), and behavioural factors (work pace, balance alteration) as risk factors for falls [Gauchard, 2001].

The hands and fingers remained the body parts at greatest risk of getting injured among the sawmill workers. A review study by Barr and colleagues [2004] suggests that these injuries are associated with the longest absences from work and are, therefore, associated with greater lost productivity and wages than those of other anatomical regions. According to this review, repetitive, hand-intensive movements, alone or in combination with other physical, nonphysical, and non-occupational risk factors, contribute to the development of hand and finger injury. On
the other hand, injuries of leg, knee & ankle are less well-understood as epidemiological studies of such injuries are scarcely available [Conti and Silverman, 2002].

In terms of nature of injury, open wounds and dislocation, sprains and strains were common categories among this study population. In this study open wounds included such injuries as cuts, lacerations, puncture wounds and traumatic amputations. The risk factors for compensated claims on sprains and strains were studied by Choi and colleagues [1996] in Ontario; they suggested a number of work environments and activities associated with a high risk of occurrence of sprains and strains, including overexertion, bodily reaction from involuntary motions, running and stretching, and slippery surfaces.

This study also identified some vulnerable job groups among sawmill workers. Machine operators, attendants, clearers & sorters, skilled trades (tools users), and material handling & unskilled employees in sawmill were found to sustain most of the injuries that required hospitalization. Interestingly, mobile equipment operators did not experience that many injuries. As expected, supervisor & foreman was found to be the safest job group relative to other job groups in sawmills. Common causes and vulnerable body parts inside the job groups were also identified.

Some other studies previously investigated sawmill injury. Barroetavena [2001] in an epidemiologic investigation of injury mortality among sawmill workers in British Columbia found the overall fatality rate to be 18.1 per 100,000 person-years for the period of 1950-1990. Machine operators and mobile equipment operators were the occupational groups with the highest crude fatality rates. Over 80% of the deaths were caused by severe trauma to the head, spinal cord, or multiple sites. Driscoll and colleagues [1995] reviewed the fatal injuries among the sawmill workers of Australia. With an injury rate of 30 per 100,000, the activities at the time
of the injury event were identified as working with a bench saw, loading/unloading, and traffic related.


In a study on Maine sawmill workers, Cooke and Blumenstock [1979] abstracted data from employer’s reports of injuries filed with the Workers’ Compensation Commission during 1972. The results showed that younger (less than 24 years) and older (more than 45 years) workers and those with temporary assignment had more severe injuries. Punnett [1994] in a case-control study examined the relationship between environmental risk factors and work-related acute traumatic injuries among sawmill workers also in Maine. The distinctive working conditions that prevailed on injured workers were jobs in machine-paced workstations, exposure to dangerous work methods and materials, loud noise levels, fast work pace, high lifting demands, and frequent postural stress.

Laflamme and Cloutier (1988) investigated the typical scenarios where injuries occur most often in Sweden. Most injuries occurred in the sawing section while workers were handling logs/planks. Regarding the types of machines involved, accidents occurred more frequently at the sawing and conveying machines.

A study by Bode and colleagues [2001] found lacerations as the most common injury among the factory floors in a Nigeria sawmill. They also found the upper limbs to be involved in
66% of the injury cases and the highest injury rate occurred among the machine operators. In another study by Burridge and colleagues [1997], who studied work-related hand and lower-arm injuries in New Zealand sawmill workers between 1979 and 1988, piercing and cutting instruments and machinery were reported to be the two most common agents of work-related hand and lower-arm injury.

A few other studies have investigated hospitalized work-related injuries in different study populations and industrial sectors. Layne and Landen [1997] studied work-related injuries to workers 55 years of age and older presented for treatment in hospital emergency departments across the United States during 1993; the types of injuries most frequently requiring hospitalization were fractures or dislocations that resulted from a fall. Husberg and colleagues [2005] used The Alaska Trauma Registry which is an injury surveillance tool focused on hospitalized nonfatal injuries in the Alaskan construction industry. During 1991-1999, the average annual injury rate was 0.39 injuries/100 workers and the leading causes of injury included falls (48%) and machinery (15%).

Physical workload and work processes have been consistently rated as high risk factors for work-related injuries. However, non-standardization of job classification makes it hard to compare findings across studies.

While there is similarity of the key findings found in this study with the other studies cited here, different injury surveillance systems make it hard to compare injury rates and statistics across studies, industries, occupations and countries. Comparing injury statistics across industries and surveillance systems is also hard because of the varying tasks done by the workers, differences in safety regulations in jurisdictions, differences in coding and reporting requirements, and differences in outcome definitions (e.g. severity of injuries). Some studies
report injuries only by nature, some by cause, whereas others by the body parts. Almost no studies were found to report injuries by all-nature, cause and body parts. Some studies described injuries by amalgamating nature and cause. However, a “struck against” injury does not provide an indication of the body part nor does it tell what the nature of the injury was. Identifying the affected body parts reveals the vulnerability of the body parts of the workers that need safeguarding. Contrary to most available literature on work-related injury, this study described injuries by cause, nature and body parts involved using standard ICD-9 diagnosis codes. Using a standardized description of injuries by following ICD-9 external cause and nature of diagnosis codes as was done in this investigation should mitigate a large part of comparability problems.

