AN ANALYSIS OF TIME-LOSS DURATION

FOLLOWING WORK-RELATED TRAUMATIC INJURIES

TO THE HAND AND WRIST

by

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at

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Dedication Page

To my parents, whose philosophy regarding education resonated with my own: “Learning takes many forms...choose the path that is right for you”.

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ABSTRACT

Objective: The purposes of this thesis included: i) To explore the annual incidence and time-loss duration of traumatic, work-related injuries of four *nature-of-injury* (fractures, nerve lacerations, tendon lacerations/disruptions and amputations) and two *part-of-body* categories (hand and wrist); and ii) To identify the incidence and time-loss duration, and examine explanatory variables that were associated with time-loss duration for subjects with hand fractures. **Methodology:** Data on incidence, time-loss duration and explanatory variables were reviewed on claims accepted between January – December 2006 at WorkSafe-New Brunswick. Descriptive statistics and non-parametric tests were used to explore incidence and time-loss duration. Using a biopsychosocial framework, explanatory variables associated with time-loss duration were analyzed using Cox Proportional Hazards regression. **Results:** The incidence for hand and wrist trauma involving fractures, tendon lacerations/disruptions and amputations was low (3%). Incidence was significantly higher for fractures and for injuries to the hand, while time-loss duration was significantly higher for the wrist ($p < .05$). The incidence rate of *hand fractures* was low (1.5%) and average time-loss duration was high (92 days). Increased time-loss duration was associated with greater medical aid costs (used as a proxy for injury severity) older age and increased receipt of therapy (Physiotherapy/Occupational Therapy). **Conclusions:** The annual incidence of specific injuries involving the hand and wrist is challenging to compare to the literature since incidence is presented in many ways. Time-loss duration following hand and wrist injuries is highly variable. Time-loss duration for hand fractures exceeded reports in the literature and predicted values reported in disability duration guidelines. Consideration of the impairment, personal and environmental factors is warranted to provide a framework to the return-to-work process for all stakeholders involved in the care of the hand- and wrist-injured worker.

LIST OF ABBREVIATIONS USED

1. ICF – International Classification of Functioning, Disability and Health
2. WorkSafe-NB – WorkSafe-New Brunswick; prior to October 6, 2008 this organization was known as Workplace, Health, Safety and Compensation Commission of New Brunswick (WHSCC-NB)
3. HISS – Hand Injury Severity Score
4. MHISS – Modified Hand Injury Severity Score
5. SD – Standard Deviation
6. DF – Degrees of Freedom
7. RR – Relative Risk

GLOSSARY

1. Cumulative Trauma Disorders – disorders of the musculoskeletal tissues that occur as a result of cumulated or repeated micro-traumas to the tissues; the cumulative effect occurs when the tissues do not have adequate rest to recover and/or repair

2. Disability of the Arm, Shoulder and Hand (DASH) questionnaire – a self-reported assessment that examines perceived ability to perform activities of work and daily living, satisfaction and simple psychological factors.

3. Disability Duration Guidelines – a disability management reference tool that provides estimates on disability duration and rehabilitation guidelines for uncomplicated illness or injury occurrences

4. Environment –cultural, institutional, physical and social elements that can enable or constrain occupational performance.

5. Hand –the musculoskeletal structures in the region from distal to the carpals to the distal part of the digits, i.e. those structures from the base of the metacarpals to the end of the phalanges

6. Hazards Rate – the effect of an explanatory variable on the hazard or risk of an event e.g. time-loss duration

7. Incidence – describes the number of new injuries (nature-of-injury, part-of-body) in the WorkSafe-NB cohort in the one-year period (2006)

8. Incidence Rate – describes the number of specific injuries (nature-of-injury, part-of-body) per total injuries in the WorkSafe-NB cohort in the one-year period (2006)

9. International Classification of Functioning, Disability, and Health – a classification system endorsed by the World Health Organization to measure health and disability at both individual and population levels.

10. Musculoskeletal injuries – injuries involving tissue composed of the muscles and bony skeleton

11. Mechanism of Injury – the method of which an injury is sustained

12. Nature-of-injury – the principal physical characteristics of an injury

13. Occupational – relates to paid employment issues

14. Part-of-Body – relates to the injured part-of-body directly affected by an injury

15. Time-loss injuries - injuries where a worker is compensated for a loss of wages following a work-related injury

16. Time-loss duration – elapsed time from cessation of work to a return-to-work following an injury; the latter was accepted as accommodated or regular work

17. Traumatic injuries – injuries caused by a specific extrinsic mechanism

18. Wrist – the musculoskeletal structures in the region from the distal forearm up to and including the distal carpal row

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Chapter 1: INTRODUCTION TO THESIS

Introduction

Traumatic, work-related hand and wrist injuries are infrequently examined in the literature with respect to time lost from work[1]. Injury is accepted as a principal cause of disability; however, the literature has advanced primarily based on the mechanisms by which to treat and measure the physical injury characteristics[2-6]. Occupational health management and research has focused on the high incidence and economic impact of all work-related disability[6] but with minimal evidence specifically related to hand and wrist injuries.

In Canada, the incidence of hand and wrist injuries, defined as the number of these injuries in a given period of time has been primarily identified in the literature through population health research and provincial Workers' Compensation Boards' annual reports[13, 14]. Comparing results of studies related to incidence is challenging, given that the data commonly includes a mixture of *nature-of-injury* and *part-of-body* categories[1,13,16-18,31,44-46]. While compensable traumatic hand and wrist injuries comprise a significant proportion of workplace accidents[14] the literature continues to question why some individuals recover and resume occupational roles faster than others with similar injuries[2, 15].

