BACK INJURIES AMONG SAWMILL WORKERS

by

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ABSTRACT

Despite the high rates of injury in British Columbia's sawmill industry no studies have specifically investigated back injury, which is one of the leading causes of work-related disability. To fill this gap, a study was devised and carried out to describe the rates and identify the risk factors associated with back injury in sawmill workers. Rates of back-related compensation claims and hospitalizations were calculated for workers employed for at least one year between January 1, 1987 and July 31, 1997. Person time at risk was determined from work history records that were available for each worker. During the study period, there were 566 compensation claims and 154 hospitalizations for back injury, representing rates of 1.35 and 0.35 per 100 person years. Rates of both compensation claims and hospitalizations varied during the study period, which may be attributed to changes in the labour market and physician practices. In addition, rates of compensation claims decreased with longer duration of employment.

A nested case-control design was used to identify physical and psychosocial risk factors associated with back-related compensation claims and hospitalizations. Results revealed that workers that had more physically demanding jobs had a higher risk of injury compared to workers that had less physically demanding jobs. As well, workers with one or more physical risk factors in their job were at a higher risk of back-related compensation claims than workers with no physical risk factors in their job. Of the psychosocial risk factors studied, job control was found to be associated with both back-related compensation claims and hospitalizations: workers with more job control had a lower risk of injury. Noise exposure was found to increase the risk of back-related

compensation claims; although the risk was lower in the highest level of noise exposure, suggesting that workers in this category used hearing protection more frequently.

This study was the first to examine the rates and risk factors associated with back-related compensation claims and hospitalizations among sawmill workers. In addition to providing this information, this study also addressed some of the methodological limitations in prior occupational back injury studies.

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CHAPTER 1 Introduction and literature review

1.0 General introduction

Canadian sawmill and planing mills are the country's leading wood products manufacturers, shipping $17.5 billion worth of products and employing approximately 65,000 workers in 1997 [1]. British Columbia (BC) has the country's largest sawmill industry, producing forty six percent of Canada's lumber [2], and employing thousands of workers [3]. In addition to being one of the largest industries in BC, the sawmill industry is also one of the most hazardous and physically demanding. From 1991 to 1995, the injury rate in this industry ranged between 8 and 10 injuries per 100 person years of employment, well above the injury rate of approximately 6 injuries per 100 person years of employment for all other industries combined [4].

Yet despite the industry's high rate of injury, there is no published research specifically on the rates and the risk factors for back injuries, which is the leading cause of work-related disability in the developed world. This lack may, in part, be due to a limited access to an established study population. The Workers' Compensation Board of BC does report rates of injury; however, their rates are not specific to back injuries and they are based on estimates of the number of workers employed, which result in inaccurate rates.

The present study is the first to produce accurate rates and identify risk factors associated with back injury by using a cohort of sawmill workers in BC that has been constructed and used to study the health impact of many occupational exposures [5, 6]. In addition, a health database exists in BC in which medical, hospital, and workers' compensation records have been linked to each other for the purposes of research.

Using these data sources, the objective of this thesis is to study back injury among a cohort of sawmill workers. The specific objectives of this research are to determine the rates of compensation claims and hospitalizations for back injury in a cohort of BC sawmill workers, and to understand the risk factors associated with back injury resulting in compensation claims and hospitalizations.

The results of this research will provide a better indication of the burden of occupational back injury in a population of sawmill workers, which can be used to allocate resources for injury prevention. As well, by identifying some of the potential risk factors for back injury, the sawmill industry can implement the relevant control measures to reduce the risk of back injury.

2.0 Thesis structure

In addition to the General Introduction, this chapter provides a review of the literature on the epidemiology of occupational back disorders, the physical and psychosocial risk factors for back injury, the use of administrative databases for the purposes of health research, the use of compensation claims and hospitalizations as outcome measures, and studies that have been conducted on sawmill populations with respect to injury or working conditions.

After Chapter one, there are three other chapters that form this thesis. Chapter two is a paper on the rates of back injury in a sub-cohort of workers from the BC Sawmill Cohort study. This paper describes the rates of compensation claims and hospitalizations for back injury, and interprets the results in the context of other studies. Chapter three is a paper on the risk factors for back injury using compensation claims and hospitalizations as outcome measures. This paper addresses the limitations from previous studies investigating the impact of psychosocial factors, and examines the relationship between noise exposure and back injury. Chapters two and three are prepared as articles to be submitted to peer-review journals.

Chapter four provides a summary of the main findings of the studies presented in this thesis, as well as some direction for further research in this area.

3.0 Epidemiology of occupational back disorders

Back disorders are the most prevalent of musculoskeletal conditions, affecting 60 to 80 percent of individuals at some point in their lifetime [7-9], and 11 to 33 percent of the population at any given time [8, 10]. Despite efforts to understand the causes of back disorders, they remain a major health and socioeconomic concern in the developed world. In an editorial, Waddell [11] points out that there have been advances in knowledge and greater resources devoted to the issue of back pain, yet the problem of back pain has become progressively worse.

Back disorders are one of the leading causes of work-related disability in industrialized countries [12]. About one quarter of compensation claims [13, 14] and one third of all compensation costs are back-related [15]. An estimated 8.8 billion dollars was spent on low back pain claims in the United States in 1995 [16]. In British Columbia (BC), Canada, the Workers' Compensation Board accepted 90,700 back strain claims from 1997 to 2001, which accounted for over 785,000 days lost and over 661 million dollars in compensation costs [17].

Rates of reported compensated back injury have varied depending on the study population used. For example, analyses of workers' compensation data from twenty six US states revealed a rate of 0.75 claims per 100 workers in 1979 [14]. Similarly, a rate of 0.6 claims per 100 workers in 1995 was found using workers' compensation provider data that covered the privately insured labour force in the US [16]. However, Volinn et al. [18] found that the rate of compensated back injury was sixty times greater in Washington than in Japan. Rates of back-related claims also depend on occupation, industry, and level of work experience. Higher rates are generally found in more physically demanding occupations and industries [14], and among workers with less experience [19].

Few studies have reported rates of back-related hospitalizations, even though they may be associated with more serious cases of injury [20]. In 1996, more than 7,000 (0.4%) of the 1.6 million actively employed workers in Finland were hospitalized due to a back disorder; most worked in physically demanding industries and occupations [21]. Over a

28 year follow-up period, eight percent of workers employed in four factories in Finland were hospitalized for a back disorder [22]. Among 57,000 Finnish men and women, 1,537 back-related hospitalizations were reported, for a rate of 0.28 hospitalizations per 100 person years [23].

4.0 Occupational risk factors for back disorders

An estimated 37% of the global low back pain burden has been attributed to occupational factors [24]. In the past several decades, hundreds of studies have been conducted to identify occupational risk factors, which researchers have generally grouped into three categories – physical, psychosocial, and individual. This literature review focuses primarily on physical and psychosocial factors.

4.1.Physical factors

Physical factors cause injury by imposing loads on the spinal structures that exceed their tolerance level. The etiology of back injury has been more specifically described using acute and cumulative models [25]. The acute model describes injury as a result of a single load large enough to exceed the tissue tolerance. This component is linked to certain activities such as falling [26] and lifting, and movements such as bending and twisting [27]. In contrast, the cumulative model represents injury as a result of repeated subfailure loads applied over time such as those associated with chronic exposure to factors such as lifting and sitting [28].

Physical factors consistently reported to be related to back disorders include heavy or repetitive lifting [8, 28-48], working postures [37, 41, 42, 44-52], and whole body vibration [28, 44, 48, 49, 53-55]. Several literature reviews have been conducted to summarize the findings, and examine the strength of association [38, 44, 56-60]. Two of the most widely recognized reviews on this subject have been conducted by Burdorf and Sorock [44], and Hoogendoorn et al. [56].

In their review, Burdorf and Sorock [44] examined 140 articles, but only 35 were considered to be methodologically acceptable. Sixteen out of 19 studies found a positive association between back injury, and lifting or carrying, with the risk estimate ranging from 1.1 to 3.1. Four out of seven found a positive relationship with heavy physical load (RR = 1.5-2.6). Nine out of 10 found an association with frequent bending and twisting (RR = 1.3-2.8). Thirteen of 14 studies found a relationship with whole body vibration (RR = 1.5-9.0).

More recently, Hoogendoorn et al. [56] conducted a systematic review based on 31 studies that were considered to be methodologically acceptable. Manual material handling (3 of 5 studies) was considered a strong risk factor for back pain, with the risk estimate ranging from 1.5 to 3.1. Bending and twisting (2 of 2 studies) were also found to be strong risk factors (risk estimate – 8.1). Three out of five studies found a statistically significant positive risk estimate of approximately 4.8 for whole body vibration. However, no evidence was found for standing or sitting as risk factors, both of which had been identified as risk factors in other reviews [58].

While most reviews have concluded that there is a relationship between back disorders and heavy and/or repetitive lifting, as well as a relationship with certain working postures, there is no consensus as to whether whole body vibration is a risk factor. When Lings and Leboefuf-Yde [61] conducted a systematic review of 24 studies involving whole body vibration published between 1992 and 1999, they found that in spite of improvements in study methodology, it is unclear whether the link between whole body vibration and back disorder is real and causal, or merely a self-perpetuating myth. In contrast, a slightly earlier review of 45 studies (only 17 were considered acceptable), concluded that a relationship does exist between back pain and whole body vibration [62]. A review of 40 studies by Teschke et al [63] also concluded a relationship between back disorders and whole body vibration.

4.2. Psychosocial factors

Physical factors have only been able to partly explain the high rates of back disorders. According to Walsh et al. [64], no more than 20% of the etiologic fraction of back symptoms can be related to physical factors. Consequently, recent studies have focused on understanding the psychosocial environment and its relationship to back injury.

Within occupational studies, "psychosocial" refers to the social aspects of the work environment and the psychological demands of work. Psychosocial stressors are factors that are perceived to be threatening or bothersome [65], or which place demands on individuals that result in a physiological adaptation response [66]. These stressors have been linked to many health outcomes including heart disease and vascular disease [67].

The classic model of job strain, which is used to explain how psychosocial factors affect health, hypothesizes that psychological strain and the resulting physiological illness are not a result of an aggregated list of stressors, but are in fact an interaction of two types of job characteristics – job demands and job control [68]. Job demands are characteristics of the work situation and job control is the freedom to make decisions to meet those demands. According to this model, psychological demands have a more adverse effect if they occur in an environment where the individual has less job control. Furthermore, psychological demands can be more devastating in situations with less social support.

There are several mechanisms through which psychosocial factors can operate. Firstly, psychosocial factors can act by directly influencing mechanical loading on the spinal structures by changes in movements, posture, and exerted forces [69, 70]. For example, a worker under time pressures may move faster or work in more compromising postures. EMG studies have found increased muscle tension when high psychological demands are present [71, 72].

Secondly, psychosocial factors can change the level of various chemicals in the body. For instance, increased muscle activity has been shown to reduce blood flow to muscles, resulting in the accumulation of metabolites [73, 74]. Studies have also demonstrated increased plasma cortisol levels [75], along with other sympathetic hormones, in response to high psychosocial demands. Increased levels of sympathetic hormones indicate that the body is in a catabolic state (as opposed to an anabolic state), during which the body mobilizes its energy reserves to meet increased demands. A prolonged period of time in this state prevents the body from rebuilding and repairing tissues, and consequently increases the potential for injury.

Thirdly, psychosocial demands can affect the perception or reporting of pain [76, 77]. Studies have demonstrated that depression or other mental illnesses increase sensitivity to pain [78]. Therefore, it is plausible that those who are under psychological stress may be more likely to report an injury than those in less stressful environments [74]. It is also possible that workers with stressful jobs may use their injury as a reason to stay off work in order to avoid potential stressors [79].

Several psychosocial factors have been related to back pain such as monotonous work [46, 80, 81], high perceived workload [80], mental stress [81, 82], social support [22, 46, 81-86], psychological demands [22, 83-85], and decision latitude [83, 84]. However, many of these results come from cross-sectional studies which are limited in their ability to infer causality. In addition, many studies have used self-reported exposure and outcome information, which increases the potential for common method bias [87]. Meanwhile, others have failed to adjust for the confounding effects of physical demands [86], despite the evidence of the importance of physical exposures and studies demonstrating a relationship between physical and psychosocial factors [88, 89].