The sawmill industry contributes significantly to the economy of the province of British Columbia. Globally, sawmills are somewhat similar in the work processes, use of tools and equipment, and handling of materials; so, findings for this sector in British Columbia should be applicable to other jurisdictions with limited awareness of the most frequent causes and nature of sawmill injuries. Information on the types of injuries and job categories at higher risk can be used to inform the design of targeted and essential workplace safety interventions in sawmills in British Columbia and around the world.

Work-related injuries requiring hospitalization have very high potential of resulting in both short- and long-term disability. As there are likely more work-related injuries reaching hospitals than the compensation agency reports [Shannon and Lowe, 2002; Alamgir et al., 2006], and hospital records are collected independently, this investigation provided a more comprehensive description of serious work-related injuries among the working population in a vital industrial sector. Depending on the coding reliability and validity of this database, hospital data represents an alternative source of information for compensation-related statistics for
serious work-related injuries. However, validity and reliability of administrative and electronically collected databases have been established in some previous studies [Vestberg et al., 1997; Rawson and Malcolm, 1995; Kashner, 1998; Beghi et al., 2001].

The findings of this study should be interpreted carefully due to the following limitations. It did not capture injuries that did not arrive at the hospitals; for example, there might be events, which were treated at the worksite and perhaps were less serious. Secondly, the findings depended solely on the reliability and validity of the coders in the hospitals. Another important limitation was this study captured only 173 cases - resulting in small numbers in some injury categories.

Future studies should describe injuries among a working population by nature, cause, and body parts involved, and follow a standardized reporting and coding approach. Consistency in injury coding will help to improve generalizability and comparability of the published studies and reports. The hospital discharge records in Canada now follow the ICD-10 diagnosis-coding schedule which also has place of occurrence indicators [ICD-10]. Studies should also collect information on the work history of the workers including the tasks they perform, age at hire, and experience at different jobs. Work characteristics should be investigated in relation to injury characteristics to help better assess the safety hazards.

Knowing the causes, nature and body parts involved and standardized description of injuries will be helpful to employers, compensation officials, and other stakeholders in countries, where sawmills are abundant. For example, the injury information could be used to identify vulnerable worker groups, and subsequently target preventive measures within an industry. Detailed describing of work-related injuries could also be used to guide regulatory processes and prevention strategies. If injuries among employed persons are not described well, policy and
prevention decisions may not be based on accurate or complete evidence and employees may not receive needed safety measures.
TABLE 7.1: NATURE OF INJURY AND CAUSES FOR 173 WORK RELATED HOSPITALIZATIONS

<table>
<thead>
<tr>
<th>Cause of Injury</th>
<th>Falls</th>
<th>Fire, Flame, natural, Environmental</th>
<th>Struck by falling object</th>
<th>Struck against</th>
<th>Caught in or between</th>
<th>Machinery related</th>
<th>Cutting &amp; piercing</th>
<th>Overexertion</th>
<th>Other causes*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture-skull, intracranium, spine &amp; trunk</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td>Fracture-upper limb</td>
<td>8</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>27</td>
</tr>
<tr>
<td>Fracture-femur, lower limb</td>
<td>8</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>Dislocation, sprains, strains</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>16</td>
<td>4</td>
<td>35</td>
</tr>
<tr>
<td>Open wounds, injuries to blood vessels</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>17</td>
<td>7</td>
<td>0</td>
<td>3</td>
<td>35</td>
</tr>
<tr>
<td>Superficial injury, crushing, foreign body</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>12</td>
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<tr>
<td>Burns</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Other nature of Injuries**</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>7</td>
<td>13</td>
<td>24</td>
<td>9</td>
<td>49</td>
<td>9</td>
<td>16</td>
<td>16</td>
<td>173</td>
</tr>
</tbody>
</table>

* Other cause of injury includes transportation, drowning, suffocation, foreign body; explosion, firearms, hot substances, electricity; other and unspecified
** Other nature of injury includes Internal injury-chest, abdomen, pelvis, injuries to nerves & spinal cord; traumatic complications, non-medicinal substances, unspecified, others
### TABLE 7.2: NATURE OF INJURY AND BODY PARTS FOR 173 WORK RELATED HOSPITALIZATIONS