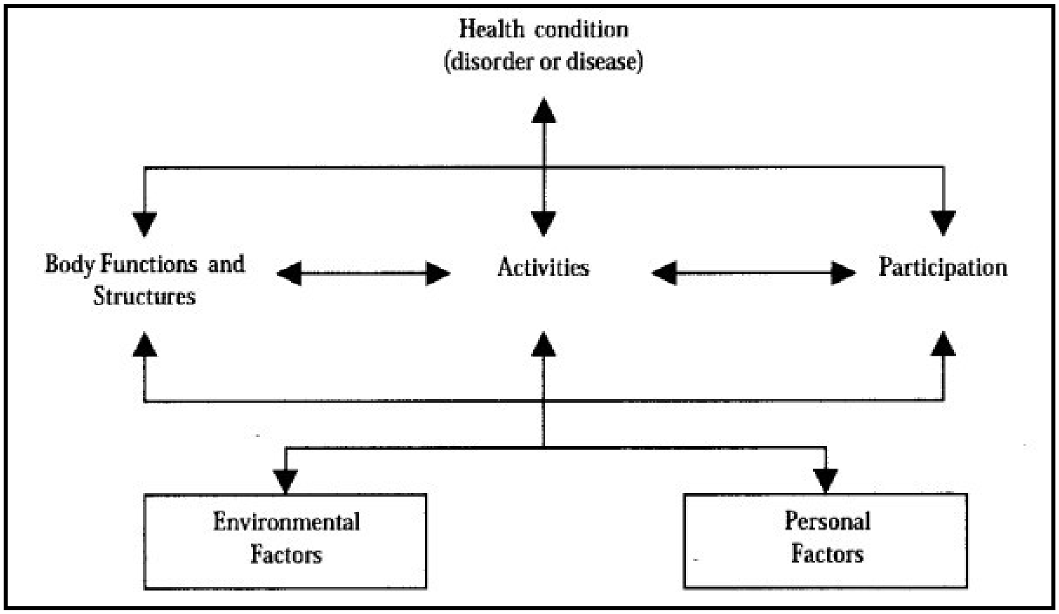
Time-loss duration, identified as elapsed time from work cessation to work-return in days or weeks, is the primary outcome measure used by insurers. The relationship between time-loss duration and traumatic injuries involving only the wrist has received nominal attention through research[1, 16-22]. There are even fewer investigations to aid our understanding of work absence that involve only hand injuries[23]. Research involving upper extremity trauma will often combine hand and wrist injuries[1, 24], which makes it difficult to determine whether specific characteristics of the injury, the body part (level) affected, or variables external to the injury itself influence the time-loss duration. While trauma to the distal forearm and wrist can affect both wrist and hand function[25], the specific nature of the injury and level of injury will often impact on healing times and medical and therapeutic management. As such, injured workers with hand and wrist trauma warrant a closer examination and evaluation of their outcomes.

A number of broad categories have been cited in the literature as influencing the experience of occupational disability[4, 26, 27]. These include health care costs, social policies, employer processes, and personal characteristics. Numerous authors[2, 6, 7, 11, 23, 25, 26, 28-32] have proposed specific predictors associated with time-loss duration, but few have addressed traumatic hand and wrist injuries as a cohort. Those who have examined these injuries purport that an array of variables influence time-loss duration, including personal, environmental, and impairment characteristics[1, 15-18, 33-36]. Thus, in addition to the physical limitations, the capacity to perform tasks and participate in work activities may be influenced by factors external to the injured worker after hand or wrist injury [2].

Examining the impact of hand and wrist injuries and defining the most accurate and relevant variables associated with time-loss duration remains controversial[7-12]. For those studies that examined predictors of time-loss duration, the sample populations represented a mixture of injury categories and body sites injured, and an array of predictor variables[24,26,73], Many challenges contribute to the limitations in the literature and the failure to link the identified variables to work absence. These include the relatively small scope of studies that have examined traumatic hand and wrist injuries, the diversity of diagnostic categories and sample populations used, as well as the range of outcome variables assessed for data collection.

Despite the inconsistency of variables used to study incidence and time-loss duration, the literature supports associations between time-loss duration and the variables of age, occupational demands, injury severity and injury characteristics. The relationship between hand impairments and challenges with occupational performance is not as clear-cut[37]. To better understand that relationship, researchers have expanded outcome measures to include both physical and psychosocial factors that contribute to health[10, 38, 39]. The International Classification of Functioning, Disability, and Health (ICF)[40,] model has gained popularity to explain the broader perspective of health, including following injury (Figure 1). However, this model has been minimally used to guide our understanding of hand and wrist injuries[38, 41].

Figure 1: International Classification of Functioning (ICF) model[40].



Using the ICF as a framework, this study seeks to first identify the incidence and time-loss duration of subjects with WorkSafe-New Brunswick having hand and/or wrist injuries that include at least one of four nature-of-injury categories, (i.e. fractures, amputations, nerve injuries or tendon lacerations) and the time-loss duration for these subjects. Second, variables associated with impairment, personal and environmental factors that potentially influence work-related activity limitations and participation restrictions (i.e. time-loss duration) will be examined. It is anticipated that the results of this research will contribute to the occupational profile and practice guidelines in the delivery of health services to those with hand and/or wrist injuries. Given that active research endeavours in this population are minimal in Canada, knowledge obtained from this Atlantic-based study can be applied to the hand- and wrist-injured population throughout this region, and beyond.

1.1 Objectives

The main purposes of this thesis were to explore the annual incidence and time-loss duration of traumatic, work-related injuries of the hand and/or wrist

(Phase 1), and to examine those factors that were associated with time-loss duration (Phase 2). Understanding these concepts should enhance the multi-faceted management processes for injured workers with hand and/or wrist injuries.

In order to achieve the purposes of this thesis, two phases for data collection and analysis were completed. The focus of Phase 1 included collection and analysis of incidence and time-loss duration for four *nature-of-injury* categories (i.e. fractures, amputations, nerve lacerations, tendon lacerations/disruptions), and two *part-of-body* categories (i.e. wrist[a] and hand[b]). The results of Phase 1 contributed to the identification of the one combined *nature-of-injury* category and *part-of-body* category that was further studied in Phase 2. The decision for the selected Phase 2 categories was completed through an analysis of both the *nature-of-injury* and *part-of-body* data.

Using data from one calendar year in WorkSafe-NB's injured-workers' database, the following objectives were identified:

Phase 1

1.1. To compare the incidence and time-loss duration among those workers who have sustained traumatic hand and wrist injuries in at least one of four *nature-of-injury* categories, namely: fractures, amputations, nerve lacerations, and tendon lacerations/disruptions and to identify the *nature-of-injury* category that had the highest incidence and time-loss duration.

1.2. To compare the incidence and time-loss duration between those workers who have sustained traumatic injuries in one of two *part-of-body* categories, namely hand injuries and wrist injuries, and to identify the *part-of-body* category that had the highest incidence and time-loss duration.