A number of reviews have been conducted to better understand the relationship between psychosocial factors and back disorders [44, 74, 90-94]. In the most recent systematic review, Hartvigsen [92] reviewed 40 prospective cohort studies of population-based samples or working population samples dealing with low back pain or consequences of low back pain (i.e. filing a compensation claim, sick leave, delayed return to work). The review examined 30 psychosocial variables and grouped them into four categories: 1) perception of work; 2) organizational aspects of work; 3) social support at work; and 4) stress at work. Using their predetermined criteria, the authors reported that there was moderate evidence for no positive association between low back pain, and perception of work, organizational aspects of work, and social support. Insufficient evidence was found for a positive association between stress at work and low back pain. In relation to the consequences of back pain, the authors reported that there was insufficient evidence for an association with perception of work, strong evidence for no association with organizational aspects of work, and moderate evidence for no association with social support at work and stress at work.

Hoogendoorn et al. [90] reviewed 11 cohort and two case-control studies; although only nine cohort and one case-control study were considered to be of high quality. The authors found insufficient evidence for work pace, qualitative demands (e.g. conflicting demands, interruption of tasks, and intense concentration for long periods), job content, job control, low decision latitude, and psychosocial factors in private life as risk factors for back pain. However, strong evidence indicated that work-related low social support and low job satisfaction were risk factors for back pain, with the risk estimates ranging from 1.3 to 1.9 and 1.7 to 3.0, respectively. In addition, the authors also noted that physical factors need to be adjusted for because of their potentially confounding effect on psychosocial factors.

In 1993, Bongers et al. [93] conducted a qualitative literature review because studies were too heterogeneous with respect to study design, measurement of outcome, and the psychosocial variables studied to combine into a meta-analysis. Twenty nine cross-sectional and three longitudinal studies were found assessing the relationship between psychosocial variables and musculoskeletal disorders. The authors found evidence to support the relationship between musculoskeletal symptoms, and monotonous work, perceived work load, and work under time pressure. They also found support for the association between social support and musculoskeletal disorders, although the results were inconsistent. The authors commented on the need to control for physical demands since many jobs with poor psychosocial environments have high physical demands. As well, the authors cautioned against studies that used both self-reported exposures and outcomes.

4.3.Noise exposure

Noise exposure works in one of two ways to influence the risk of back injury. The first is that it can prevent workers from recognizing potential hazards [95]. Moll van Charante [96] found that the risk attributed to noise and hearing loss accounted for 43% of injuries in a Dutch shipyard. The second mechanism is via changes in hormone levels. Chronic exposure to noise has been demonstrated to elevate circulating catecholamines [97], which, as previously described, is an indication that the body is in a catabolic state. Catabolism favors energy mobilization instead of energy storage, which prevents the body from fully repairing and regenerating itself, thus increasing the risk of injury.

Several studies have found elevated levels of noise exposure in sawmills [98-103]. Koehncke et al. [98] assessed the level of noise exposure in nine Alberta, Canada sawmills using personal and area noise measurements. Based on personal measurements from 213 workers, only 10 percent of the noise readings were below the acceptable exposure limit (to prevent hearing loss) of 85 decibels. Furthermore, the majority of measurements in all mills were between 85 and 94 decibels.

The effects of noise exposure on sawmill workers has been studied by Frankenhaeuser and Gardell [104], who found that workers complained of their exposure to noise, commenting that "it takes hours for the noise and the machine paced tempo of the mill to disappear from the mind and body". In the same study, the authors reported higher levels of circulating catecholamines in workers exposed to chronic noise.

4.4.Individual factors

Several individual factors have been linked to back disorders including job duration [19], age [105], gender[69], and prior back injury[106]. Others have reported associations with smoking [107], and obesity [108], although recent reviews have concluded that there is insufficient evidence for these factors [109, 110].

5.0 Previous studies of sawmill workers

To date there have been no epidemiological studies of back injuries among sawmill workers. A few studies have examined injuries in general [111] [112], while others have investigated working conditions in sawmills [104, 112, 113].

Frankenhauser and Gardell [104] examined the concepts of stimulus underload and overload and their impact on circulating catecholamine levels using a Swedish sawmill population. In their pilot study, the authors compared "machine-paced" workers (graders and edgermen) and "man-paced" workers (maintenance) and found that machine-paced workers were exposed to elements of both underload and overload. Referring to machine-paced workers, the authors stated, "they are required to make skilled judgments at very short intervals under conditions which are rigorously controlled by the machine system". Machine-paced workers also had higher levels of noise exposure, and experienced more job strain and ill health than man-paced workers. Additionally, catecholamine output was found to be decreasing towards the end of the day in the man-paced group, whereas in the high-risk group it was increasing. The authors concluded that "the high catecholamine levels and the high frequency of psychosomatic symptoms as well as other signs of stress and maladjustment manifested by the high-risk group, is because of the monotonous, coercive, machine-paced nature of their work".

Ager [113] examined noise levels, physiological demand, and psychosocial conditions among 700 sawmill workers. More than 70% of workers had noise levels above 85 decibels, high enough to impair hearing. Working postures were considered to be a problem in most mills, and many workers considered work to be hectic and mentally strenuous. The majority of sawmill workers (75%) revealed that other than the financial rewards, there was no satisfaction in their work.

Punnett [112] conducted a case-control study to investigate potential risk factors for injury among sawmill workers. Results indicated that cases were more likely than controls to be in machine-based jobs and exposed to dangerous work methods and materials, and they were also more likely to experience louder noise levels and faster work pace, higher lifting demands and more frequent awkward postures, and lower decision latitude and social support. In addition, multivariable analyses revealed that high physical demands were a risk factor, while decision latitude and social support provided protection. Having less than one year of experience in the current job and not being able to take a break when needed were also risk factors.

After reviewing the studies on the occupational risk factors for back injury, as well as those assessing the physical and psychosocial risk factors in the sawmill industry, it is clear that a multifactor study of occupational back injury among sawmill workers is needed.

6.0 Use of administrative databases for research purposes

6.1.Background

One of the first studies using administrative data for the purposes of health research was published in the early 1970's [114]. In this study, administrative databases were used to describe patterns of hospitalizations in the state of Vermont. The use of administrative databases has since become a common tool to understand population health trends [115, 116], monitor patient outcomes [117], and determine the efficacy of various treatments and medical interventions [118].

Administrative databases generally comprise information routinely collected from compensation agencies, medical services plans, and hospitals for the purposes of billing and accounting (service providers submit claims in order to be reimbursed). Several characteristics make administrative data an appealing tool for health research such as their readiness, wide geographic coverage, and relatively complete capture of episodes of patient contact with the health care system [119, 120]. Many health institutes or agencies support the use of administrative databases, including the National Institutes of Health (e.g. [121]), the Agency for Health Care Research and Quality (e.g. [122]), the Health Care Financing Administration (e.g. [123]), and the Department of Veterans Affairs (e.g. [124]).

In Canada, the use of administrative databases began with the establishment of the Manitoba Centre for Health Policy and Evaluation and their development of POPULIS, a health information system [125]. In British Columbia, the BC Linked Health Database (BCLHD) was constructed in 1996 by the Centre for Health Services and Policy Research [126]. The BCLHD is a data resource for population health research, which contains individual level information on health care service use, as well as claims made to the Workers' Compensation Board. This database has the ability to link hospital, medical services, and compensation files allowing researchers to study health utilization and compensation trends for a given individual in BC.

Despite the relative importance and potential impact that the BCLHD has on health research, there are no published studies assessing the validity of this database for research purposes. Allan et al. [127], explored the usefulness of the BCLHD as a source of information to inform health care decision making and policy development in palliative and end of life care. Although the authors found administrative databases to be an important source of longitudinal information on health service utilization, they discovered many limitations surrounding the type of information available in the database for their specific research needs.

6.2. Validity of administrative databases

Numerous researchers have addressed the issue of validity of administrative databases [128-137]. Researchers generally consider two questions pertaining to the validity of administrative databases: 1) whether data diagnoses and procedures in administrative databases match other records, and 2) whether administrative data provide a complete or sufficient clinical picture [138].

Although the results tend to be mixed, in general there is a high level of support for administrative databases. Using medical charts as the standard, Petersen et al. [139] examined data from the Veterans Affairs Administration for 5,151 discharges. The positive predictive value of acute myocardial infarction in the primary coding position was 96.9%. Quan et al. [140] examined the accuracy of procedural codes in administrative databases by using medical charts as the standard. Twelve hundred procedures were randomly selected over a one year period. Thirty five procedures were studied and the sensitivity varied from 0% to 94%. Of the six major procedures studied, five had relatively high sensitivity (69% or more), and one had a low sensitivity (41%). The sensitivity of lumbar puncture, the only back-related procedure, was 69%. Muhajarine et al. [132] examined the overall agreement in detecting hypertension between self-report and clinical measures, and physician claim data. The overall agreement was moderate to high: 82% (kappa = 0.56) for self-reported and physician claims hypertension; and 85% (kappa = 0.60) for clinically measured and physician claims hypertension.

The question of whether administrative databases provide a complete or sufficient clinical picture has been addressed by Cooper et al. [141] who assessed the validity of measuring tumor stage using Medicare claims data. They found that Medicare claims data were accurate with regard to cancer diagnosis, but limited in their ability to provide detail about cancer stage. Lacasse et al. [142] examined the validity of diagnosing COPD from an administrative database and found that for patients over 65 years of age COPD was twice as prevalent in administrative databases than a national population health survey.

6.3.Strengths and limitations of administrative databases

Population coverage is perhaps the greatest advantage of using administrative databases. For example, in the 1993/94 fiscal year, over 4.1 million individuals were enrolled in the BC Medical Services Plan [143]. Administrative databases also allow for comparisons across populations, countries, and systems of care, given that there are common elements in a compatible format [138]. Since data in administrative databases have already been collected, both the costs and time required for data collection are reduced, especially for long-term follow-up of cohorts. As well, loss of follow-up is less of an issue when using administrative databases, as opposed to traditional methods of follow-up [144]. Biases such as recall and non-response bias are also less likely to be present in administrative databases [132].

Since administrative databases contain identifiers such as social insurance number, birth date, and name, it is possible to link administrative data with other sources. These linkages allow medical services data with compensation data and vital statistics data, as well as data from cancer agencies to be linked, for example, with employee records from occupational cohort studies. As well, administrative data can also be linked with group level data such as geographic location or census variables.

Despite these advantages, there are some weaknesses in administrative databases. Some researchers argue that the use of secondary data is invalid because the data was not collected for the purposes of research and investigation, but instead for the purposes of payment, and quality is highest for items that are directly associated with payment [138].

As a result, detailed clinical information is generally not included in administrative databases. In addition, fields may be present in administrative databases that may not be required for payment and consequently may contain information of variable quality. For example, in the United States the form used to submit hospital insurance claims for payment, the UB-92, has a field for reporting the mechanisms of injuries (i.e. ICD-9 E codes). However, Virnig (unpublished data; as cited in [138]) reported that the mechanism of injury field is frequently not coded on this form.

7.0 Use of compensation claims and hospitalizations to study back injury

7.1.Compensation claims

Compensation claims have often been used as outcomes for studies because they provide an objective indication of injury. Additionally, compensation records supply detailed injury related information on the nature of injury, source of injury, and body part injured, as well as any associated medical costs. However, the use of compensation claims to represent injury is limited by the fact that there are often non-injury factors that are related to the adjudication of claims. For instance, Rosenman et al. [145] revealed that only 25% of workers with a diagnosis of a work-related musculoskeletal disorder filed a compensation claim. Some of the factors associated with filing a claim included increased duration of employment, lower annual income, and worker dissatisfaction with co-workers.

A telephone survey in Connecticut revealed that of the 292 respondents with self-reported or doctor diagnosed work-related upper extremity pain, approximately 10% had filed a compensation claim [146]. Hirsh et al. [147] found that union workers were more likely to file a claim than non-union workers. Some of the reasons were because unionized workers were provided with information from union representatives, supervisors were more likely to inform workers and less likely to discourage them from filing a compensation claim, and workers were less likely to fear being penalized for filing claims.

Jefferson and McGrath [148] calculated the incidence of back pain among workers in an airport engine factory using self-report, workers' compensation records, and medical records. Forty one percent of workers had clinically significant back pain, and 69% had self-reported back pain in the past year. However, occupational health records revealed that only 27% had back pain, while only 2.3% lost work because of their back symptoms. Pransky et al. [149] discovered that only five percent of workers officially reported an injury or illness in the past year, although 85% experienced work-related symptoms, 50% had chronic work-related problems, and 30% lost time from work or experienced work-restriction because of their injury or illness.

Although research has demonstrated that compensation claims tend to underreport injuries, they are likely to represent more serious cases of injury. Shannon and Lowe [150] used a survey to gather information about work-related injury in the Canadian population. Out of 2,500 respondents, 143 had been injured but 57 had not filed a compensation claim. The strongest predictor of filing a compensation claim was severity of injury.