<table>
<thead>
<tr>
<th>Nature of Injury</th>
<th>Hand &amp; Finger</th>
<th>Head, Face &amp; Neck</th>
<th>Leg, Knee &amp; Ankle</th>
<th>Shoulder &amp; Arm</th>
<th>Trunk, Back &amp; Groin</th>
<th>Other body parts</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture of skull, intracranium, spine &amp; trunk</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>Fracture-upper limb</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Fracture-femur, lower limb</td>
<td>8</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>23</td>
</tr>
<tr>
<td>Dislocation, sprains, strains</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>35</td>
</tr>
<tr>
<td>Open wounds, injuries to blood vessels</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>17</td>
<td>4</td>
<td>35</td>
</tr>
<tr>
<td>Superficial injury, crushing, foreign body</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Burns</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Other Injuries*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>7</td>
<td>13</td>
<td>9</td>
<td>49</td>
<td>24</td>
<td>173</td>
</tr>
</tbody>
</table>

* Other nature of injury includes *Internal injury-chest, abdomen, pelvis, injuries to nerves & spinal cord; traumatic complications, non-medicinal substances, unspecified, others*
TABLE 7.3: WORK-RELATED HOSPITALIZATIONS AMONG SAWMILL WORKERS BY NATURE, CAUSE AND BODY PARTS INVOLVED

<table>
<thead>
<tr>
<th>Injury Category</th>
<th>Work-related hospitalization frequency (%)</th>
<th>Work-related Hospitalization Rate per 1000 person-years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cause of Injury</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinery related</td>
<td>49 (28)</td>
<td>1.54</td>
</tr>
<tr>
<td>Falls</td>
<td>30 (17)</td>
<td>0.94</td>
</tr>
<tr>
<td>Struck against</td>
<td>24 (14)</td>
<td>0.75</td>
</tr>
<tr>
<td>Overexertion</td>
<td>16 (9)</td>
<td>0.50</td>
</tr>
<tr>
<td>Struck by falling object</td>
<td>13 (8)</td>
<td>0.41</td>
</tr>
<tr>
<td>Cutting &amp; piercing</td>
<td>9 (5)</td>
<td>0.28</td>
</tr>
<tr>
<td>Caught in or between</td>
<td>9 (5)</td>
<td>0.28</td>
</tr>
<tr>
<td>Fire, Flame, Natural &amp; Environmental</td>
<td>7 (4)</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>Other Causes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand &amp; Finger</td>
<td>57 (33)</td>
<td>1.79</td>
</tr>
<tr>
<td>Leg, Knee &amp; Ankle</td>
<td>44 (25)</td>
<td>1.38</td>
</tr>
<tr>
<td>Head, Face &amp; Neck</td>
<td>27 (16)</td>
<td>0.85</td>
</tr>
<tr>
<td>Trunk, Back &amp; Groin</td>
<td>24 (14)</td>
<td>0.75</td>
</tr>
<tr>
<td>Shoulder &amp; Arm</td>
<td>7 (4)</td>
<td>0.22</td>
</tr>
<tr>
<td>Others</td>
<td>14 (8)</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>Nature of Injury</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open wounds</td>
<td>35 (20)</td>
<td>1.09</td>
</tr>
<tr>
<td>Dislocation, sprains &amp; strains</td>
<td>35 (20)</td>
<td>1.09</td>
</tr>
<tr>
<td>Fracture-upper limb</td>
<td>27 (16)</td>
<td>0.85</td>
</tr>
<tr>
<td>Fracture of Head and Trunk</td>
<td>23 (13)</td>
<td>0.72</td>
</tr>
<tr>
<td>Fracture-lower limb</td>
<td>23 (13)</td>
<td>0.72</td>
</tr>
<tr>
<td>Superficial injury &amp; crushing,</td>
<td>12 (7)</td>
<td>0.38</td>
</tr>
<tr>
<td>Burns</td>
<td>9 (5)</td>
<td>0.28</td>
</tr>
<tr>
<td>Traumatic complications/non-medicinal substances/unspecified/others</td>
<td>5 (3)</td>
<td>0.16</td>
</tr>
<tr>
<td>Internal injury-chest, abdomen &amp; pelvis</td>
<td>4 (2)</td>
<td>0.13</td>
</tr>
<tr>
<td>Total</td>
<td>173 (100)</td>
<td>5.43</td>
</tr>
</tbody>
</table>
### TABLE 7.4: WORK-RELATED HOSPITALIZATIONS BY JOB CATEGORIES AMONG SAWMILL WORKERS