1.3. To establish the combined *nature-of-injury/ part-of-body* category for study in Phase 2 using the *nature-of-injury* category identified in 1.1, and

[a] Wrist includes injuries to the musculoskeletal structures in the region from the distal radius/ulna to and including the carpals

[b] Hand includes injuries to the musculoskeletal structures in the region from distal to the carpals to the distal part of the digits

the *part-of-body* category identified in 1.2. For example, amputation (i.e. *nature-of-injury*) combined with wrist (i.e. *part-of-body*) would lead to *wrist amputations.*

Using the combined *nature-of-injury/part-of-body* category identified in objective 1.3, Phase 2 was then completed with the following objectives addressed:

Phase 2

2.1 To identify the incidence and describe the time-loss duration for subjects who sustained the combined *nature-of-injury/ part-of-body* category identified in Phase 1.

2.2 To use multivariate analysis to explain time-loss duration in the subjects who sustained the combined *nature-of-injury/ part-of-body* category identified in Phase 1 based on variables set in the context of the ICF model (impairment of body functions/structures, personal factors, and environmental factors).

1.2 Hypotheses

The hypotheses for the two phases of this thesis were as follows:

Phase 1

There are differences in incidence and time-loss duration among subjects who sustained work-related traumatic injuries, based on the *nature-of-injury* categories (i.e. fractures, amputations, nerve lacerations or tendon lacerations/disruptions) and the *part-of-body* categories (i.e. hand or wrist).

Phase 2

For subjects with the combined *nature-of-injury/ part-of-body* category from Phase 1, there are associations among time-loss duration and explanatory variables set in the context of the ICF model (i.e. impairment of body functions / structures, personal and environmental factors).

1.3 Structure of Thesis Manuscript

The structure of this thesis manuscript is described as the following:

Chapter 1: Chapter 1 introduces the thesis topic, including identification of the problem and an overview of the rationale for the development and implementation of the thesis content. The objectives, hypotheses for the two phases of the study, and structure of the thesis manuscript are described.

Chapter 2: This chapter provides a review of the literature relevant to the thesis topic. Highlights of this section include discussion of the incidence and costs of hand and wrist injuries, workplace injury processes, time-loss duration as an outcome, and potential variables associated with time-loss duration.

Chapter 3: Chapter 3 provides details of the methodology of this thesis study. The study's design, sample description including inclusion and exclusion criteria, procedures for each phase of the study with respect to data collection outcome measures, and data analysis methods are named. This section also describes a summary of the pilot work that was completed to enhance the author's understanding of the database used to study the subjects.

Chapter 4: The results of the thesis study for both Phase 1 and Phase 2 are presented in Chapter 4.

Chapter 5: This chapter provides an in-depth discussion of the results of this study, as they pertain to the intent of the study's objectives and the reviewed literature. Implications for clinical relevance are also presented.

Chapter 6: Chapter 6 summarizes this study, providing concluding remarks on the study findings and identification of future study and recommendations relevant to the thesis topic.

Chapter 2: LITERATURE REVIEW

2.1 Hand Function

Humans have the unique ability to manage, influence, and perceive the environment through their hands with accuracy and finesse. Movement patterns, sensation, strength, endurance and dexterity all enable the hand to perform a range of tasks from simple to complex. A seemingly innocuous injury can affect the complex interconnectedness of the physical components necessary for hand function, creating a range of functional challenges, such as difficulty picking up a coin or effectively grasping a tool[42] (p 927). Despite our knowledge that hand and wrist injuries have devastating consequences on functional performance and participation in daily life, minimal references to their impact exist within the literature[38].

Limitations in the early stages of hand impairment can trigger adaptive skills though compensatory strategies or alternative methods of performance[2]. Prolonged recovery times may influence an individual's ability to adapt, depending on an individual's motivation, coping skill, and severity of injury[2, 23]. Psychosocial challenges related to the trauma itself or to the recovery process can negatively impact occupational performance and the ability to derive pleasure from activities that give meaning in one's daily life[26, 43]. The failure to recover hand function to meet one's physical capacity, belief systems, or role participation can have devastating consequences on an injured worker, such as the inability to return to one's pre-injury workplace, the loss of financial independence, or the helplessness to provide for one's family[1, 15-18]. It is critical to avoid such destructive outcomes by identifying those injured workers at risk and understanding the variables that contribute to successful outcomes.

Although impairment, such as decreased range of motion, strength or sensation, is accepted as a vital component influencing hand function [1, 16, 35], impairment alone is questioned as a primary predictor of time-loss duration[12, 17, 38]. Evaluating functional outcomes after upper extremity injury has been moderately studied[1, 2, 6, 7, 9, 11, 16-18, 23, 25-27, 29-32, 34-36]; however, the extent to which such injuries impact return-to-work outcomes is challenging to interpret from the available studies. Researchers report challenges linking available evidence, such as impairment, with workplace accommodations, insurance practice and policy development[4, 6, 26, 28]. This is apparent in many studies involving tendon and nerve lacerations where impairment is the primary outcome variable, but the translation to functional ability is not stated or is unclear[10].

2.2 Incidence of Hand and Wrist Injuries

In order to appreciate the variables that may contribute to workplace disability, it is important to first understand the representation and rate of incidence of hand and/or wrist injuries. In the last 10 years, the observed trend of annual hand and wrist injury incidence ranged from 20-42% of the total number of injuries within general Canadian and international populations[13, 31, 44-46]. Statistics Canada, in their 2003 Canadian Community Health Survey[13], identified a range of epidemiological data with all injuries in the general population. Notably, hand and wrist injuries were at the top of the list, accounting for 31% of activity-limiting work injuries, followed by a 16% incidence of low-back injuries. This trend in the general population is contrary to the available statistics in provincial Workers' Compensation Boards' annual reports[14], in which back injuries tend to assume the greater incidence. Possible explanations for this dissimilarity suggest that compared to compensation data, population survey data may capture three additional categories of injuries: injuries that are both work and non-work related, injuries in which a compensation claim is not initiated despite being work-related, and, injuries incurred by self-employed individuals who do not qualify for compensation benefits[13].

Hand and wrist injuries are a common result of work-related accidents[12, 13, 28, 36, 47, 4824]. Across several Canadian Workers' Compensation Boards, the incidence of hand and wrist injuries is noteworthy, ranging from 14-17% (Table 2.1). Comparison of the data from one province to another can be a challenge as the definition of upper extremity injuries is inconsistent across different boards. Of the provincial Workers' Compensation Boards examined, all differentiated finger injuries from the remainder of the upper extremity injuries.