7.2.Hospitalizations

Hospitalizations for back injury represent the most serious cases. As such, it is valuable to study individuals with injuries requiring hospitalization since they tend to be associated with the most disability and the highest economic costs. However, using hospitalizations to represent injury can be problematic since rates have been shown to vary considerably by geographic area [151] , suggesting that physician practices may influence decisions about whether to hospitalize a patient.

Cherkin et al. [152] examined rates of back surgeries among eleven developed countries and found that there was a 40% higher rate of surgery in the United States than any other country. Wennberg et al. [153] found that residents in Boston were four times more likely than residents of New Haven to be hospitalized with the same diagnosis, even though the cities are demographically similar. Variation in hospitalization rates by geographic areas have also been reported by others [154, 155]. While some have attributed the variation in rates to socioeconomic differences [156], others have credited it to differences in medical practice styles. According to estimates, 98% of the variation was due to differences in practice styles ([157] as cited in [158]) and only a small portion of the variation could be attributed to sociodemographic characteristics, compensation claim rates, or physician or bed supply [154].

In addition, studies have also found differences in hospitalization rates over time, which are considered to reflect changes in medical practice. Analyses of the US National Hospital Discharge Survey from 1987 to 1990 showed a 55% increase in surgical operations for low back pain from 147,500 in 1979 to 279,900 in 1990, corresponding to 102 and 158 per 100,000 adult person-years, respectively [155]. However, during the same period non-surgical hospitalizations decreased from 580,500 to 265,000, representing rates of 402 and 150 per 100,000 adult person years, respectively. Lavis et al. [159] compared trends of hospitalizations for neck and back pain between Washington, USA and Ontario, Canada and found that the rate of medically treated cases decreased by 75% and 52%, respectively between 1982 and 1992. In contrast, the rate for surgically treated cases in Washington and Ontario increased by 35% and 14%, respectively during the same period.

Overall there are some validity and data depth issues surrounding the use of administrative databases; however, there are some advantages to using administrative databases such as their readiness for use and wide demographic coverage. In addition, although administrative databases have rarely been used in the occupational health field, they provide the opportunity to supplement hospitalization data with more detailed injury data from compensation databases.

8.0 References

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CHAPTER 2 Rates of back-related compensation claims and hospitalizations in a cohort of sawmill workers[1]

1.0 Introduction

Occupational back disorders are recognized as one of the main causes of work-related disability [1]. Back-related injuries represent approximately one quarter of all workers' compensation claims [2-4], and one third of all compensation costs [5]. The resulting global economic burden is enormous, with estimates of £12 billion in the UK in 1998 [6], and $27 billion in the US in 1988 [7].

A number of studies have reported rates of compensated back injury; however, results have varied depending on the study population and the definition of back injury. Peek-Asa et al. [8] reported a rate of 4.4 acute low back injuries per 100 full-time equivalent (FTE) among workers aged 45 through 54 in a cohort of material handlers. Klein et al. [3] reported rates of compensation claims for back injury ranging from 0.2 claims per 100 employees in the finance industry to 1.6 claims per 100 employees in the construction industry in 1979. Using only initial back strain/sprain compensation claims, Abenhaim and Suissa [9] reported an overall rate of 1.37% among Quebec workers. Many of these studies, however, have been limited by the use of census or payroll data to calculate rates, instead of more accurate measures of person time at risk.

Despite the variability in rates, there are certain risk factors that are commonly associated with back injury. These factors include heavy or repetitive lifting, working postures, and

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whole body vibration [10, 11] as well as individual factors such as duration of employment [12] and prior back injury [13]. More recently, occupational back injury has been associated with psychosocial factors such as monotonous work and working under time pressure [14], although the evidence is not as strong as it is for some physical and individual factors.

Work environments that are organized according to the principles of the moving belt - where tasks are machine-paced, repetitive, and short paced - tend to possess both physical and psychosocial risk factors [15], and thus could be expected to have a high incidence of back injuries. Sawmills are a prime example of this type of environment, with assessments of sawmills revealing high physical demands [16], excessive noise exposure [16, 17], and poor psychosocial conditions [15]. Certain types of sawmill workers, such as edgermen and graders, are required to make skilled decisions while working at a constant machine pace, with little opportunity to leave their workstation or take breaks at their own discretion. Furthermore, they are often required to work in awkward or static postures, must sometimes work on vibrating surfaces, and are frequently exposed to excessive noise. It is not surprising, then, to learn that sawmill workers are, in fact, at extremely high risk for work-related injuries.

A study of sawmill workers in Maine, United States found the incidence of reportable injuries in 1987 to be 29.1 cases per 100 workers, more than double the statewide rate ([18], as cited in [19]). Based on Workers' Compensation Board of British Columbia (BC) (Canada) data from 2000 to 2004, the Wood and Paper Products sub-sector was responsible for 6.0% of all days lost [4]. During this period, the injury rate for this subsector was above the rate for all other subsectors combined [4].

Despite the high risk of injury to workers and the significant impact that sawmills have on the economy of many countries, few studies have investigated injury risk in this population. Punnett et al. [19] investigated reportable injuries among sawmill workers in Maine, and Barroetavena [20] studied injury mortality in a cohort of BC sawmill workers. However, no studies to date have specifically reported rates of back injury in sawmill workers.

The study of back injury is made even more difficult by its chronic nature and ability to progress over time in severity. In their attempts to understand these different levels of injury severity, researchers have previously used only one of many outcomes such as self-reported injury, workers' compensation claims, or hospitalizations. However, using multiple outcomes allows the researcher to study injury from more than one aspect. This study makes novel use of multiple outcomes, specifically compensation claims and hospitalizations, to provide a more definitive picture of the cumulative incidence of back injuries in a cohort of sawmill workers than previous research has allowed.

This more accurate information can be used for the purposes of allocating injury prevention resources. Additionally, this study will address some of the limitations of previous studies reporting rates of back injury, such as those concerning the use of census or payroll data to calculate rates, by using the actual days that employees have worked as the denominator in rate calculations.

2.0 Methods

The BC Sawmill Cohort study consists of approximately 28,000 workers who worked in 1 of 14 sawmills between 1950 and 1998 [21]. This cohort has been used to study fungicide [22], wood dust [23], and noise exposures [24] in the sawmill environment. As well, the cohort has been used to understand the health impact of downsizing and industrial restructuring [25, 26]. As part of these previous studies, socio-demographic and work history information were abstracted from personnel records at each mill. Probabilistic linkage techniques were used to link personnel records with hospitalization and compensation records contained within the British Columbia Linked Health Database (BCLHD) [27].

For this study, a subset of workers were selected that were employed for at least one year between January 1, 1987 - the earliest data that workers' compensation information was available, and July 31, 1997 - the latest date that all fourteen sawmills were followed. Person-years began at the latest of study start date or start of employment; and ended at the earliest of date of injury or hospitalization, date worker left the industry/employment, or study end date.

Using workers' compensation records, short-term and long-term disability claims related to back strains/sprains were identified. Back-related hospitalizations were identified from hospital separation records using International Classification of Disease Ninth Revision codes (ICD-9) [28], where the primary or most responsible diagnosis indicated a back-related hospitalization (Table 2.1). Since prior back injury increases the risk of subsequent injury, only the first compensation claim or hospitalization was included for workers that had multiple claims or hospitalizations during the study follow-up period.

The National Institute for Occupational Safety and Health Life Table Analysis System (LTAS) was used to generate a file with observed events, and person-time at risk for each combination of level of risk factors [29, 30]. Normally, LTAS is used to compare mortality rates in a cohort under observation with another, typically unexposed population, and generate standardized mortality ratios (SMRs). For this study, rates of compensation claims and hospitalizations for back injury in a referent population were not available; therefore, LTAS was used to distribute person time into categories defined by covariates of interest: race, age, calendar year, gender, and duration of employment. Race was categorized into Caucasian (reference category), East-Indian, and Asian. Nine categories of age were defined: <25 (reference category), 25-30, 30-35, 35-40, 40-45, 45-50, 50-55, 55-60, >60. Age categories <25 and 25-30 were grouped together for hospitalizations. Calendar periods were defined as prior to 1990 (reference category), 1990-1995, and after 1995. Duration of employment was categorized as 0-5 years (reference category), 5-10 years, 10-15 years, 15-20 years, 20-25 years, 25-30 years, and >30 years.

To further examine the patterns of compensation claims and hospitalizations for back injury, internal comparisons were made using the STATA POISSON regression procedure [31].

3.0 Results

3.1. Description of cohort and person-time

From the original BC Sawmill Cohort study, a sub-cohort of 6949 workers who had worked for at least one year between January 1, 1987 and July 31, 1997 was identified. One hundred and fifty-one (2.2%) workers in this sub-cohort were female. The majority of workers were Caucasian (86.5%), while 11.9% were East-Indian, and 1.6% were Asian. Average age at the start of follow-up was 39 years, with the median age being 37 years. Seventy-five percent of the cohort was below 48 years of age at start of follow-up.

Total person-time, when considering compensation claim as the time to event, was 41,828 person years. Alternatively, when hospitalization was considered as the time to event, the total person-time was 43,756 person years.

3.2. Compensation claim and hospitalization characteristics

The mean and median durations of all time-loss claims were 40.7 days and 18 days, respectively (Table 2.2). As expected, short-term disability (STD) claims (representative of time loss claims) had a considerably lower average duration (33.1 days) than long-term disability (LTD) claims (representative of permanent disability injuries) (202.8 days).

The average cost associated with STD claims ($6,004.92) was considerably lower than LTD claims ($197,839.40). Total days lost and costs associated with both STD and LTD claims were 22,951 days, and $8,386,477.54.

Information on the source of injury was available for 561 (99%) of the claims. The largest percentage (40.6%) of back injuries was associated with logs and tree products, followed by bodily motion (8.4%) and working surfaces (7.3%).

The mean and median duration of hospital stays for workers with a back-related hospitalization was 4.3 days and 3 days, respectively. Of the 154 hospitalizations, there were no procedure codes for 66 (43%). Of the remaining 88 hospitalizations, almost half (49%) of the procedures were related to the spinal canal, and approximately 17% were due to the spinal joint structures.

3.3.Rates of compensation claims and hospitalizations

From January 1, 1987 to July 31, 1997 there were 566 compensation claims and 154 hospitalizations for back-related injuries, representing crude rates of 1.35 and 0.35 per 100 person years. Rates of compensation claims were highest in 1990 to 1992, and dropped considerably from 1995 to 1997 (Figure 2.1). Hospitalization rates for back-related injuries decreased steadily from 1987 to 1992 and remained relatively constant for the remaining five years (Figure 2.2).

Rates of claims were highest among workers between the ages of 25 and 35 years (Table 2.3). The adjusted rate ratio (adjusted for the other covariates in the model) for workers between the ages of 25-30 was 1.69 (95% CI 1.08-2.65) and ages 30-35 was 1.61 (95% CI 1.05-2.47), compared to workers under the age of 25 years (Table 2.3). After age 35, there tended to be a decrease in the risk of injury: workers in the highest age category (>60 years) had the lowest rate ratio (Incidence Rate Ratio (IRR) = 0.73; 95% CI = 0.37-1.41). However, after adjusting for duration of employment (in addition to the other covariates), workers in the 50-55 year age category had the highest risk of injury (IRR=1.87; 95% CI = 1.15-3.05), and all age categories had an elevated risk compared to the reference category.

For the most part, crude rates of hospitalizations were consistent across age categories, with the exception of the highest age category (>60 years) having the highest rate of hospitalizations (0.46 per 100 person years) (Table 2.4). Among ethnic groups, East-Indian workers had the highest rate of hospitalizations (0.47 per 100 person years), with a rate ratio of 1.39 (95% CI 0.92-2.10); as well as compensation claims (1.65 per 100 person years), with a rate ratio of 1.27 (95% CI 1.02-1.59) (Table 2.3&2.4).

With increasing duration of employment in the industry, there was a reduced risk of compensation claims for back injury (Table 2.3). Workers employed for more than five years had less risk than workers employed for less than five years (Table 2.3). However, the same was not true for hospitalizations. With the exception of workers employed for five to ten years, the level of risk remained relatively constant among categories of employment duration (Table 2.4), although the lowest risks were observed among the most experienced group of workers for both claims and hospitalizations (25-30 years) and (>30 years).