<table>
<thead>
<tr>
<th>Job Category</th>
<th>Work-related injury Number (%)</th>
<th>Hospitalization Rate per 1000 person-years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine operators/attendants/clearers/sorters</td>
<td>51 (29.48)</td>
<td>5.96</td>
</tr>
<tr>
<td>Skilled trades (use tools)</td>
<td>48 (27.75)</td>
<td>6.91</td>
</tr>
<tr>
<td>Material handling/unskilled</td>
<td>43 (24.86)</td>
<td>5.52</td>
</tr>
<tr>
<td>Inspector, grader, other skilled worker (non tool user)</td>
<td>14 (8.09)</td>
<td>4.84</td>
</tr>
<tr>
<td>Mobile equipment operator</td>
<td>7 (4.04)</td>
<td>2.34</td>
</tr>
<tr>
<td>Foreman/Supervisor</td>
<td>6 (3.47)</td>
<td>3.61</td>
</tr>
<tr>
<td>Non-wood industry &amp; non-production</td>
<td>4 (2.31)</td>
<td>3.97</td>
</tr>
</tbody>
</table>
### TABLE 7.5: DISTRIBUTION OF WORK-RELATED HOSPITALIZATIONS BY JOB CATEGORIES AMONG SAWMILL WORKERS

<table>
<thead>
<tr>
<th>Cause of Injury</th>
<th>Foreman/Supervisor</th>
<th>Skilled trades (Use tools)</th>
<th>Mobile equipment operator</th>
<th>Material handling/unskilled</th>
<th>Machine operators/attendants/clearers/sorters</th>
<th>Inspector, grader, other skilled worker (non tool user)</th>
<th>Non-wood industry &amp; non-production</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery related</td>
<td>1</td>
<td>13</td>
<td>3</td>
<td>13</td>
<td>16</td>
<td>3</td>
<td>0</td>
<td>49</td>
</tr>
<tr>
<td>Falls</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Struck against</td>
<td>0</td>
<td>11</td>
<td>0</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>Overexertion</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>16</td>
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<tr>
<td>Struck by falling object</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Caught in or between</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
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<td>9</td>
</tr>
<tr>
<td>Cutting &amp; piercing</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Fire, Flame, natural, Environmental</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>7</td>
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<tr>
<td>Other causes</td>
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<td>2</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>48</td>
<td>7</td>
<td>43</td>
<td>51</td>
<td>14</td>
<td>4</td>
<td>173</td>
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</table>

<table>
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<tr>
<th>Body parts</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Hand &amp; Finger</td>
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<td>17</td>
<td>2</td>
<td>14</td>
<td>17</td>
<td>5</td>
<td>0</td>
<td>57</td>
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<tr>
<td>Leg, Knee &amp; Ankle</td>
<td>2</td>
<td>10</td>
<td>0</td>
<td>14</td>
<td>13</td>
<td>3</td>
<td>2</td>
<td>44</td>
</tr>
<tr>
<td>Head, Face &amp; Neck</td>
<td>1</td>
<td>8</td>
<td>2</td>
<td>7</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>27</td>
</tr>
<tr>
<td>Trunk, Back &amp; Groin</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>5</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>Others</td>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Shoulder</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>48</td>
<td>7</td>
<td>43</td>
<td>51</td>
<td>14</td>
<td>4</td>
<td>173</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Nature of Injury</th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dislocation, sprains, strains</td>
<td>2</td>
<td>11</td>
<td>0</td>
<td>9</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>35</td>
</tr>
<tr>
<td>Open wounds, injuries to blood vessels</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>9</td>
<td>11</td>
<td>4</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>Fracture-upper limb</td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Fracture of skull, intracranium, spine &amp; trunk</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td>Fracture-femur, lower limb</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>7</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>Superficial injury, crushing, foreign body</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Burns</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Traumatic complications, non-medicinal subs, unspecified, others</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Internal injury-chest, abdomen, pelvis, nerves &amp; spinal cord</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>48</td>
<td>7</td>
<td>43</td>
<td>51</td>
<td>14</td>
<td>4</td>
<td>173</td>
</tr>
</tbody>
</table>
FIGURE 7.1: DISTRIBUTION OF WORK-RELATED INJURY REQUIRING HOSPITALIZATION BY AGE AMONG SAWMILL WORKERS

![Bar chart showing distribution of work-related injury requiring hospitalization by age among sawmill workers. The chart displays the number of cases by age group, with the highest number of cases occurring in the 30-39 age group.](chart.png)
7.5 REFERENCES


CHAPTER 8
DISCUSSIONS AND CONCLUSIONS

8.1 KEY FINDINGS AND POLICY IMPLICATIONS

The results of this study provided significant insights into surveillance, epidemiology, costs, and compensation of work-related sawmill injuries. The programs of research of this dissertation were centred on the use of hospital discharge records to examine its use as a work-related injury surveillance tool, estimating the costs and compensation associated with such injuries, and investigate the epidemiology of these injuries in a study population of sawmill workers in the Canadian Province of British Columbia.