Nova Scotia, Prince Edward Island, and Ontario also differentiated the hand and wrist from the arm, while Alberta combined these categories. New Brunswick did not specify injuries involving the wrist, although it is plausible that wrist injuries were combined with the arm in this report[49].

Table 2.1: Percentage of Workers' Compensation Board (WCB) Claims by Part-of-body affected for Hand and Wrist Injuries, 2006

Provincial WCB	% of total of all injuries				
	Fingers	Hand	Wrist	Arm*	Total
ALTA	15.0	11.1		7.3	33.4
NS	6.6	3.4	4.0	4.4	18.4
PEI	7.3	3.1	5.9	5.2	21.5
ONT	8.4	4.0	4.2	4.5	21.1
NB	11.0	4.0	Unspecified	11.0	26.0

* excludes shoulders

In a review of the 2006 annual report of WorkSafe-NB[49, 50], the combined total rate of injury affecting arms (excluding shoulders), hands, fingers, and thumbs was 26%, second only to back and spine injuries at 28.4%. Although a decline was reported in the number of all claims, a rise in overall claim length for 2006 was noted compared to 2005[50]. An aging population was offered as one possible explanation for this finding, given the suggestion that older aged workers are injured less often but remain off work longer[49]. This relationship is weakly supported in the literature with injuries involving fractures, in particular distal radius fractures[18, 20, 33], and unsupported for injuries involving amputations, tendon injury/disruptions, or nerve lacerations[16]. Details of incidence or time-loss duration per *nature-of-injury* were not published in the WorkSafe-NB 2006 report[49], suggesting further studies may offer additional or alternative rationale for this increased claim duration.

Documented evidence of the *nature-of-injury* trauma to the hand and/or wrist most often indicates damage to bone, joint, tendon or nerve structures[13, 17, 47, 48, 51]. However, reports of the incidence of each *nature-of-injury* trauma are few, and many contain categories that are ambiguous. For example, "cuts" and "fractures" contributed to the second and third most frequent categories, respectively, of all injuries within the 2007 Statistics Canada report[13], exceeded only by “sprains and strains”. While “cuts” and “lacerations” are frequently noted in the literature[1, 31, 45], these may describe the mechanism of injury rather than actual structural injury. Furthermore, “cuts” and “lacerations” may range from simple to complex trauma, such as a superficial paper cut versus a tendon or nerve laceration.

Wong (2008)[1] identified a proportion of *nature-of-inju*ry categories for her 109 subjects with hand and/or wrist trauma. Fractures accounted for 46% of the sample while tendon lacerations and amputations represented 26% and 6%, respectively. “Simple lacerations” was a category with 17% incidence, although details of structural injury were not offered[1]. Results of a Danish study of 73 hand injuries from farm accidents[48] indicated 45% lacerations/amputations, 36% fractures, and 6% tendon lesions. Combining lacerations and amputations may result in missing data (e.g. nerve injury), potentially generating unreliable data on which to build conclusions. Researchers in Sweden [52] completed an epidemiological study on peripheral nerve injuries and amputations over a 9-year period. Their findings showed a rate of 63% and 77% for peripheral nerve injuries and amputations, respectively, at the wrist and hand.

In contrast, the findings of Cann et al.[31] and Jaskolka[45] showed lower rates of specific trauma for *nature-of-injury* compared to others[1, 13, 47, 48, 52]. Both studies examined work-related injuries at a Canadian university over a five year period. Despite a high incidence of injuries involving the hand (i.e. 40%[31] and 30%[45]), bone and joint trauma (including fracture, dislocation or subluxation) occurred at rates of only 0.5%[31] and 2.5%, respectively[45]. For both studies, the majority of hand injuries occurred as a result of cumulative trauma, sprains/strains, or flesh wounds. A distinction between the incidence of cumulative trauma and specific trauma is required to discern the impact of these *nature-of-injury* categories.

For a number of reasons, criteria for many cumulative trauma disorders are not universally accepted across Workers’ Compensation Boards[53]. Within Workers’ Compensation Board databases, differentiation of an *acute* (i.e. trauma*)* versus *repetitive* (i.e. cumulative) mechanism of injury is not stated [14]. Some authors[53, 54] postulate that the accuracy and reliability of recording cumulative trauma injury challenges health care providers and administrators of databases. For example, the largest incidence of *nature-of-injury* category across Canadian Worker's Compensation Boards[14] is "sprains and strains". However, these categories are not clearly defined and could potentially represent either an acute trauma or a repetitive injury[14]. Furthermore, enumeration errors can occur within Workers' Compensation Board databases given the coding system of assigning only one anatomical region per injury, even if multiple sites are injured[53, 54]. Similarly, a potential issue relates to the coding process where only one injury can be entered into the database, even if multiple injuries occur [53]. This may result in the multi-factorial *nature-of-injury* being overlooked, and the inaccurate identification of the injury that is limiting activity participation. Exploring the impact of specific trauma versus cumulative trauma in work-related injuries is a challenging process because the incidence rates of the two are frequently combined[53, 54]. Van Eerd[53] and Zakaria[54] recommend that specific trauma and cumulative trauma be separated for in-depth studies.

2.3 Economic Impact of Hand and Wrist Injuries

The current review has exposed challenges in determining the full financial impact related to this work-injured cohort. Only two studies examined impact from an economic perspective[44, 55]. On average, the annual rate of hand and wrist injuries was 20% according to Schofields' historical review of Ontario's work-related injuries from 1998-2002[44]. For that cohort, the average yearly wage replacement costs incurred for that time period was close to $52 million. In a 1995 epidemiological study, Kelsey et al.[55] examined the frequency, impact, and cost of upper extremity disorders in the United States. Their results demonstrated that almost 33% of total body injuries were related to the upper extremity, with the total annual medical and indemnity costs of these disorders estimated to be $19 billion[55]. For both of these studies, the nature of these disorders was unclear, (i.e. specific trauma and cumulative trauma injuries were not delineated).

Interestingly, the results of Cann et al.[31] indicated that the highest health care costs were associated with hand injuries (72%) and, the lowest with back injuries (41%), whereas lost time costs were highest in the back-injured (59%) and lowest in the hand-injured groups (28%)[31]. While the incidence of specific traumatic hand and wrist injuries appears remarkable within the literature and Workers' Compensation Board reports and the research raises concern for the associated costs, little documentation is available against which to compare incidence and costs, or to assess their impact on work absence.