4.0 Discussion

Although no other study has specifically reported rates of back-related compensation claims among sawmill workers, the overall rate (1.35 claims per 100 person years) in this study was comparable to other studies of working populations. In a study of Quebec workers compensated for back injury in 1981, the 1-year incidence of back injury was 1.37% [9]. Klein et al. [3] reported the incidence of back strain/sprain related compensation claims in the construction and mining industries to be 1.6 claims and 1.5 claims per 100 workers in 1979, respectively. Bond [32] and Leavitt [33] also found annual incidence rates for compensable back injuries among industrial workers to be around 2%. Volinn et al. [34] found a slightly lower rate of 0.58 back pain claims filed per 100 workers among Washington state employees in 1999.

There appears to a slight discrepancy, however, between the rates reported in this study and those of the WCB in BC. From 1991 to 1995, the short-term disability claim rates in the BC sawmill industry ranged between 8 and 10 injuries per 100 person years of employment [35]. If 25% of compensation claims are reported to be back-related [2-4], then the estimated rates of back-related compensation claims ranged between 2 to 2.5 per 100 person years of employment. Assuming that these estimated rates are representative of the entire study period; they are slightly higher than the rates in the current study. The discrepancy may be due to the differences in the way that the rates were calculated. The denominator for these rates was based on actual person time at risk extracted from employment records, while the denominator for the provincial rates was based on the number of workers employed estimated from payroll data. As well, the rates in the present study were based on only fourteen BC sawmills, whereas the provincial rates were based on all sawmills – some of which may have higher rates of injury than those included in the study cohort.

A considerable drop in the claim rates in 1996 and 1997 was observed, which may be reflective of some of the changes that were occurring in the industry at that time. From the early 1980's to the late 1990's, the BC Sawmill industry experienced restructuring and downsizing due to a recession in the province, which led to many workers being laid off. In the sawmill industry, like many other unionized type industries, layoffs are based on seniority level. Due to less experienced employees being laid off, coupled with the fact that by the late 1990's many sawmills were not hiring new employees, those who remained in the industry were most likely older and more experienced. Since rates of claims have been shown to be higher among more inexperienced workers [12], it is quite plausible that the drop in compensation rates in 1996 and 1997 may in part be attributed to a more experienced workforce. Another possible explanation for the decrease in compensation rates is that restructuring of the industry resulted in mechanization of jobs that were previously performed by unskilled workers. Many of the jobs that were eliminated by 1997 were heavy, noisy, low-control, unskilled jobs [36]. As a result, the jobs that remained in the industry were less physically and psychologically demanding, and presented a lower risk of injury.

Workers aged 25-35 presented the highest risk for compensation claims. However, after adjusting for duration of employment, the risk estimate increased across all categories of age, and the trend towards decreasing risk with age was not as apparent. This suggests that duration of employment may have confounded the relationship between age and compensation claims for back injury. Breslin and Smith [12] found that the relationship between age and compensation claims weakened after adjusting for other variables, including job tenure. An overall inverse relationship was found between duration of employment and claim rates, which has also been reported by others [12].

In the current study, a rate of 0.35 hospitalizations per 100 person years was reported. Using 57,000 Finnish men and women, Heliovaara et al. [37] observed 1537 back-related hospitalizations during 558,074 person years of follow-up, for a rate of 0.28 per 100 person years. The slightly lower rate in the Finnish study may be attributed to their use of a general occupational population, which consists of both high and low risk populations. In addition, the lower rate reported by Heliovaara et al. [37] may be because they used only herniated lumbar intervertebral disc or sciatica diagnoses, whereas the present study used a broader definition of back disorder. In another study, Leino-Arjas et al. [38] reported that 0.4% of occupationally active Finns were hospitalized for a back disorder in 1996.

The decrease in rates of hospitalizations from the late 1980's to the mid 1990's may be indicative of changes in medical practices that were prescribed for back pain or injury. For instance, prior to the reported efficacy of early modified activity following injury, it was common practice to prescribe more passive forms of treatment such as narcotics for pain control and in-hospital treatment such as bed rest and traction [39]. Cherkin and Deyo [39] found that nearly half of nonsurgical hospitalizations for nonspecific back pain and herniated discs were for diagnostic tests, and the other half for pain control. Based on their findings and other evidence they argued that many hospitalizations for back problems were unnecessary. Taylor et al. [40] examined trends in low back pain hospitalization from 1987 to 1992 in Washington, USA, and found that surgical rates changed little, whereas nonsurgical hospitalization rates fell from 15.5 to 5.1 per 10,000. Lavis et al. [41] also reported a 52% decrease in hospital admission rates for medically treated mechanical neck and back problems in Ontario, Canada from 1982 to 1992, and a 14% increase in surgical treatment over the same period.

Age-specific rates for hospitalizations were expected to follow the same trends as age-specific rates for compensation claims. Rates of back-related hospitalizations have been shown to be highest among middle aged workers, and then tend to decline with increasing age [37, 42]. However, the results indicated that the highest rate of hospitalization was among workers greater than 60 years of age. A possible explanation for the increased risk in older workers in this study may be that workers waited until retirement or until they left the industry to undergo diagnostic or surgical treatment. Unfortunately, this hypothesis was not tested.

Some of the limitations of this study should be noted. While, an attempt was made to measure the incidence of back-related compensation claims and hospitalizations, there was no outcome information prior to 1987, which made it impossible to determine whether workers had prior claim or hospitalization histories. By not excluding workers with prior compensation claims or hospitalizations, the incidence rates may be slightly overestimated, especially in the early years of the study follow-up period.

Another limitation stems from the fact that the figures on back injury rates come from compensation claims and hospitalizations, neither of which describes the actual rate of back pain or injury in the cohort. In the case of compensation claims, there are many administrative and policy decisions that affect claim adjudication. As well, many injured workers do not report their injuries. Roseman et al. [43] found that only 25% of workers diagnosed with a work-related musculoskeletal disorder filed a compensation claim. Based on questionnaire and interview information from workers from three industrial facilities, Pransky et al. [44] found that only 5% had officially reported a work-related injury or illness in the past year, although over 85% experienced work-related symptoms, 50% had persistent work-related problems, and 30% reported either lost time from work or work restrictions due to their injury or illness. Hospitalizations tend to reflect more serious cases, and therefore, less critical episodes of back pain or injuries for which the worker was not hospitalized would not be captured.

Despite these limitations, the study provides valuable insight into the risk of back injury in sawmill workers. This study is the first to use actual person-time information from work history records to determine rates of back-related compensation claims and hospitalizations. These results are consistent with others who have found an inverse relationship between injury risk and duration of employment. Considerable changes in compensation and hospitalization rates over time were observed, which may be reflective of labour market conditions and medical practices for back pain and injury. Findings from this study provide some insight into the pattern of rates of claims and hospitalizations for back injuries; however, further investigation is required to understand the risk factors that are present in sawmills.

Table 2.1 – International Classification of Disease Ninth Revision codes used to identify back-related hospitalizations

ICD-9 code		DESCRIPTION
720		**Ankylosing spondylitis and other inflammatory spondylopathies**
	720.0	Ankylosing spondylitis
	720.1	Spinal enthesopathy
	720.2	Sacroiliitis, not elsewhere classified
	720.8	Other inflammatory spondylopathies
721		**Spondylosis and allied disorders**
	721.0	Cervical spondylosis without myelopathy
	721.1	Cervical spondylosis with myelopathy
	721.2	Thoracic spondylosis without myelopathy
	721.3	Lumbosacral spondylosis without myelopathy
	721.4	Thoracic or lumbar spondylosis with myelopathy
	721.5	Kissing spine
	721.6	Ankylosing vertebral hyperostosis
	721.7	Traumatic spondylopathy
	721.8	Other allied disorders of spine
	721.9	Spondylosis of unspecified site
722		**Intervertebral disc disorders**
	722.0	Displacement of cervical intervertebral disc without myelopathy
	722.1	Displacement of thoracic or lumbar intervertebral disc without
	722.2	Displacement of intervertebral disc, site unspecified, without myelopathy
	722.3	Schmorl's nodes
	722.4	Degeneration of cervical intervertebral disc
	722.5	Degeneration of thoracic or lumbar intervertebral disc
	722.6	Degeneration of intervertebral disc, site unspecified
	722.7	Intervertebral disc disorder with myelopathy
	722.8	Postlaminectomy syndrome
	722.9	Other and unspecified disc disorder
724		**Other and unspecified disorders of back**
	724.0	Spinal stenosis, other than cervical
	724.1	Pain in thoracic spine
	724.2	Low back pain
	724.3	Sciatica
	724.4	Radicular syndrome of lower limbs
	724.5	Backache, unspecified
	724.6	Disorders of sacrum
	724.7	Disorders of coccyx
	724.8	Other symptoms referable to back
	724.9	Unspecified back disorder

Table 2.1 continued

ICD-9 code		DESCRIPTION
839		**Other, multiple, and ill-defined dislocations**
	839.2	Closed dislocation, thoracic and lumbar vertebra
	839.3	Open dislocation, thoracic and lumbar vertebra
	839.4	Closed dislocation, other vertebra
	839.5	Open dislocation, other vertebra
	839.8	Closed Dislocation, Multiple And Ill-defined Sites ; Back; Hand; Multiple locations, except fingers or toes alone; Other ill-defined locations; Unspecified location
	839.9	Open dislocation, multiple and ill-defined sites
846		**Sprains and strains of sacroiliac region**
	846.0	Lumbosacral joint sprain
	846.1	Sacroiliac ligament sprain
	846.2	Sacrospinatus ligament sprain
	846.3	Sacrotuberous ligament sprain
	846.8	Other specified sites
	846.9	Unspecified site
847		**Sprains and strains of other and unspecified parts of back**
	847.0	Neck sprain
	847.1	Thoracic sprain
	847.2	Lumbar sprain
	847.3	Sacral sprain
	847.4	Coccyx sprain
	847.9	Unspecified
953		**Injury to nerve roots and spinal plexus**
	953.0	Cervical root
	953.1	Dorsal root
	953.2	Lumbar root
	953.3	Sacral root
	953.5	Lumbosacral plexus
	953.8	Multiple sites
	953.9	Unspecified site
956		**Injury to peripheral nerve(s) of pelvic girdle and lower limb**
	956.0	Sciatic nerve

Table 2.2 – Mean, median, and total duration and costs of claims by STD, LTD, and all claims from 1987 to 1997

	STD (N= 540)	LTD (N = 26)	All claims (N = 566)
Claim duration (days)			
Mean	33.1	202.8	40.7
Median	16	167	18
Total	**17,881**	**5,070**	**22,951**
Claim costs (Canadian dollars)			
Mean	6,004.92	197,839.40	14,817.10
Median	2,580.38	133,932.90	2,984.62
Total	**3,242,654.31**	**5,143,823.23**	**8,386,477.54**

Table 2.3 – Number, rate, and crude and adjusted IRR for claims by categories of race, gender, age, and calendar period from 1987 to 1997^

	Number of claims	Rate (per 100 person years)	Crude IRR	Adjusted+ IRR (95% CI)	IRR adjusted» for duration of employment (95% CI)
Race					
Caucasian	465	1.32	1	1.0	1.0
East-Indian	97	1.65	1.25	1.27 (1.02-1.59)*	1.27 (1.02-1.59)*
Asian	4	0.54	0.41	0.44 (0.16-1.18)	0.41 (0.15-1.11)
Gender					
Male	558	1.36	1	1.0	1.0
Female	8	0.89	0.66	0.65 (0.32-1.30)	0.55 (0.27-1.11)
Age					
<25	27	1.05	1	1.0	1.0
25-30	67	1.80	1.70	1.69 (1.08-2.65)*	1.77 (1.12-2.79)*
30-35	96	1.73	1.63	1.61 (1.05-2.47)*	1.81 (1.16-2.85)*
35-40	88	1.35	1.27	1.25 (0.81-1.92)	1.53 (0.96-2.42)
40-45	99	1.51	1.43	1.39 (0.91-2.13)	1.77 (1.12-2.81)*
45-50	65	1.07	1.01	0.99 (0.63-1.56)	1.35 (0.83-2.20)
50-55	72	1.39	1.31	1.32 (0.85-2.05)	1.87 (1.15-3.05)*
55-60	39	0.98	0.93	0.94 (0.58-1.54)	1.42 (0.82-2.45)
>60	13	0.77	0.72	0.73 (0.37-1.41)	1.11 (0.55-2.26)
Calendar					
1987-1989	199	1.33	1	1.0	1.0
1990-1994	294	1.59	1.19	1.20 (1.00-1.44)*	1.21 (1.01-1.45)*
1995-1997^	73	0.87	0.65	0.68 (0.52-0.89)*	0.69 (0.53-0.90)*
Duration of employment					
0-5 years	145	1.60	1	------	1.0
5-10 years	106	1.56	0.98	------	0.90 (0.69-1.17)
10-15 years	111	1.52	0.95	------	0.83 (0.63-1.09)
15-20 years	87	1.18	0.74	------	0.66 (0.49-0.90)*
20-25 years	71	1.30	0.82	------	0.76 (0.55-1.05)
25-30 years	20	0.67	0.42	------	0.42 (0.25-0.69)*
>30 years	26	0.90	0.57	------	0.59 (0.36-0.95)*