There were different but related objectives in the six papers of the thesis: 1) the first paper examined the validity of hospital discharge records as a tool for work-related injury surveillance, 2) the second paper tested the capturing patterns of such injuries by workers' compensation agency compared to hospital discharge records, 3) the third paper assessed the accuracy of injury diagnosis coding of workers' compensation records compared to hospital discharge records, 4) the fourth part analyzed costs and compensation patterns of the injuries, 5) the fifth paper estimated hospitalization costs and compensation patterns of the injuries, and 6) the last paper conducted an epidemiological investigation of these injuries.

This chapter recaptures and summarizes the key findings and conclusions, describes how these add up to the current state of knowledge, and addresses some other issues that influence the results and interpretation of this study, summarizes the strengths and limitations of the study, and provide some guidelines on future research in these areas.
8.1.1 WORK-RELATED INJURY SURVEILLANCE: HOSPITAL DISCHARGE DATA AND WORKERS’ COMPENSATION DATA

Two indicators-ICD-9 external cause of injury codes and payment codes were available in hospital records to effectively identify serious work-related injuries requiring hospital admissions. The agreement between them in identifying such injuries was good (Kappa = 0.77). However, it was found that the pattern of capturing work-related injuries using these two indicators varied by cause of injury. Together, these two indicators were quite exhaustive in capturing work-related hospitalized injuries as the capture-recapture method results suggested that very few events (about 1%) requiring hospital admissions remained unascertained by these two surveillance indicators.

According to the findings on the concordance between workers’ compensation claims database and hospital discharge records, the provincial compensation agency in the Canadian province of British Columbia was found to under-report even the more serious and acute work-related injuries reaching hospitals by about 10% in a population actively working in a large unionized industry. This study also documented several vulnerable groups of workers, like, older and non-white people, and specific injury categories, like, overexertion and falls, that were related with greater under-reporting.

Hospital discharge datasets have comprehensive information on the type and severity of injuries and depending on coding reliability and validity, they can work as an available and efficient alternative to the provincial compensation agency reports for examining serious injury trends and have the potential to be integrated with the compensation dataset to work as a comprehensive work-related injury surveillance system in British Columbia. As work-related injuries are not always reported for compensation and compensation agencies do not compensate
all claims filed to them, learning about the causes and nature of injuries from a different and independent source is useful to regulators and policy makers to identify vulnerable groups of workers and work-processes and devise preventive measures within an industry. This study also suggests that the WCB data collection systems should be upgraded with detailed information on all types of injuries irrespective of their severity (e.g., it could collect injury information on health care only claims representing less serious injuries). To improve the compensation patterns, education and training of the susceptible group of workers and their supervisors on the compensation system and claim filing method at workplaces, and precautionary measures taken by the compensation claims handlers to deal with the claims from the vulnerable workers and for the commonly under-compensated injury types might be useful.

Surveillance data are essential both to establish the need for public health action and to assess the effectiveness of interventions. The injury surveillance programs should seek to reduce serious injuries by monitoring the incidence, trends, risk factors and circumstances of these injuries and disseminating this information to injury prevention advocates. These data should be useful to inform and influence decision-making regarding the development and evaluation of injury prevention initiatives and policies.

As described in the beginning of the thesis and in Figure 1.2, there were work-related injuries that were beyond the scope of this investigation. An injury coded as occurred in a workplace might not always be work-related. To differentiate a work-related case from a non-work related case in the workplace was not possible by the tools the current study helped to develop and proposed to use. There were other work-related injuries that did not reach hospitals or were not filed for claims, and there were some other cases that were not work-related but were claimed for compensation. The compensation system has claim adjudication process where their
experts decide about the acceptance and amount of compensation for each claim. There is also an appeal process where workers can challenge a decision. But, surely some claims remain unaccepted or under-compensated. The workers' compensation system's data on rejected claims will help the researchers to dig into more which injuries have higher likelihood of being rejected. Unless these records are made available, workers of particular types and injuries of particular nature might continue to be uncompensated. Also, inaccuracy in the hospital records, like, coding error and missing data might result in overestimation of some injuries as work-related. Amid widespread argument and counter argument of under-compensation and defrauding with the workers' compensation system, independent investigation as done by this thesis would provide immensely helpful information in the occupational health and safety arena. In addition, there will be some injury cases where establishing work-relatedness will be inherently difficult because of the unusual circumstances. These important issues were not within the scope of the current thesis. Further research is required on under-compensation, rejection of a genuine claim, shortcomings of adjudication and appeal processes, claims for non work-related injuries, and filing for fraudulent claims.