2.4 Workplace Injury Processes

From a broader perspective, disability management has become a core organizational focus for insurers and employers in order to address incidence of injury, safety and injury prevention, and workplace absence[3, 56, 57]. These initiatives are not without challenges however, due to the numerous stakeholders involved, the complicated and varied paths injury can require for recovery, and the barriers encountered with administrative political or legal processes following workplace injuries[57]. Successful return to work outcomes must ensure integrated approaches to treatment[3, 4], use reliable instrumentation to measure disability[5], and address risk factors related to the injured worker and the environment to which the worker returns[4]. The environment would include both the physical and socio-cultural environments as a means to understand the physical demands on the worker, as well as the policies and practices that contribute to and influence workplace processes[3, 4].

Many processes are implemented following a workplace injury, including reporting practices to establish the administrative file, employer communication to facilitate workplace return, and case adjudication/management to ensure appropriate financial remuneration and interventions for the injured worker. Researchers who study these processes have documented concern with measurement error which may lead to under-enumeration of the injured worker[53, 54]. If specific conditions are not captured properly within a system's database, adverse risks associated with inadequate or improper processes may impact the administrative and/or economic issues influencing work disability[53, 54]. In order to appreciate and study injuries in the workplace, it is important to understand these multi-faceted processes that occur with injury claims.

In Canada, the primary sources of annual data available that identify hand and wrist injuries are captured by the provincial Workers' Compensation Board[14]. Most provinces adhere to similar practices when an injury occurs in the workplace with respect to adjudication and/or case management (Appendix A). Based on the submitted records, administrative files are created to enumerate the details of the claims. A number of studies have examined this process citing validity and reliability challenges that impact accurate extraction methods when analyzing these databases[53, 54, 58]. These challenges include: illegibility of written reports submitted for the file[53], coding of multiple body site injuries as one primary site[53, 54, 58], and, lack of universal agreement with specific diagnostic categories such as neck pain[53] or traumatic brain injury[58]. Consequently, administrators may fail to identify those injured workers at risk for lengthy workplace disability, or to ensure that appropriate case management practices are upheld[59].

Perhaps the most challenging aspect of extracting data on hand and wrist injuries retrospectively is the coding system within Canadian Workers' Compensation Boards. Although this has been reported as reliable[53], it currently does not allow for transparent identification of injuries specific to nerve or tendon lacerations. While the *nature-of-injury* and *part-of-body* may be identified, information may be misinterpreted if the level of detail is insufficient to judge the specific structure(s) injured, the location of injury, or the severity of the injury. For example, a common and potentially significant hand injury is a tendon laceration. For a zone 3 (palmar) laceration affecting the flexor digitorum profundus to the long finger, the *part-of-body* coded may be the "hand, except fingers", and, the *nature-of-injury* may be "cuts, laceration". This would warrant the same code as a more innocuous injury such as a skin laceration in which no critical structures, such as a tendon, were affected. The potential impact on work absence may be overlooked or inappropriately case-managed if the significance of the injury is unrecognized in its early stages. Although the research literature contributes to the differential management of these similar-coded injuries[60-62], the Workers' Compensation Board databases do not allow transparent identification of all trauma-induced hand and wrist injuries. As such, guidance for administrators may not be available as to the multi-faceted treatments necessary, the potential threats to extended work disability, or the need for special consideration to ensure successful work reintegration.

The increasing costs of long-term work absence have become a distinct focus in occupational health management and research. Reed[63] documented that the longer an individual is away from his/her workplace, the more difficult it is to return successfully to the workforce[63]. The literature supports the identification of health care and wage replacement as the primary costs associated with occupational injuries[27]. However, in order to mitigate economic losses and facilitate timely return-to-work, collaboration, communication and coordination among stakeholders requires a large investment of energy and finances to ensure successful outcomes[6]. Disability duration guidelines, a tool that provides estimates on disability duration, are frequently used by insurance companies and occupational health advisors to influence return-to-work following musculoskeletal injuries. These guidelines generally offer optimum days of disability duration for a range of work demands, from sedentary to very heavy[63]. While there are four main publishers of disability duration guidelines, only one[63] was available for detailed review at the time of this study's development and implementation. This particular set of guidelines, *Medical Disability Advisor*[63], appears to be the mostly widely used across Canadian Workers' Compensation Boards[14].

Two common criticisms of disability duration guidelines are that they are based solely on physiological components, and only provide predictive time-loss duration for uncomplicated recovery from a medical condition, injury or procedure[63-65]. To be specific, most do not denote the effects of co-morbidities, complications, or psychosocial variables that can subsequently impact return-to-work expectations. While injury characteristics and medical management procedures (e.g. surgery) can not be ignored, psychosocial issues may play an integral part in upper extremity injury management and recovery[66]. Another limitation of the scope of disability duration guidelines is the absence of time-loss duration recommendations for specific – and critical – details on tendon and nerve lacerations[63]. Surgical and therapeutic management of these injuries often require specific and at times unique interventions depending on the type or level of structure injured[42, 100]. As such, the outcomes associated with these varied injury characteristics may influence the time it takes to resume occupational performance[100]. The level of injury (i.e. wrist, palm, or digit) is unspecified in Reed's[63] Disability Duration Guidelines and only vague reference is made to a longer duration of disability for flexor compared to extensor tendons. This is illustrated in Table 2.2 with examples of common *nature-of-injury* categories.

In the absence of guidelines for return-to-work, every individual involved in the management and treatment of tendon and nerve lacerations should understand the impact of these injuries and respect individual client needs for resumption of work activities[63]. Disability duration guidelines often suggest use of specialist healthcare professionals to treat tendon and nerve lacerations[63]. However, access to these practitioners may be limited from a geographical perspective. Ensuring sufficient competency is paramount to optimizing client outcomes, and is supported by hand therapy literature that identifies the need for sound clinical reasoning, judgement, and skill in the delivery of therapeutic assessment and intervention for this population[67].