*significant at the 95% 0.05 level
+adjusted for the other covariates in the model
»adjusted for the other covariates in the model including duration of employment
^workers were followed until July 31, 1997

Table 2.4 – Number, rates, and crude and adjusted IRR for hospitalizations by categories of race, gender, age, and calendar period from 1987 to 1997

	Number of hospitalizations	**Rate (per 100 person years)**	**Crude IRR**	**Adjusted+ IRR (95% CI)**	**IRR adjusted» for duration of employment (95% CI)**
Race					
Caucasian	123	0.33	1	1.0	1.0
East-Indian	29	0.47	1.40	1.39 (0.92-2.10)	1.38 (0.91-2.09)
Asian	2	0.27	0.80	0.78 (0.19-3.17)	0.72 (0.18-2.92)
Gender					
Male	151	0.35	1	1.0	1.0
Female	3	0.32	0.91	1.05 (0.33-3.32)	0.97 (0.30-3.14)
Age					
<30	15	0.23	1	1.0	1.0
30-35	22	0.38	1.63	1.60 (0.83-3.09)	1.59 (0.80-3.14)
35-40	28	0.41	1.76	1.82 (0.97-3.42)	1.99 (1.02-3.90)*
40-45	26	0.38	1.63	1.74 (0.92-3.29)	1.98 (0.99-3.97)
45-50	25	0.39	1.70	1.84 (0.97-3.50)	2.19 (1.08-4.43)*
50-55	15	0.28	1.20	1.33 (0.65-2.73)	1.63 (0.74-3.58)
55-60	15	0.36	1.57	1.66 (0.81-3.40)	2.12 (0.94-4.77)
>60	8	0.46	2.00	1.98 (0.84-4.68)	2.54 (0.97-6.67)
Calendar period					
1987-1990	89	0.65	1	1.0	1.0
1990-1995	50	0.27	0.42	0.43 (0.30-0.60)*	0.43 (0.31-0.62)*
1995-1997^	15	0.17	0.26	0.27 (0.16-0.47)*	0.27 (0.15-0.46)*
Duration of employment					
0-5 years	24	0.26	1	------	1.0
5-10 years	39	0.54	2.08	------	1.85 (1.09-3.11)*
10-15 years	28	0.36	1.38	------	0.97 (0.54-1.75)
15-20 years	27	0.35	1.35	------	0.99 (0.54-1.81)
20-25 years	19	0.33	1.27	------	1.00 (0.51-1.96)
25-30 years	7	0.22	0.85	------	0.71 (0.29-1.77)
>30 years	10	0.34	1.31	------	0.91 (0.38-2.16)

*significant at the 95% 0.05 level
+adjusted for the other covariates in the model
»adjusted for the other covariates in the model including duration of employment
^ workers were followed until July 31, 1997

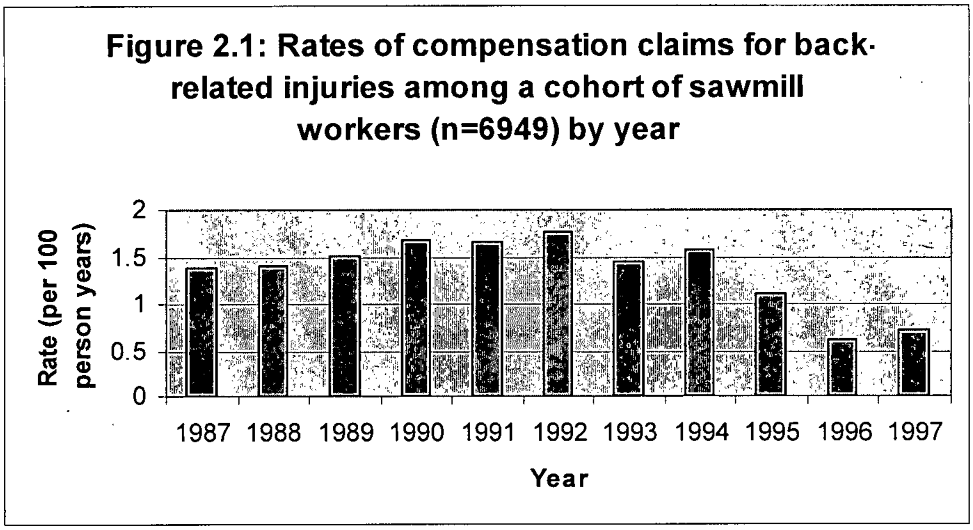
Figure 2.1: Rates of compensation claims for back-related injuries among a cohort of sawmill workers (n=6949) by year
Rate (per 100 person years)
2
1.5
1
0.5
0
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997
Year

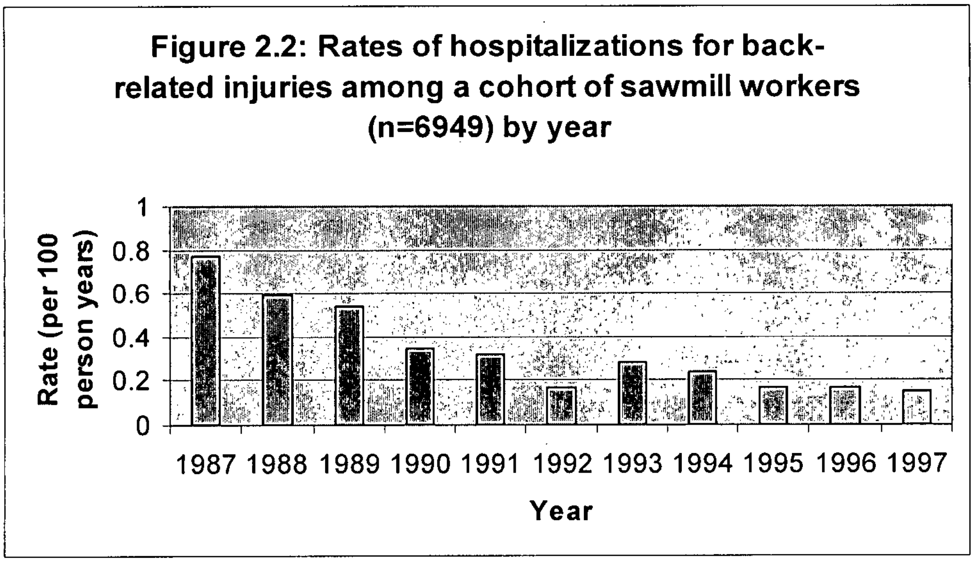
Figure 2.2: Rates of hospitalizations for back-related injuries among a cohort of sawmill workers (n=6949) by year
Rate (per 100 person years)
1
0.8
0.6
0.4
0.2
0
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997
Year

5.0 References

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CHAPTER 3 Risk factors for back-related compensation claims and hospitalizations among sawmill workers[2]

1.0 Introduction

Occupational back injury is a major source of health and economic concern in the developed world. In the United States, back-related injuries represent approximately one fifth of all compensation claims and a third of all compensation costs [1]. From 1995 to 2004, the Workers' Compensation Board of British Columbia (BC) (Canada) accepted approximately 173,000 back strain claims or 24.9% of all claims [2]. During the same period, 7,291,000 days were lost due to back strain or 23.3% of all days lost [2].

The etiology of back injury has been described has having two components – acute and cumulative [3]. In the acute model, back injury results from an immediate exposure that places a load on the spinal structures that exceeds the structures' strength or tolerance. This model is associated with specific incidents such as falling [4] or activities such as lifting, and movements such as bending and twisting [5]. In contrast, the cumulative model explains back injury as a result of repeated exposures, which over time weaken the tissues and increase the probability of injury. Chronic exposures to activities such as lifting and sitting have been related to this model of back injury [6]. To fully understand the causes of back injury, both components need to be studied. One study that did examine these factors was a nested case-control study of firefighters, in which Nuwayhid et al. [7] identified both acute and chronic risk factors. Recent intense firefighter activities were strongly associated with first episodes of back pain, while physical

[2] A version of this chapter will be submitted for publication to the journal Spine

inactivity and time spent driving were considered long-term factors. However, much more information is needed on the acute and chronic risk factors that contribute to back injury.

For both the acute and cumulative models, it is generally agreed that there are many different factors that contribute to back injury. These factors are normally grouped into three categories – physical (e.g. force, repetition), psychosocial (e.g. job control, decision latitude), and personal (e.g. age, previous injury). Much of the focus in the past has been put on physical risk factors; however, in recent years, more attention has been placed on the role of psychosocial factors in causing, or at least contributing to back disorders [8]. A review of the association between occupational psychosocial factors and musculoskeletal disorders concluded that social support, job control, and work stress appear to be related to musculoskeletal disorders [8]. Although, in a more recent systematic review, low social support and low job satisfaction were found to be risk factors for back pain, while insufficient evidence was found for low job control and high work pace [9].

Despite the fact that psychosocial factors have been given more consideration in the recent past, there are limitations in some of the studies investigating their impact on back injury. One of the criticisms is that some studies have not adequately adjusted for the physical demands of the job [10], even though jobs with poor psychosocial work factors have been shown to have high physical demands [11, 12]. Another limitation is that many studies investigating psychosocial factors have used a cross-sectional design, and therefore are unable to infer causality [13]. As well, several studies have measured both psychosocial exposures and health outcomes using self-report, which increases the potential for common method bias [14].

The purpose of this study is to investigate back injury among sawmill workers as part of a multi factor model with valid measurement of both physical and psychosocial factors. One of the main reasons for examining this particular population is that the BC sawmill industry has a considerable impact on the province's economy, and unfortunately also happens to be one of the most physically demanding and hazardous industries [15]. For instance, in the mid 1990's, approximately 23,000 workers were employed in the industry, which shipped over five billion dollars in goods worldwide [16]. Sadly, injury rates in the sawmill industry were consistently higher than in all other BC industries combined [17]. Despite the considerable risk to workers, few studies have actually identified potential risk factors for injury [18], and to date, no study of sawmill workers has specifically investigated risk factors for back injury.

Most studies of occupational back injury have used either compensation claims or hospitalizations as their outcome measures; however, to the researcher's knowledge, none have studied these two outcomes concurrently. Since hospitalizations may capture more severe episodes of injury, it may be informative to study them in relation to compensation claims, especially because back injuries often progress in severity. A nested case-control study was conducted to assess the relationship between physical and psychosocial risk factors, and the risk of back-related compensation claims and hospitalizations. As well, an attempt was made to address some of the methodological concerns of other back injury studies. In particular, this study used objective back-related outcomes, physical and psychosocial exposures that were assessed quantitatively by experts rather than subjects, and a study design (nested case-control) in which temporality is known so that inferences about causality are not precluded.

2.0 Methods

2.1.Study group

The study population was drawn from a cohort of sawmill workers in BC who were employed for at least one year in the sawmill industry and followed from 1950 to 1998. This cohort was originally created to examine the association between fungicides and cancer [19]. Demographic data (date of birth, sex, race) and work history information (job title, start and end dates) were collected on approximately 28,000 workers during the study period [20]. For the analyses, only workers with a back-related compensation claim or hospitalization while actively employed between January 1, 1987 and July 31, 1997 were selected as cases. Four controls were matched to each case at the date of birth (five year periods) and the controls had to employed in the sawmill industry at the date of case diagnosis. Workers were eligible to serve as controls for more than one case. Once a worker became a case they were ineligible to serve as a control.

2.2.Data collection

Analyses were conducted using two different back injury outcomes: 1) workers with a back strain/sprain related time-loss compensation claim, and 2) workers with a back-related hospitalization. Back strain/sprain related time-loss compensation claims were identified using the "nature of injury" and "body part" fields from workers' compensation records, and back-related hospitalizations were identified using back-related International Classification of Disease Ninth Revision codes (ICD-9) [21] from hospital separations records (Table 3.1). Compensation claims and hospitalizations were used as separate outcome measures because they may represent different severities of injury. Since not all injuries result in hospitalizations [22, 23], those workers who are hospitalized may represent more critical injuries. Both work and non-work-related hospitalizations were used. January 1, 1987 and July 31, 1997 were chosen as start and end dates because they represented the earliest date that compensation information was available and the latest date that all fourteen sawmills were followed. Some workers had multiple back-related claims or hospitalizations, in which case only the first claim and hospitalization were used.