The study findings suggest that a comprehensive work-related injury surveillance system should be developed independent from the compensation system. The compensation system can be used in combination with the hospital discharge records as suggested by these study findings to be more comprehensive to include more cases, but, since the hospital records only captures serious injuries, the potential for underreporting will exist. A more direct injury data collection system should be developed that can report all incidence to an independent data collection and research agency. Irrespective of claim approval status, this agency might work as data store house for all work-place injury and perform necessary analysis to produce policy related
documents and reports from all these injuries. Standard reporting forms can be developed to use in workplaces where employees and supervisors can independently fill relevant portions. This standard form should also collect information about the hazards present and describe the corrective actions taken by the employer to eliminate or reduce the hazards. It might also collect information on near misses so that organizations can be pro-active in preventing injuries.

This injury surveillance system should also gather information on nature and cause of an injury and also identify the body parts involved. From prevention aspect, the cause of injury is more useful, but for diagnostic and clinical outcome and costs estimation, nature of injury is more meaningful. The body parts involved in an injury will also help develop means for safeguarding.

Workers' compensation datasets are widely used by researchers and policy makers as a tool for injury surveillance; therefore, investigating the accuracy of their injury codes was imperative. Our study also examined the accuracy of the injury related diagnosis codes of the compensation system holding hospital discharge dataset as the comparative standard. Very few published studies provided insight into the level of error to be expected for the injury codes in the compensation systems. Overall, despite the limitations of our methodology, this study found good agreement on injury codes between the two data sources (Kappa was 0.63 for nature of injury, and 0.71 for body parts) which strengthened the support for using compensation datasets for occupational epidemiology investigations and research in British Columbia. However, the findings suggested that the accuracy of injury codes was stronger for sharp and acute type injuries (*burns* and *fracture of lower limbs*) and weaker for superficial injuries.

Training of the coders of both hospitals and compensation agency on data extraction, injury coding and ICD systems, and frequent reliability and validity testing on the important
variables will provide greater confidence on using these datasets. It will be helpful if the coders understand the various uses of the codes beyond administrative or financial tasks – importance of codes from other perspectives as well. Cooperation and collaboration of records keeping and data coding between the hospital staff and compensation agency staff should be encouraged to create more comparability for these data sources. The study findings also suggested that claims datasets follow a more standardized approach of injury coding as recommended by the ICD systems (nature and cause codes), so that their data can be effectively used and compared across other sources and studies.

8.1.2 EPIDEMIOLOGY OF WORK-RELATED SAWMILL INJURY

The epidemiological investigation using the hospital discharge records found the overall injury rate for work-related hospitalization to be 5.4 per 1,000 person years during the ten-year follow-up period. During the study period, the most frequent causes of injury were machinery related, falls and being struck against, and in terms of body parts, the hand & finger were associated with a third of all injuries followed by the leg, knee & ankle, which made up one fourth. The job groups that were at high risk of sustaining serious injuries were skilled trades followed by machine operators, attendants, clearers & sorters and material handling & unskilled workers.

As sawmills worldwide are to some extent comparable in the work processes, use of tools and equipment, and handling of materials; epidemiological findings like these in British Columbia should be relevant to other jurisdictions. Information on the types of injuries and job categories at higher risk can be used to inform designing of targeted and essential workplace safety interventions in sawmills in British Columbia and around the world.
Studies like this focusing on the descriptive epidemiology of injury update on the proximal etiology of injuries. Though, new advances in the prevention of such injuries will necessitate a more systematic approach to understanding the complex array of factors that influence the incidence and outcomes of injury. Simultaneously, it is important for investigators to conduct rigorous evaluations of new interventions to better inform the establishment of programs and policies.

8.1.3 ECONOMIC CONSEQUENCES OF WORK-RELATED INJURY

Thus study reported that the median costs for non-health care services (in 1995 Canadian Dollars) were $16,559 per injury and for healthcare were $4,377 per injury during the study period (1989-1998). Our study identified the injury categories that had a high probability of resulting in long-term disability (for example, caught in or between, and fire, flame, natural & environmental). By median costs, fire, flame, natural & environmental was identified as the most costly causes of injury.

It also suggested that a substantial amount of the costs of work-related serious injuries remained un-captured or uncompensated. About 10% of the serious and acute work-related injuries were not matched to a workers' compensation claim. The injuries without a workers' compensation claim were associated with 9% of the total costs of $12.14 million. These costs were eventually transferred to other parts of the social safety net including the public health care system.

This study also investigated hospital costs separately as incurred following an injury as it makes up a large component of the total healthcare costs. Costs were estimated from the health care system's perspective. Fire, flame, natural & environmental had the longest median stay (18
days) in hospitals and the highest median cost ($10,575). These findings highlight the high expenses associated with the treatment of acute work-related injuries, much of which results from the length of hospital stay. The provincial compensation agency apparently did not compensate 12% of the total hospital costs ($434,990).