Table 2.2: Disability Duration Guidelines for Examples of Nature-of-Injury and Part-of-Body (Reed 2007)[63]

Nature-of-Injury	Part-of-Body	Optimum Disability Duration: Sedentary - Very Heavy (days)
Fractures	Wrist	7-147
	Palm	7-42 (closed fracture)
	Fingers	3-42
	Thumb	3-42
Tendon injury	Wrist	Unspecified by part-of-body level
	Palm	or type (flexor or extensor)
	Fingers	56-84
	Thumb	
Nerve Injuries	Wrist	Unstated
	Palm	Unstated
	Fingers	Unstated
	Thumb	Unstated
Amputations	Wrist	Unstated
	Palm	Unstated
	Fingers	14-42
	Thumb	35-77

A final concern with disability duration guidelines is that they typically use the job classification system of sedentary, light, medium, heavy and very heavy strength requirements[63-65]. Challenges exist if the injured worker experiences other physiological deficits that impact function, but are not specific to strength. To illustrate this point, a distal radius fracture injury without deformity is examined. For a sedentary job classification, the minimum and maximum duration of disability is 3 and 21 days, respectively[63]. If the individual does not have full forearm rotation into pronation after 21 days, and the essential job duties are working on a keyboard, a conflict exists between worker capacity and the insurer expectations for resuming those duties based on disability duration guidelines[63]. The complicating issue is not the fracture itself or the presence or absence of adequate strength, but other residual deficits such as decreased mobility that can persist indefinitely and impact required function. In clinical practice, there are limited measurement options available on which to evaluate work demands for those with hand and/or wrist injuries[68].

Despite the challenges of existing databases and disability guidelines, there are benefits with their use. Workers' Compensation Board databases are a rich accumulation of longitudinal information and as such, offer power in their numbers and in meeting the administrative needs of their respective boards[18, 5320,37]. Additionally, databases provide a tool for case managers to highlight areas of concern, such as cost or injury trends within a given industry[69]. Researchers may circumvent subject recruitment challenges by accessing databases, thus increasing the feasibility of a study, particularly if time restrictions are a concern[69]. Likewise, disability duration guidelines offer some measures to guide case managers who may not have background knowledge in specific injuries and patterns of recovery[53]. Regardless, information yielded by databases and disability duration guidelines can impact the return- to-work process and should be interpreted with caution. Case managers, influenced by administrative policy, must allow for the accuracy of data enumeration, the variability of injury recovery and, the allowable costs afforded to claim adjudication[53]. Given these salient points, it is reasonable to ensure that both professional and scholarly vigilance should be directed toward transparent enumeration of hand and wrist injuries that may influence timely resumption of occupational participation.

Understanding the return-to-work process and its associated outcomes is a complex entity. Numerous researchers have identified this multi-factorial process, noting the importance of potential threats for prolonged work absence, the effect of evidence-based practices, and the advantages of collaborative management approaches[4]. With the evolution of a paradigm shift from medically-based models to more biopsychosocial approaches such as the ICF, consideration of the individual, the environment and the social influences of disability is enabled[4, 5, 38]. Current management approaches and outcome measures may not fully address the client's ability to engage optimally in typical occupational activities, particularly if impairment alone is used to guide the return to work process [3, 38]. Advocating a biopsychosocial approach that encompasses client-centered therapeutic interventions and outcome measures is recommended in current hand rehabilitation literature[66, 70].

2.5 Time-Loss Duration

Work absence following an occupational injury is a multidimensional challenge. Current literature demonstrates considerable variability regarding outcomes with injuries to all parts of the body, but a paucity of evidence is available on time-loss duration specifically. Among studies examining all injuries, cumulative trauma disorders or a mixture of cumulative trauma disorders and specific traumatic injuries comprised most samples investigated[13, 28, 71, 72]. Reported average time-loss duration for cumulative soft tissue injuries was 12 and 11 weeks respectively, for Carpal Tunnel Syndrome and enthesopathy[c] claims[28], and 11.4 weeks for repetitive shoulder pathology[72]. Time-loss duration for fracture injuries of various parts of the body averaged 18 weeks[73]. The range in these findings may be attributed to a variety of factors, including: the range of diagnostic categories studied, the inconsistency of injury management, and the lack of standardization of return-to-work measurement[5]. A major interpretation challenge with the available literature is that diagnostic categories are often combined, such that specific trauma and cumulative trauma injuries in the hand and/or wrist are rarely differentiated[13, 31, 44, 55]. This variability can appreciably influence outcomes related to time-loss duration and its associated factors.

The literature tends to be more accurate with specific trauma-incurred injuries, such as fractures, lacerations, and amputations[54]. These diagnoses often have well-defined medical, diagnostic, and therapeutic management, which allows likelihood of similar care and functional impact across geographical

[c] Enthesopathy – disorder of the soft tissue attaching to bone including peripheral ligamentous or muscular attachments e.g. lateral epicondylitis

regions[73]. Conversely, cumulative trauma injuries often require more in-depth processes to diagnose and treat, and/or may be accompanied by complicating factors that influence recovery, such as worker-employer relationships, work task requirements, and psychosocial characteristics[27]. Exploring risk factors or predictors of work disability tends to take different paths for cumulative trauma versus specific trauma-induced injuries. The literature suggests that time-loss duration for cumulative trauma injuries is related to the presence of psychosocial issues (e.g. conflictual work relationships)[74], blaming oneself for the injury, and pre-operative absenteeism for those who later have surgery[22]. Wong[1] is the sole researcher who has examined time-loss duration with specific diagnostic trauma in the hand, exclusive of cumulative trauma injuries[1]. Her findings reported an association between longer time-loss duration and severity of injury, number of operations and presence of compensation claims. The limitation of that study was the use of a combined group of subjects injured both at and away from the workplace. Given the differences in baseline demographics[75] and time-loss duration between work-injured and non-work-injured subjects identified in the upper extremity-injured literature[2, 24, 72, 73], it is reasonable to study these subjects independently.

Few researchers have examined specific hand and/or wrist recovery times with respect to time-loss duration. Of the studies reviewed, the majority have focused on distal radius fractures, citing a variety of average time-loss durations ranging from 7 weeks[18] to 9 weeks[9] to 13 weeks[76]. Dutch researchers reported a 31-week average of time-loss duration from work for peripheral nerve lacerations involving the hand and wrist[16]. The authors went on to speculate that this time-loss duration was underestimated since Dutch insurance policy capped time-loss duration at 52 weeks. Consequently, results may have been skewed through this artificial ceiling. Another study[19] noted an average of 35 weeks time-loss duration for wrist injuries with combined tendon and nerve lacerations. Close to half of these subjects remained off work at least one year post-injury, supporting extended time-loss duration findings of other researchers who examined complex lacerations[16]. Skov et al.[24] reported a low average time-loss duration (i.e. 6 days) for all occupational hand and wrist injuries in their Danish study of 1022 subjects. While half of their subjects did not lose any time from work, 62% of those who did lost more than 10 days in total. Insufficient information prevented a thorough understanding of their subjects' injuries, e.g. extent and severity, and all time-loss duration information was self-reported[24]. It appears that within the category of hand and wrist injuries, there is considerable diversity of time-loss duration averages.