Information on back injury outcomes was obtained from the British Columbia Linked Health Database (BCLHD). The BCLHD is a resource of data for research purposes containing workers' compensation, medical, and hospitalization data files. Approval for access to these data for research projects is coordinated through the Ministries of Health and is governed by the *Access Policy for Research Uses of Linked Health Data* [24]. Employment records were linked with workers' compensation and hospital discharge records using personal identifiers (social insurance number, name, date of birth). Researchers were then provided a data file with the personal identifiers removed from the linked data.

2.3. Exposure information

Three different sources of exposure information were used in this study: ergonomist-assessed physical exposures, union/industry expert assessed physical and psychosocial factors, and job categories based on skill level.

2.3.1. Ergonomic assessment exposure information

In collaboration with the Workers' Compensation Board of BC, the International Woodworkers Association (the union representing sawmill workers) and the Council of Forest Industries created the Industrial Musculoskeletal Injury Reduction Program (IMIRP) [15]. This program has evaluated and assessed 106 of the most common jobs in the sawmill industry for risks of musculoskeletal injuries, and collapsed these jobs into 66 "tool kits". Trained ergonomists identified physical risk factors (force, repetition, awkward posture, static posture, vibration) in each job and by each body part (neck, shoulder, arm, back, leg). The five physical risk factors were assessed as dichotomous variables (present/absent). These exposures were then assigned by the study researcher to jobs in the BC Sawmill Cohort study.

2.3.2. Union/Industry rater based exposure information

Since the late 1960's, a union-management system of job evaluators has been used to measure the physical and psychosocial demands in the sawmill industry for the purposes of determining wage rates. As part of a previous study, four of these expert raters were asked to rate the occupations in a "typical" coastal sawmill using a shortened version of Karasek's questionnaire on psychosocial factors [25]. Information from the expert raters was used to create five exposure variables – physical demands, psychosocial demands, job control, social support, and noise. These exposures were quantified as continuous variables.

2.3.3. *Skill-based job classification information*

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 [18]. Jobs were classified by the type 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 8) Other. These job classifications were assigned by occupational epidemiologists in the BC Sawmill Cohort study as part of previous work [26].

2.4. Statistical analyses

To account for matching, conditional logistic regression was used to model the relationship between independent variables and the likelihood of an accepted compensation claim or being hospitalized for back injury, with the odds ratio being a measure of this association. Twelve separate multivariable regression models were created – six of these used compensation claims as the outcome and the other six used hospitalizations.

Three of the models included the variables of force, repetition, awkward posture, static posture, and vibration all as assessed by ergonomists. The first model examined the five physical factors that were present in the job at the time of injury. In this model the reference category for each risk factor consisted of those workers that were not exposed to the particular risk factor in their job. The second model involved the same exposures as the first analysis; however, in this analysis the total number of exposures in each job was counted and given a score out of five. For example, having none of the five exposures in the job put the worker in the first category (reference category); having one or two exposures put them in the second category; having three exposures put them in the third category. These first two models were considered to be "acute" analyses because they were based on exposures that were present in the job held at the time of injury. The third model was a "cumulative" analysis because all five of the physical exposures in the past year were considered.

For the cumulative analyses, the number of days worked for each job was divided by the total number of days worked in the past year and converted to a percentage to determine the proportion of work time in the previous year. Next, the proportion of work time was multiplied by the level of exposure in each corresponding job. For each worker, the exposure score for each factor was summed across all jobs to determine a single exposure score per worker. Data on individual physical factors (i.e. force, repetition, awkward postures, static postures, and vibration) were coded as binary variables (absent=0, or present=1). Therefore, in the cumulative analyses, the number of days in each job was multiplied by 0 (absent) or 1 (present), which transformed these variables from dichotomous to continuous. These continuous variables were then grouped into three categories: Low – score of 0 (reference category), Moderate – score between 1 and 98, and High – score of 99 and greater.

The next two models (models 4 & 5) included the physical demand, psychological demand, control, social support, and noise variables as assessed by industry experts. The first of these two models assessed the exposures that were present in the job at the time of injury (acute analysis), and the second assessed exposures in the past year (cumulative analysis) using the method described above. Physical demand, psychological demand, job control, social support, and noise were measured as continuous variables and categorized into quartiles based on the distribution of each variable in the study population. The first quartile was the reference category for this analysis.

In the last model (model 6), the worker's job category (based on the Maine Sawmill Injury study) at the time of injury was used as a surrogate for exposure. The reference category consisted of foreman/supervisors. However, a cumulative analysis was not done using this exposure information; only an acute analysis was conducted.

Gender, mill, and duration of employment were entered into each multiple regression to obtain adjusted effects. The models were fitted using the CLOGIT command in Stata statistical software [27].

3.0 Results

Table 3.2 reports the number of cases and controls that fall into the various categories of exposures. There were a total of 566 back strain claims and 154 hospitalizations for back injury in the period between January 1, 1987 and July 31, 1997.

Unadjusted and adjusted odds ratios from the analysis using physical exposures assessed by ergonomists are displayed in Table 3.3. None of the five individual physical factors were significantly associated with compensation claims or hospitalizations for back injury on their own. There appeared to be weak, but elevated risks of compensation claims with vibration (OR=1.21; 95% CI=0.97-1.51) and awkward posture (OR=1.30; 95% CI=0.75-2.25); and weak, but elevated risks of hospitalizations with vibration (OR=1.34; 95% CI=0.84-2.15), awkward posture (OR=1.29; 95% CI=0.50-3.33), and repetition (OR=1.50; 95% CI=0.89-2.50).

Table 3.4 presents unadjusted and adjusted odds ratios based on the number of the five physical factors that were present in the job at the time of injury. Workers exposed to one or more of the five exposures were found to have an increased risk of compensation claim compared to workers having none of the exposures. However, no relationship was seen between hospitalizations and the number of exposures present in the job.

Table 3.5 presents results from the cumulative analyses using physical exposures assessed by ergonomists. Similar to results from the acute analyses, none of these exposures individually demonstrated a strong relationship with compensation claims or hospitalizations for back injury, although there was a weak, but elevated risk of compensation claim for the highest category of vibration exposure (OR=1.24; 95% CI=0.97-1.58), and the highest category of awkward posture exposure (OR=1.42, 95% CI=0.76-2.67). As well, there was a significantly elevated risk of hospitalization in the moderate category of vibration (OR=2.95; 95% CI=1.32-6.58), but no excess was observed in the highest category.

Adjusted odds ratios based on industry expert assessed physical demand, psychosocial demand, control, social support, and noise are reported in Table 3.6 for both the acute and cumulative analyses. There appeared to be a non-significant positive association between physical demands and compensation claims, which was consistent for both the acute and cumulative analyses. In addition, there was a slight dose-response relationship between cumulative physical demand and compensation claims. On the other hand, there was a weak negative relationship between physical demand and hospitalizations.

Increased job control had a protective effect on both the risk of compensation claims and hospitalizations. There was a dose-response relationship between job control and hospitalizations for the adjusted cumulative analyses, with the risk level being the lowest among workers with the most job control. As well, the second and third quartiles of acute noise exposures were significantly associated with compensation claims; however, the level of risk weakened in the highest level of noise exposure, and there was no pattern for cumulative exposures or with hospitalizations.

Unadjusted and adjusted odds ratios for compensation claims, and hospitalizations using the skill based job categories are presented in Table 3.7. Results indicated that jobs that tend to have high physical demands (e.g. skilled trades, material handlers, etc.) have higher risks of compensation claims compared to jobs with low physical demands (e.g. foreman/supervisor). Material handlers were the only job category to have a slightly elevated risk of hospitalization (OR=2.27; 95% CI=0.93-5.55).

4.0 Discussion

The objective of this study was to assess the relationship between occupational physical and psychosocial factors, and the risk of compensation claims and hospitalizations for back injury among sawmill workers. Exposure information was based on three different sources: 1) professional ergonomic assessments, 2) union/industry raters, and 3) job classifications of sawmill jobs based on the Maine Sawmill Injury study.

None of the five individual physical exposures as assessed by ergonomists were found to be significantly associated with an increase in compensation or hospitalization risk, but there were consistent patterns in the risk level between outcomes. When the number of exposures in a job was considered, having one or more of any of them was found to significantly increase the risk of compensation claims. In addition, when jobs were categorized based on skill level, those that tend to be more physically demanding were associated with higher risks of compensation claims. Also, physical demands that were assessed using union/industry experts demonstrated a weak, but elevated risk of compensation claims.

Based on these results, the conclusion is that physically demanding jobs in the sawmill industry increase the risk for back injury. Numerous other studies have also found a relationship between physically demanding jobs and risk for back injury [28-30]. Studies have also demonstrated a relationship between specific physical factors and back injury [31]. In the current study, the absence of a relationship between specific physical factors and back injury was most likely because these exposures were assessed as dichotomous variables. Since the sawmill industry is a very physically demanding industry, most workers are exposed to some level of force, repetition, and awkward and static postures; and therefore, using dichotomous exposure variables makes it difficult to differentiate between high and low risk groups.

In the cumulative analysis using the five specific physical exposures, the results were similar to those in the acute analysis. After converting these variables from dichotomous to continuous, it was anticipated that there would be a wide distribution of exposure scores. However, since most of these exposures were highly prevalent, many workers fell into the highest category of exposure. The only exception was for vibration, where most of the workers fell into the lowest category of exposure.

As already mentioned, one of the limitations of some of the previously published studies investigating psychosocial variables is that many of them have failed to adjust for the physical demands of the job. This is especially important since many jobs with high psychosocial demands have high physical demands as well [11, 12, 32] . In the current study, after controlling for physical demands, more job control had a slightly protective effect on compensation and hospitalization risk. The protective effect of job control on back injury risk has been reported by others [31]. However, no notable relationship was found between back injury risk and psychological demand. In their study of automobile workers, Kerr et al. [33] discovered that after adjusting for physical demand, psychological demand was no longer significantly associated with back pain. They argued that the Job Content Instrument was a better measure of physical demand than it was of psychological demand. In addition, Kerr et al. [33] found slightly better coworker support among cases than controls. Similarly, in the current study, when compared to the reference population, a higher level of social support was associated with a higher risk of compensation (only in the acute analysis).

The fact that a strong relationship was not observed between any of the psychosocial variables and back injury may result from the use of union/industry experts, as opposed to self-report, to assess psychosocial exposures. Several of the studies that have found relationships between psychosocial variables and back injury have used self-reported exposure information [34, 35]. One of the disadvantages of using self-report is that the presence of pain or injury may bias the self-assessment of psychosocial exposures [33, 36], and possibly lead to an overestimation of the strength of any association. Since, in the current study, a more objective method of assessing risk was used, the potential for this bias was reduced. In a review of the impact of psychosocial work characteristics on low back pain, the authors observed more positive associations when self-reported outcomes were used [37].

The results also indicated that acute noise exposure was associated with an increased risk of compensation claims. Noise can work in one of two ways to increase the risk of injury. The first is that it reduces the worker's ability to hear any potential danger, increasing the risk of an acute injury. The second is that chronic noise exposure has been associated with increased levels of circulating catecholamines [38], although our results did not show a relationship with cumulative noise exposure and injury. Increased catecholamine levels are an indication that the body is in catabolic state, as opposed to an anabolic state, and as a result the body is less able to regenerate and repair itself, thereby increasing the risk of injury. In a study of sawmill workers, subjects complained about the chronic exposure to noise, saying, "it takes hours for the noise and the machine-paced tempo of the mill to disappear from the mind and body" [39].

Although a significantly elevated risk of injury was found in the second and third categories of acute noise exposure compared to the reference category, the risk weakened and was non significant in the highest category of noise exposure. A possible explanation is that workers in areas with high levels of noise may wear protective hearing devices, which reduces the effect of this exposure on the risk of injury. However, further research is required in order to determine whether in fact this was the case.

While others have reported associations between occupational physical and psychosocial factors and back-related hospitalizations [31, 40], this study failed to establish a relationship. The reason for the unobserved association may be because some workers were not hospitalized immediately after injury, but instead at some time much later. Musculoskeletal disorders are generally episodic and recurrent in nature [41, 42], often progressing to greater severity and consequently requiring more specific treatments[43]. While at first the injury may not have been critical enough to require hospitalization, with time it may have worsened, thereby resulting in hospitalization. Prior to opting for a more invasive approach, an injured worker may have chosen to examine other types of less invasive treatment (e.g. physiotherapy, massage therapy, chiropractic). During the period between injury and hospitalization, it is also possible that workers may have been transferred into less physically demanding jobs. Studies have demonstrated that workers who have developed a musculoskeletal disorder in physically demanding jobs are more likely to transfer to less demanding jobs [44]. If this, in fact, was the case in the current study, exposure would have been misclassified and the level of risk underestimated.