Findings on the cost of workplace injury play an important role in occupational safety initiatives. Knowing the associated costs and the category of costly injuries are helpful to the employers, compensation officials, and other stakeholders to identify vulnerable job groups and work processes. Findings on costs highlight that avoiding one injury event can save significant amount of resources and also help to estimate how cost-effective an intervention is. This information can then be used to design and implement targeted preventive measures within an industry. Injuries among employed persons are to be appropriately compensated so that policy and prevention decisions are based on accurate and complete burden; otherwise, the costs of some work-related injuries will continue to be paid by other social safety mechanisms. The hospitals and compensation agencies should work together to resolve some of these issues regarding identifying and billing all eligible injuries.

This study also highlighted that it is not mandatory for the traditional compensation system to compensate many of the costs associated with a work-related injury. The burden on the society for a long-term disability case is massive. The spouse and family members of an injured worker also suffer when the earning member’s work life is drastically shortened because of an injury. Quality of life and other methodological research is ongoing to study the costs of pain, suffering and other emotional consequences. From the employer’s side, costs associated with loss of productivity, hiring and retraining, loss of employee morale are huge but so far remain unstudied. Methods to estimate most of these costs associated an injury are yet to be developed.
The implications of the study findings will be different for the employers, employees, workers' compensation system and the public health care system. For example, if more injuries can be identified as work-related than compensated, to reimburse for those cases workers' compensation system might try to charge higher premiums from the employers; employers might try further to implement better safety environment to avoid a raise in the premiums and improve employee morale and productivity; employees, through unions, might try to push for proper compensation from the compensation system and might suggest the employers to provide safer workplaces; the public healthcare system might try to recover some of the healthcare costs from the compensation system.

8.2 STUDY STRENGTHS AND LIMITATIONS

8.2.1 STRENGTHS

This study has a number of specific strengths that enhance the credibility of the results. First of all, it used two administrative data sources. These data are collected for administrative reasons, and are readily available, easy to access, and inexpensive. These are especially suitable for retrospective studies covering longer periods of observation. Hospital discharge records have detailed information on the injuries and the records are collected objectively. Workers' compensation claims data represents an important source of information on work-related injuries. These are compiled using officially reported and accepted claims, and provide detailed information on the causes and costs of injury.
Secondly, it used a large study population from large, unionized sawmills. The population was employed in an important and high risk workplace setting to investigate the work-related injury surveillance. Their detailed demographic and work-history information was collected as part of previous studies. The job history had information on each job they held during their work life in sawmills and the exact start and end dates.

Thirdly, to link and match the claims records with the hospitalization records, this study did not use any complicated formula; it relied simply on injury diagnosis and date information. This should make it easy to replicate such linking in other jurisdictions for such data sources.

For economic analyses, the actual compensated costs for each claim were captured rather than estimating these from secondary sources or using average claim costs. The dollar values were expressed in constant Canadian dollars by using consumer price index and discount rates.

For estimating hospital costs this study used a detailed and accurate collation of billing charts from which costs were derived- the billing rate was year and hospital specific. Each patient-day was accounted for. Use of the cost per weighted case or Cost per Resource Intensity Weight (RIW) methodology was avoided as it is fairly complicated, not fully developed or verified. This is not also how the hospitals currently bill the compensation agency for work-related hospitalizations.

Finally, this study's use of hospital discharge records is itself a strength. Because of the public health care system in Canada which provides comprehensive coverage of hospitalizations at the population level, hospital data has potential to capture serious injuries. Almost all eligible residents of BC are enrolled with the provincial Medical Services Plan and the plan captures all
medical services records of physicians, specialists, other health care practitioners, laboratory services, and diagnostics services and hospitalizations.

8.2.2 LIMITATIONS

As with any study, this one is not without limitations, but none of this significantly affected the findings.

Use of hospital discharge records precludes any injury that does not reach hospitals. Thus, this study captured and focused only on serious injury. Hospital discharge records will never be an independent tool in the strict sense. But it was assumed that serious enough injuries require more attention as they result in more misery and suffering for workers and consume more resources of the society. Moreover, it is expected that most of these significant cases be compensated and should have matching claims in the workers’ compensation datasets.

This study depended heavily on the accuracy of the codes available in hospital data. However, numerous studies outside Canada and inside Canada have used hospital discharge datasets and other administrative datasets. The reliability and validity of hospital records were favorably examined by some studies. Use of electronically available administrative data is increasingly becoming common in research studies.

There is no gold standard for work related injury surveillance tools. The workers’ compensation agency does not capture, accept, or report on all injuries. While there are complaints of underreporting to the workers’ compensation authority, it should be sensitive enough to capture information on injuries severe enough to reach a hospital. Matching of a work related hospital record with actual claim can help validate compensation records as a potential surveillance tool.
Another limitation of the study was unavailability of data on rejected claims in the workers' compensation dataset. If this data were available, it would have been possible to differentiate between injuries identified in the hospital discharge dataset that were never recognized by the compensation system versus those that were submitted and subsequently rejected. This information will add value to such study by investigating the agreement of rejected claims with the responsibility of payment and place of occurrence fields. However, even with rejected claims data it would not be possible to differentiate between claims that were appropriately versus inappropriately rejected. An underlying assumption in this thesis is that claims identified as potentially work-related were indeed work-related.