2.6 Variables Associated with Time-Loss Duration

As a broad measure of health outcome, the ICF has been used as a framework to guide many authors who have examined all variables that impact return-to-work[10, 38, 77]. Although consideration of impairment is an important factor impacting return-to-work, using this in isolation is not recommended[10, 17]. As such, researchers studying therapeutic and surgical outcomes have shifted their focus to include not only impairment but also disability and handicap[10, 37, 38, 77]. The ICF identifies three primary domains related to the impact of injury or disease, namely: *Body Functions and Structures,* describing the impairment or deficits in anatomical or physiological structures; *Activity,* reflecting the challenges one may have in the execution of activities of daily living; and, *Participation,* indicating one's ability to engage in roles and activities[37, 40]. Since an individual's functioning and disability take many perspectives, the ICF also includes environmental and personal factors that influence these domains[40]. Consideration of potential variables that may influence time-loss duration (i.e. *Impairments*, *Environment* and *Personal* factors) would allow a more thorough examination of the hand- and/or wrist-injured worker in the pursuit to return to work, the ultimate goal for participation.

2.6.1 Impairments of Body Functions and Structures

The extent of anatomical and physiological impairment in the hand and/or wrist has led many researchers to investigate the contribution of hand injury severity on time-loss duration[1, 25, 30, 32, 35]. Several studies have examined the severity of hand injuries and time-loss duration using the Hand Injury Severity Score (HISS)[25, 30, 78]. This scoring system was developed by Campbell and Kay[79] not only as a research tool to measure severity, but also as a potential clinical tool to predict functional outcomes. The HISS allows evaluators to score and rate the extent of a hand injury as minor, moderate, severe or major for these injuries that occur distal to but not including the wrist. A modified HISS (MHISS) was developed by Urso-Baiarda et al.[25] as a quantitative tool to evaluate both hand and forearm (including the wrist) injuries, since the latter can impact hand function. This tool offers detailed documentation of the description, extent, and level of an injury, including tendon/muscle, neurovascular, bone, and integument involvement distal to and including the forearm[25] (Appendix B). Details of injury characteristics, such as an open fracture or contaminated wound, are factored into the final score to account for potential threats to recovery[25].

Using the HISS, Wong[1] and Mink van der Molen et al.[35] examined time-loss duration in Chinese and Dutch populations, respectively. Both reported similar average time-loss durations (11[1] and 12[35] weeks) and ranges of work absence for minor to major injuries (5-24 weeks[1] and 4-22 weeks[35]). Despite the similarities in their findings, 85% of the subjects in the Chinese sample[1] had only minor or moderate injury severity, while the Dutch subjects showed close to equal distribution across the four severity categories. Watts et al.[32] reported an average of 14.4 weeks time-loss duration for a mean HISS score of 73 points (i.e. “severe” rating) but did not specify the type of injuries sustained or details of the hand severity.

Several researchers have examined the value of using a descriptive severity scoring scale with hand injuries, finding a strong correlation between time-loss duration and both the HISS[30, 35, 78, 79] and MHISS[25]. A primary criticism is that results of the HISS and MHISS do not actually reflect functional outcomes, despite the original intent[79]. For example, Mink van der Molen (2003)[78] examined a homogenous cohort of 71 work-related hand and wrist injuries, and found only a weak correlation between HISS and their functional outcome comparison, the Disability Arm, Shoulder and Hand (DASH) questionnaire[35]. Thus, their attempt to link measures of injury severity with disability was unsubstantiated. Conversely, Saxena et al. (2004)[30] noted a significant relationship with injury severity and the DASH with 23 subjects. A possible explanation for the different outcomes in these two studies could be the timeline post-injury within which the DASH was offered. For the 2003 study[35], the DASH was administered 6 months after injury, while the subjects in the 2004 study[30], completed the DASH an average of 32 months after the injury. It is plausible that with a longer elapsed time e.g. 32 months, recovery and adaptation to impairment have been maximized, and functional outcomes have been clearly declared.

The only study to examine time-loss duration using the MHISS identified hand injury severity prospectively, identifying Welsh participants with an existing database and evaluating severity through postal questionnaire or telephone interview[25]. Those who responded (n=84) tended to be older and have more "major" severity scores, compared to those who did not respond (n=92)[25]. While their findings identified a positive association of injury severity to time-loss duration, response rate was low (48%) thereby threatening the validity of their findings. Furthermore, it is possible that this association may have been influenced by the bias of those responders who were more severely injured [25]. Given the strong potential for forearm injuries to impact the hand and its function, the MHISS provides an alternative method to identify those injuries with minor to major categories of severity

While severity was identified as a strong predictor of time-loss duration in the aforementioned studies[1, 25, 30, 32, 35], it is rarely used outside of the research paradigm[25] and thus may only be useful as a global predictor, and not specific to individuals. Given that Workers' Compensation Board data does not routinely specify the nature of all hand and/or wrist trauma, capturing details of the injury itself in the early stages might better contribute to the understanding of the severity and healing of an injury [25], particularly for those depending on administrative disability duration guidelines[63]. This would ensure accuracy and reliability of progressive administrative and injury management, and associated research endeavours.

Since severity of injury is rarely used as an evaluation tool in practice[25], it has been suggested that health care costs may be used as a proxy for severity for retrospective analysis[18]. It is also speculated that variables such as therapeutic interventions[6] and surgical interventions[1] could be substituted as indicators of injury severity which may influence workplace absence. This endorses Bruyns et al.'s proposal[16] that specific structural damage and location of injury may reflect injury severity since the post-injury management of many hand and/or wrist injuries includes specific and intensive interventions to restore function of the injured structures.