There were several limitations in this study. The first, as previously mentioned, was that the physical risk factors were assessed as dichotomous variables resulting in few unexposed workers, therefore making it difficult to have an internal comparison group. The second limitation was that exposures may have been misclassified. Mills generally differ with respect to the level of exposure because of differences in technology and safety programs. Additionally, workers also vary with respect to their size and strength, and the manner in which they carry out a task. As a result, the method of assigning a single level of exposure to all workers in each job across all 14 sawmills may not be entirely representative of the actual level of exposure experienced by the workers. The third limitation is due to not having compensation information prior to 1987, and as a result, being unable to determine whether workers had a previous back-related injury. This information would have been valuable, since prior injury increases the risk for subsequent injury.

This study attempted to address some of the methodological issues surrounding previous back injury studies. Firstly, outcome information was used that was not self-report but instead based on objective measures – compensation claims and hospitalizations – that require medical confirmation. As well, exposure information was based on assessments done by professional ergonomists and industry raters, as well as jobs categorized by skill level. This was important, as some studies reporting associations between occupational factors and back injury have done so using self-reported exposure and outcome information [34, 35]. The problem with using self-reported exposures and outcomes is that workers may be aware of the relationship between occupational factors and injury, which may tend to influence their responses to questions about the exposures or the outcomes.

Secondly, an attempt was made to contribute better temporal information to evaluate causality using a nested case-control design, something not allowed by the use of cross-sectional studies. In a review of 66 back injury studies, Davis and Heaney [37] found 21 cross-sectional studies. Studies using a cross-sectional design are limited in their ability to contribute to evaluations of causality, and at best can only identify the co-existence of exposures and outcomes.

Thirdly, the acute and cumulative natures of back injury were investigated. Unfortunately, the definition of acute may not actually reflect only "acute" exposures, since in many cases a worker may have held the job for many years. However, an attempt was made to distinguish between the risks of injury in the job held at the time of injury, and those in the year prior to injury. As well, though the definition of cumulative refers only to exposures in the year prior to injury or hospitalization, it may have been exposures earlier on in a worker's job history that were also responsible for the injury.

Results from this study provide evidence that physically demanding jobs in the sawmill industry are associated with higher risks of compensation claims for back injury. However, specific physical risk factors were not identified, which makes it more difficult to design controls or implement policies to reduce the risk of injury among sawmill workers. After controlling for physical demand we found that job control was the only psychosocial variable that was related to back injury. Increased job control was associated with a reduced risk of injury. An increased risk among workers exposed to higher levels of noise was also reported; however, a dose-response relationship was not observed, suggesting that workers in the highest category of noise exposure may be wearing hearing protection more frequently.

Table 3.1 – International Classification of Disease Ninth Revision (ICD-9) codes used to identify back-related hospitalizations

ICD-9 code		DESCRIPTION
720		**Ankylosing spondylitis and other inflammatory spondylopathies**
	720.0	Ankylosing spondylitis
	720.1	Spinal enthesopathy
	720.2	Sacroiliitis, not elsewhere classified
	720.8	Other inflammatory spondylopathies
721		**Spondylosis and allied disorders**
	721.0	Cervical spondylosis without myelopathy
	721.1	Cervical spondylosis with myelopathy
	721.2	Thoracic spondylosis without myelopathy
	721.3	Lumbosacral spondylosis without myelopathy
	721.4	Thoracic or lumbar spondylosis with myelopathy
	721.5	Kissing spine
	721.6	Ankylosing vertebral hyperostosis
	721.7	Traumatic spondylopathy
	721.8	Other allied disorders of spine
	721.9	Spondylosis of unspecified site
722		**Intervertebral disc disorders**
	722.0	Displacement of cervical intervertebral disc without myelopathy
	722.1	Displacement of thoracic or lumbar intervertebral disc without
	722.2	Displacement of intervertebral disc, site unspecified, without myelopathy
	722.3	Schmorl's nodes
	722.4	Degeneration of cervical intervertebral disc
	722.5	Degeneration of thoracic or lumbar intervertebral disc
	722.6	Degeneration of intervertebral disc, site unspecified
	722.7	Intervertebral disc disorder with myelopathy
	722.8	Postlaminectomy syndrome
	722.9	Other and unspecified disc disorder
724		**Other and unspecified disorders of back**
	724.0	Spinal stenosis, other than cervical
	724.1	Pain in thoracic spine
	724.2	Low back pain
	724.3	Sciatica
	724.4	Radicular syndrome of lower limbs
	724.5	Backache, unspecified
	724.6	Disorders of sacrum
	724.7	Disorders of coccyx
	724.8	Other symptoms referable to back
	724.9	Unspecified back disorder

Table 3.1 continued

ICD-9 code		DESCRIPTION
839		**Other, multiple, and ill-defined dislocations**
	839.2	Closed dislocation, thoracic and lumbar vertebra
	839.3	Open dislocation, thoracic and lumbar vertebra
	839.4	Closed dislocation, other vertebra
	839.5	Open dislocation, other vertebra
	839.8	Closed Dislocation, Multiple And Ill-defined Sites ; Back; Hand; Multiple locations, except fingers or toes alone; Other ill-defined locations; Unspecified location
	839.9	Open dislocation, multiple and ill-defined sites
846		**Sprains and strains of sacroiliac region**
	846.0	Lumbosacral joint sprain
	846.1	Sacroiliac ligament sprain
	846.2	Sacrospinatus ligament sprain
	846.3	Sacrotuberous ligament sprain
	846.8	Other specified sites
	846.9	Unspecified site
847		**Sprains and strains of other and unspecified parts of back**
	847.0	Neck sprain
	847.1	Thoracic sprain
	847.2	Lumbar sprain
	847.3	Sacral sprain
	847.4	Coccyx sprain
	847.9	Unspecified
953		**Injury to nerve roots and spinal plexus**
	953.0	Cervical root
	953.1	Dorsal root
	953.2	Lumbar root
	953.3	Sacral root
	953.5	Lumbosacral plexus
	953.8	Multiple sites
	953.9	Unspecified site
956		**Injury to peripheral nerve(s) of pelvic girdle and lower limb**
	956.0	Sciatic nerve

Table 3.2 – Number of cases and controls by levels of exposure for the various risk factors

	Back injury CLAIMS		Back injury HOSPITALIZATIONS	
	Cases	Controls	Cases	Controls
PHYSICAL RISK FACTORS				
Force				
No	84	340	36	117
Yes	482	1735	118	445
Repetition				
No	139	595	49	199
Yes	427	1480	105	363
Awkward posture				
No	28	143	15	58
Yes	538	1932	139	504
Static Posture				
No	91	334	29	106
Yes	475	1741	125	456
Vibration				
No	308	1199	75	307
Yes	258	876	79	255
NUMBER OF RISK FACTORS (e.g. force, repetition, etc)				
None of the exposures	15	122	15	43
One or two of the exposures	59	168	10	68
Three of the exposures	97	355	27	86
Four of the exposures	194	776	45	190
Five of the exposures	201	654	57	175

Table 3.2 continued.

	Back injury CLAIMS		Back injury HOSPITALIZATIONS	
	Cases	Controls	Cases	Controls
UNION/INDUSTRYBASED EXPOSURES				
Physical demand				
1st quartile	95	458	48	131
2nd quartile	162	573	18	102
3rd quartile	119	480	44	189
4th quartile	190	564	44	140
Psychological demand				
1st quartile	118	490	36	107
2nd quartile	167	534	45	149
3rd quartile	125	537	34	150
4th quartile	156	514	39	156
Control				
1st quartile	169	515	42	134
2nd quartile	148	502	37	121
3rd quartile	113	546	37	165
4th quartile	136	512	38	142
Social				
1st quartile	150	589	28	98
2nd quartile	141	450	45	157
3rd quartile	172	632	46	185
4th quartile	103	404	35	122
Noise				
1st quartile	60	305	26	71
2nd quartile	193	611	46	172
3rd quartile	164	587	42	173
4th quartile	149	572	40	146
JOB CATEGORIES				
Foreman/supervisor	16	106	10	45
Skilled trades	132	418	30	126
Material handler/unskilled	156	512	36	111
Machine operator/attendant/clearer/sorter	171	596	43	156
Mobile equipment operator	48	185	19	70
Inspector/grader	34	202	10	40
Nonwood production	5	42	6	11
Unknown	4	14	0	3

Table 3.3 – Unadjusted and adjusted* odds ratios (and 95% CIs) for back-related compensation claims and hospitalizations by physical risk factors present in job at time of injury or hospitalization (acute analysis)

	Back Injury CLAIMS		Back Injury HOSPITALIZATIONS	
Risk factor	**Unadjusted odds ratio (95% CI)**	**Adjusted* odds ratio (95% CI)**	**Unadjusted odds ratio (95% CI)**	**Adjusted * odds ratio (95% CI)**
Force	0.97(0.70-1.34)	0.94 (0.68-1.31)	0.74(0.43-1.27)	0.68(0.37-1.27)
Repetition	1.16(0.90-1.49)	1.13 (0.87-1.46)	1.24(0.79-1.96)	1.50(0.89-2.50)
Awkward posture	1.44(0.84-2.48)	1.30 (0.75-2.25)	1.25(0.53-2.94)	1.29(0.50-3.33)
Static posture	0.80(0.58-1.10)	0.80 (0.58-1.11)	0.83(0.44-1.56)	0.90(0.44-1.84)
Vibration	1.18(0.96-1.45)	1.21 (0.97-1.51)	1.34(0.88-2.04)	1.34(0.84-2.15)

*Adjusted for mill, gender, and job tenure

Table 3.4 – Unadjusted and adjusted* odds ratios (95% CIs) for back-related compensation claims and hospitalizations by number of physical risk factors present in job at time of injury or hospitalization

	Back Injury CLAIMS		**Back Injury HOSPITALIZATIONS**	
Risk factor	**Unadjusted odds ratio (95% CI)**	**Adjusted* odds ratio (95% CI)**	**Unadjusted odds ratio (95% CI)**	**Adjusted* odds ratio (95% CI)**
None of the exposures	Reference	Reference	Reference	Reference
One or two exposures	**2.89(1.56-5.38)**	**2.59 (1.38-4.87)**	0.47(0.19-1.13)	0.55(0.21-1.43)
Three exposures	**2.22(1.24-4.00)**	**1.90 (1.04-3.45)**	0.99(0.47-2.10)	1.14(0.50-2.59)
Four exposures	**2.02(1.15-3.55)**	1.74 (0.98-3.09)	0.70(0.35-1.38)	0.91(0.43-1.93)
Five exposures	**2.55(1.45-4.49)**	**2.18 (1.23-3.88)**	1.01(0.52-1.98)	1.29(0.62-2.68)

*Adjusted for mill, gender, and job tenure

Table 3.5- Unadjusted and adjusted* odds ratios (95% CIs) for back-related compensation claims and hospitalizations by categories of physical risk factors present during the past year (cumulative analysis)

	CLAIMS		HOSPITALIZATIONS	
Risk factor	**Unadjusted odds ratio (95% CI)**	**Adjusted* odds ratios (95% CIs)**	**Unadjusted odds ratio (95% CI)**	**Adjusted * odds ratios (95% CIs)**
Force				
Low	Reference	Reference	Reference	Reference
Moderate	1.41(0.73-2.71)	1.42 (0.74-2.75)	0.75(0.23-2.45)	0.76 (0.21-2.74)
High	1.14(0.79-1.64)	1.10 (0.76-1.59)	0.80(0.45-1.44)	0.78 (0.40-1.53)
Repetition				
Low	Reference	Reference	Reference	Reference
Moderate	0.96(0.54-1.71)	0.92 (0.51-1.65)	0.56(0.19-1.62)	0.70 (0.21-2.30)
High	1.06(0.81-1.38)	1.03 (0.78-1.36)	1.23(0.76-1.99)	1.52 (0.88-2.60)
Awkward Posture				
Low	Reference	Reference	Reference	Reference
Moderate	1.26(0.54-2.95)	1.15 (0.48-2.73)	3.90(0.75-20.39)	3.04 (0.47-19.61)
High	1.53(0.82-2.83)	1.42 (0.76-2.67)	1.09(0.44-2.71)	1.01 (0.36-2.81)
Static Posture				
Low	Reference	Reference	Reference	Reference
Moderate	1.52(0.85-2.74)	1.48 (0.82-2.70)	0.40(0.12-1.34)	0.51 (0.14-1.91)
High	0.79(0.55-1.12)	0.76 (0.53-1.09)	0.85(0.43-1.68)	0.99 (0.46-2.11)
Vibration				
Low	Reference	Reference	Reference	Reference
Moderate	0.81(0.56-1.18)	0.76 (0.52-1.12)	**2.53(1.27-5.07)**	**2.95 (1.32-6.58)**
High	1.19(0.95-1.50)	1.24 (0.97-1.58)	1.12(0.72-1.75)	1.06 (0.64-1.75)