Despite the favorable comparison between data from the hospitalization database and compensation databases, this study cannot establish the true validity of clinical data from the compensation databases because the hospitalization database is not a gold standard; but the agreement between these two independent sources of data lends some credence to the clinical information that can be ascertained from claim records.

This study had a number of limitations in its linking methodology. A 1-month window beyond admission and separation dates was used for the initial linkage strategy. This captured primarily acute work events needing immediate health care attention; injuries that were admitted to hospital after a long latent period were excluded from our linking strategy.

A broad injury category rather than exact ICD-9 code was used to match the linked cases that occurred during the 1-month window between the two data files. This was allowed because the injuries were coded by two different organizations, which should be able to match on broad injury categories but not necessarily on the specifics of the injury. However, an individual might
sustain two injuries within the time window, which were of same broad category injury, but were indeed different events. A matching criterion of even 1 day could also link two disparate events.

The WCB file does not have detailed information on injuries for health care-only claims—which limits its use as a comprehensive data source for all claimed injuries. But this study looked at serious injuries requiring hospitalization, which were unlikely to be health care only claims.

The costs estimated were not comprehensive for all injuries in this sector. Cost information was available up to 2005, which provided 7 years to develop costs for all the injury events studied, as the last injury captured in our study occurred in 1998. However, it is likely that major costs were developed within the first 7 years after an injury event.

The method of using daily charge for hospital stays has limitations. For example, it considered all injuries consumed similar amount of resources per day. However, when exploring the billing relationship between the hospitals and the compensation agency, it is appropriate to use this rate. This study argues that when Ministry sets the daily rates, it should incorporate overhead and administrative costs of the hospitals into it.

The cost estimates were likely to be underestimates of societal costs because the perspective of the workers' compensation agency was taken. 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 or spouse/family members, ambulance fees, retraining, recruiting, and overtime costs for the employers. There was insufficient information available to include all these costs. However, as the compensation agency covers some important cost components associated with an injury, the costs captured in this study should have included most of these significant costs.
8.3 FUTURE RESEARCH

This thesis highlights the needs of and helps to guide future research studies to enrich the understanding of surveillance of occupational injury and the associated economic consequences. Foremost, it suggests and recommends the use of hospital discharge records as a potential source of information on serious work-related injuries. Occupational health researchers can use this rich data source to study acute and serious injuries across different regions, industries, occupational groups and study populations.

It suggests that future studies should describe injuries among a working population by nature, cause and body parts involved, and follow a more standardized approach in reporting them so that study findings can be compared and generalized with greater ease. It also establishes the validity of workers' compensation data sources so that injury researchers and policy makers can use this information with greater confidence. Further research is warranted to enhance validity of and comparability between the hospital records and claims records. Future research should also target to establish validity and reliability of other commonly used administrative data sources in occupational safety. Studies with larger working population from a mix of different industrials sectors will help better determine the accuracy of injury coding in such data sources. They might also suggest better ways of linking and matching different data sources.

The workers' compensation agencies should solicit and undertake investigations why some segments of the working population are not reporting or getting compensation for work-related incidents. The barriers that prevent them from claiming (for example, language and unfamiliarity with the system) need to be identified in today's workplace, which is more
multicultural and multiethnic than ever before. More studies should look into other likely barriers- discouraging supervisors and colleagues, age and experience of workers, sex, physician participation, delay in compensation, etc.

Future cost studies might incorporate 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 or spouse/family members, ambulance fees, retraining, recruiting, and overtime costs for the employers. As 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, future studies should look into it, and estimate how much of the total costs the provincial compensation bodies are covering, and what other cost categories should be covered by them instead of shifting the burdens to the employees, employers, or other social safety nets. Additional studies can explore how much is the retraining, hiring, and training cost to the employers to replace an injured worker. Such findings will encourage employers to instate interventions to save their own resources. The short-term and long-term disability costs the compensation systems are paying should be investigated to see how much the injured workers are actually getting compared with the earning trajectory of non-injured workers with similar education and experience.

Future hospital cost studies could improve upon this study by incorporating differential resource consumption patterns by injury cases within each hospital. Further research is also necessary to identify the circumstances surrounding the diversion of these costs from the workers’ compensation system to the public health care sector.

Future epidemiological investigations can compare and contrast risk factors of all work-related injury and hospitalized work-related injury. Extracting detailed information on the work
history of the workers including the tasks they perform in a job, the work processes, the physical hazards, age at hire, and experience at different jobs will help elaborately and credibly assess the safety hazards in an industrial sector.