* Adjusted for mill, gender, and job tenure

Low = 0; Moderate = 1-98; High = 99-100

Table 3.6 – Adjusted odds ratios* for back-related compensation claims and hospitalizations by categories of physical demand, psychological demand, job control, social support, and noise for acute and cumulative (1 year) analyses

	CLAIMS		**HOSPITALIZATIONS**	
	ACUTE	CUMULATIVE	ACUTE	CUMULATIVE
Physical				
1st quartile	Reference	Reference	Reference	Reference
2nd quartile	1.22(0.86-1.73)	1.13(0.84-1.53)	0.64(0.30-1.36)	**0.48(0.23-1.00)**
3rd quartile	1.18(0.81-1.74)	1.14(0.81-1.60)	0.68(0.37-1.26)	0.75(0.42-1.35)
4th quartile	1.17(0.74-1.86)	1.26(0.84-1.91)	0.98(0.41-2.30)	0.59(0.25-1.35)
Psychological				
1st quartile	Reference	Reference	Reference	Reference
2nd quartile	1.07(0.75-1.51)	0.99(0.72-1.35)	0.89(0.47-1.67)	1.34(0.74-2.44)
3rd quartile	0.78(0.53-1.15)	0.94(0.66-1.33)	0.70(0.33-1.49)	1.13(0.53-2.40)
4th quartile	1.36(0.93-1.99)	1.02(0.72-1.44)	0.84(0.40-1.79)	1.13(0.54-2.40)
Job control				
1st quartile	Reference	Reference	Reference	Reference
2nd quartile	0.81(0.55-1.19)	0.86(0.63-1.16)	0.65(0.30-1.46)	0.77(0.39-1.53)
3rd quartile	**0.52(0.34-0.79)**	**0.68(0.47-0.97)**	0.65(0.29-1.49)	0.61(0.26-1.40)
4th quartile	0.70(0.41-1.20)	0.89(0.57-1.38)	0.66(0.25-1.84)	0.48(0.20-1.16)
Social support				
1st quartile	Reference	Reference	Reference	Reference
2nd quartile	1.45(0.96-2.20)	1.07(0.78-1.47)	1.06(0.52-2.16)	0.67(0.32-1.42)
3rd quartile	1.37(0.94-1.99)	1.12(0.79-1.59)	0.80(0.40-1.61)	1.65(0.69-3.96)
4th quartile	1.20(0.72-2.00)	0.96(0.66-1.38)	0.95(0.42-2.15)	0.85(0.43-1.68)
Noise				
1st quartile	Reference	Reference	Reference	Reference
2nd quartile	**1.65(1.08-2.52)**	1.22(0.91-1.65)	0.93(0.47-1.86)	1.13(0.59-2.14)
3rd quartile	**1.81(1.16-2.83)**	0.99(0.71-1.38)	0.98(0.45-2.09)	0.79(0.39-1.59)
4th quartile	1.26(0.81-1.94)	0.83(0.58-1.20)	1.05(0.44-2.50)	0.87(0.44-1.82)

* Adjusted for mill, gender, and job tenure

The 4th quartile represents the highest level of physical and psychological demand, job control, social support, and noise exposure

Table 3.7 – Unadjusted and adjusted odds ratio (95% CIs) for back-related compensation claims and hospitalizations by job category at the time of injury or hospitalization

	Back Injury CLAIMS		**Back Injury HOSPITALIZATIONS**	
Job category	**Unadjusted Odds ratio (95% CI)**	**Adjusted* Odds ratio (95% CI)**	**Unadjusted Odds ratio (95% CI)**	**Adjusted* Odds ratio (95% CI)**
Foreman supervisor	Reference	Reference	Reference	Reference
Skilled trades	**2.17(1.23-3.83)**	**2.16(1.21-3.86)**	1.13(0.51-2.48)	1.28(0.54-3.03)
Material handler/ unskilled	**2.04(1.15-3.61)**	**2.00(1.11-3.61)**	1.42(0.65-3.12)	2.27(0.93-5.55)
Machine operator/ attendant/ clearer/ sorter	**1.94(1.10-3.40)**	**1.86(1.05-3.31)**	1.27(0.59-2.71)	1.74(0.74-4.05)
Mobile equipment operator	1.75(0.94-3.27)	1.79(0.95-3.38)	1.16(0.49-2.77)	1.59(0.62-4.13)
Inspector/grader	1.17(0.61-2.24)	1.10(0.57-2.13)	1.19(0.44-3.18)	1.86(0.61-5.66)
Non-wood production	0.80(0.27-2.33)	0.91(0.31-2.68)	2.26(0.68-7.50)	2.66 (0.68-10.39)
Unknown	1.80(0.53-6.16)	1.94(0.56-6.70)	------	------

------Too few subjects to make analyses possible

*Adjusted for mill, gender, and job tenure

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CHAPTER 4 General discussion

1.0 Discussion

The two main objectives of this research are to describe the rates of back-related compensation claims and hospitalizations in a cohort of British Columbia (BC) sawmill workers, and to identify the risk factors associated with back injuries resulting in compensation claims and hospitalizations. In addition to meeting these objectives, this research also addresses some of the methodological limitations that have plagued prior occupational back injury studies.

This thesis is organized into four chapters. The first chapter consists of the Introduction and Literature Review; Chapter two is a descriptive paper on the rates of back-related compensation claims and hospitalizations; and Chapter three is an analytical paper on the risk factors associated with back injury. Chapters two and three are written as papers for submission to peer-reviewed journals. This final chapter summarizes the main findings from these papers, discusses the strengths and limitations of the research, and presents some ideas for future research in this area.

Chapter one examines the current literature on the epidemiology of occupational back disorders, the physical and psychosocial risk factors for back injury, the studies conducted on sawmill populations with respect to injury or working conditions, the use of administrative databases for the purposes of health research, and the use of compensation claims and hospitalizations as outcome measures. Based on this literature review, there is a need for a study of risk factors for back injury in the sawmill industry that includes physical and psychosocial factors, as well as noise exposure, with objective measurements of both exposures and outcomes.

Chapter two describes the rates of back-related compensation claims and hospitalizations in a cohort of sawmill workers employed from 1987 to 1997. The results demonstrate that during this period, the sawmill industry was a high risk industry with rates of back-related compensation claims similar to those of other high risk industries such as construction and mining [1]. In addition, the rates of compensation claims and hospitalizations declined over the study period (1987-1997), which previous studies have suggested may be attributable to changes in the labour market and in physician practices [2-4]. However, these hypotheses were not tested in this study and should be investigated in future studies of back injury in the BC sawmill population.

Chapter three examines the relationships between back injury, and physical and psychosocial occupational factors in a multi-variable model. One of the main findings from this chapter was that jobs that tend to be more physically demanding (e.g. skilled trades, material handlers) have a higher risk of compensation claims compared to jobs that tend to be less physically demanding (e.g. foreman/supervisor). This link between back injury and more physically demanding jobs has also been demonstrated by others [5] . Using a cohort of approximately 31,000 workers, Gardner et al. [5] found that those who had the most physically demanding jobs had an injury rate of 3.64 per 100 person years, compared to an injury rate of 1.82 per 100 person years among workers with less physically demanding jobs. The current study also reports that although no single physical risk factor (e.g. force, repetition, awkward posture etc.) significantly increases the risk of injury, jobs with one or more risk factors have a higher risk of injury compared to jobs with none of the risk factors.

Another important finding reported in Chapter three was that workers with more job control have lower risks of back-related compensation claims and hospitalizations. Using hospitalizations for back injury as an outcome measure, Leino et al. [6] also found that workers with more job control were less likely to be hospitalized. The present study, however, did not demonstrate any association between back injury and psychological demand. Kerr et al. [7] also reported that, after controlling for physical demand, psychological demand was not associated with back injury, and they argued that the Job Content Instrument was a better measure of physical demand than it was of psychological demand.

Interestingly, noise exposure was found to increase the risk of compensation claims; however, this risk decreased in the highest category of exposure, which may be due to greater use of hearing protection. While there appears to be no published study that has reported a relationship between back injury and noise exposure, prior studies have demonstrated that noise levels in some sawmills are above recommended levels [8-12], and that employees have complained about the effects of noise remaining after completing their work shift [13]. Although the mechanism of injury is unclear, noise exposure may increase the risk of injury either by increasing catecholamine output [14], or by reducing a worker's ability to hear potential dangers [15].

The findings from this research provide evidence for a multi-factor etiology of back injury that involves physical and psychosocial factors, as well as noise exposure. These results also confirm that there are both acute and cumulative components in the etiology of back injury. For instance, the cumulative analyses revealed that job control is associated with back injury; whereas, the acute analyses discovered risk factors such as having a job that tends to be more physically demanding, and having one or more of the five physical factors (i.e. force, repetition, awkward and static postures, and vibration) in the job are associated with injury. The association between job control and back injury also supports the idea that psychosocial factors can affect musculoskeletal injury risk, perhaps by increasing spinal loads via changes in movements, postures, and exerted forces [16, 17]; increasing muscular tension [18, 19] causing reduced blood flow to muscles resulting in the accumulation of metabolites [20, 21]; and increasing plasma cortisol levels, as well as other sympathetic hormone levels indicating that the body is in a catabolic state [22]. Psychosocial factors can also alter the perception or the reporting of pain [23, 24].

These results provide valuable information for workers, managers, and health and safety professionals in the sawmill industry, as well as other heavy industries, which can be used to design and implement safety interventions. Based on these results, one of the main occupational health and safety priorities should be to reduce the physical demands associated with certain high risk industrial groups such as skilled tradespersons and manual labourers. Specific attention should also be placed on identifying jobs with multiple physical risk factors, and eliminating or reducing the impact of those risk factors.

In addition, managers, as well as health and safety professionals, should understand the importance of job control in relation to injury risk, and incorporate that understanding into the workplace culture. Hearing protection, in addition to engineered noise control, should also be advocated as a safety measure that can not only prevent occupational hearing loss, but can also potentially reduce the risk of back injury.

In addition to providing information to help reduce the risk of injury in sawmills and other heavy industries, this research also addressed some of the methodological limitations that have proved problematic in prior occupational back studies. For instance, in the analytical aspect of this research, quantitatively assessed exposure and objective outcome information was used, which reduces the risk of common method bias, as well as the potential for recall bias. As well, the physical demands of the job were controlled while examining psychosocial factors, because high physical demands and poor psychosocial conditions have been shown to be present in the same job [25, 26]. As well, we used data from a longitudinal study, which has a greater power to infer causality than a cross-sectional study design that has been used in most previous investigations of back injury [20].

Some of the improvements in the descriptive component of this research included using accurate denominator information to calculate rates of injury. Whereas others, including the Workers' Compensation Board, have used estimates of the number of workers employed taken from census or payroll data, this research used actual days worked from employment records. As well as providing more accurate rates, this research specifically calculated back-injury rates among sawmill workers, which have never been reported in the literature.

While this study has several strengths that build upon the existing occupational back injury literature, there were some limitations that should be noted and addressed in future studies. Firstly, as previously mentioned, there was no association between any one physical factor (e.g. force, repetition, awkward posture, etc.) and back injury risk. As described in Chapter three, these null results may be due to the use of exposures that were assessed dichotomously (present/absent), which, in a high risk industry such as the sawmill industry, makes it difficult to find an adequate comparison group. Secondly, because the same exposure information was applied to all jobs irrespective of the type of mill or the worker characteristics, this increased the chance of exposure misclassification. Thirdly, there was no compensation or hospitalization information prior to 1987, which made it impossible to determine whether workers had sustained previous back injury – a risk factor for subsequent injury.

These limitations could be addressed by conducting further research using exposures assessed more accurately and specifically by mill and worker. In addition, a back injury-free period could be used to eliminate workers with a prior back injury. Future studies should also calculate rates specifically by job category, as these rates would assist in determining the effectiveness of the interventions on injury risk.

2.0 References

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