Research outcomes offer further insight into injury characteristics of subjects having hand and/or wrist injuries. The type and level of injury within the upper extremity have been examined for their association with disability duration[1, 16, 33]. Features such as the type of nerve (e.g. median versus ulnar), tendon injured (i.e. extensor versus flexor), or whether the injury occurred at the wrist or digit level have been identified as predictors of time-loss duration [10, 16]. Other authors[9, 17] have studied the characteristics of upper extremity fractures, such as alignment of the fracture and the presence of bony fracture involving the joint surfaces (i.e. intra-articular). Only pre-reduction (i.e. initial radiographs) and not post-reduction alignment of a fracture was noted as having an association with time-loss duration[9, 17]. For these studies, it was possible that post-reduction mal-alignment was reflective of a variable that lacked data distribution. Given that these subjects all received fracture reduction at a specialized hand center with experienced practitioners, only acceptable reduction would be expected [17]. In longitudinal studies, it is unclear if fracture reduction or if articular cartilage damage would automatically progress to adverse effects and contribute to functional impact (i.e. relapse in work ability) over time[80].

While these studies examining severity suggest possible prognostic value, it is unclear if informed individual and employment decisions would or could be altered in the early stages following such injuries[25]. Consequently, it appears that explanatory models that consider only the structural impact of injury on time-loss duration could be augmented by an understanding of the impact on activities and participation through contextual factors e.g. environmental or personal. Agreement is noted across many studies[4, 6, 26, 27] that the physical impairments alone do not contribute to work absence, but are in combination with the person, his or her environment, and the systems that influence recovery, such as health care or injury compensation organizations. This would include attention to not only the clinical injury features but also the demographic characteristics, early medical and rehabilitation management, and work practices and policies[7, 75, 81].

2.6.2 Personal Factors

Personal factors such as gender and age appear to have controversial relationships with return-to-work among a variety of work-related injuries[3, 18, 20, 24, 25]. Seland et al.[18] found females and those subjects aged 18-24 three times more likely to return to work than males and those subjects over age 45 with similar wrist or ankle fractures. Similar associations were described in another study[3] examining fractures of the lower extremity, although males were identified as having less time-loss duration. Homogenous groups may have contributed to this finding as males outnumbered females by a ratio of greater than 3:1, and a higher proportion of the subjects fell within the 25-34 age range. Conversely, age and gender were not identified as having any relationship with time-loss duration in a study examining work absence following occupational hand injuries[24]. However, distributions of both age and gender were not described in this study. The literature asserts stronger associations of age and gender with the possibility of incurring injury, rather than specific associations between these personal factors and extended time-loss duration[82]. Age has been found to be associated with injury recovery abilities[83]. Gender appears to be linked with specific occupational demands and *nature-of-injury*, particularly with non-specific upper extremity trauma[82].

Hand-injured status (dominant versus non-dominant), has been another variable studied in the hand- and/or wrist-injured population[2, 9, 25] and supported as an influencing factor on time-loss duration in disability duration guidelines[63]. However no association linking hand-injured status and time-loss duration was found in the literature. Little explanation has been offered in the literature for this lack of relationship to time-loss duration, but it is speculated that adaptive or compensatory strategies such as the use of the uninjured hand, are triggered as coping mechanisms to enable function, regardless of injury involving the dominant hand[2, 23]. The lack of extensive evidence suggests these issues warrant further investigation.

Psychosocial factors play a key role in evaluating current health outcomes and have dislodged traditional perspectives that physical impairments alone contribute to time-loss duration[3]. Worker satisfaction and worker motivation have been offered as explanatory reasons for lower rates of work absence[12, 73, 75], although this literature has focused primarily on non-specific trauma injuries e.g. cumulative trauma disorders, or low back sprains. Conflictual relationships at work with colleagues and/or superiors may precipitate avoidance of work-site interactions, particularly if subjects assign “blame” within the work environment [26]. This “blame” might include attributing the work injury to co-worker irresponsibility, poor work organization, or faulty equipment. Consequently, while physical ability to return to work may exist, time-loss duration may be prolonged if self-perceived disability is perpetuated through fear of re-injury or avoidance of returning to work[2, 26].

Psychosocial influences are often captured in self-reported measures of disability[9, 26, 36, 84], or psychological perceptions of ability. While psychosocial factors have been associated with time-loss duration in subjects with distal radius fractures, this is less clear in studies examining other injuries such as low back pain[17, 33, 71]. Gauthier et al. (2006)[71] examined subjects who had sustained a low back injury resulting in workplace absence and focused on assessing psychosocial influences as predictors of time-loss duration. Their overall findings identified stronger associations between self-reported disability and psychosocial *processes* e.g. fear of pain or fear of re-injury, and not self-reported disability and subjects’ perceptions of their true limitations[71]. This key outcome may have been a manifestation of a biased cohort, since the subjects in this study had all voluntarily agreed to participate in a program that was part of a cognitivebehavioural intervention program, thereby challenging the generalizability of the results [71].

Unlike Gauthier et al.(2006)[71], MacDermid et al.(2007)[17] suggest that higher scores on self-reported disability are associated with poor return to work outcomes following distal radius fractures. This was particularly true if self-reported disability was completed during early stages of healing/recovery. However, follow-up on physical impairment measures (e.g. strength, mobility) ended at 3 months post-injury while self-reported disability continued up to 12 months post-fracture[17]. Given that the majority of primary healing occurs between three to six months post-injury[102], and the majority of improvement for physical impairment components will occur within 6 months[36], MacDermid's (2007)[17] results may not have reflected a true variation of the factors influencing time-loss duration.

Length of employment as a predictor of work disability is a variable that has received scant attention in the literature[83]. Shorter lengths of employment have been associated with poorer outcomes of return-to-work but only in subjects with low back pain[85], a population which can have varying risk factors related to workplace absence compared to other injuries[71]. Results of another study specifically explored relationships between length of employment and return-to-work for 92 hand-injured subjects[26]. No significant associations were found between these variables, but rather the authors identified potential fear of re-injury and workplace avoidance as having stronger relationships with time-loss duration than length of employment[26]. It may be postulated that longer lengths of employment could represent a stronger sense of loyalty to an employer, and thus act as a motivator for an employee to return to work sooner, although this was not substantiated in the literature.

2.6.3 Environmental Factors

Environmental factors, or factors external to the injured worker, have been recognized as having a positive or negative effect on an individual's ability to function[41]. Examples include: occupational demands (i.e. institutional , physical), social systems and services (i.e. receipt of injury compensation, therapy or surgery), and geography. As part of a biopsychosocial approach, these factors are acknowledged as both a key contributor to health[38] and an important consideration within the workplace[86].

Many financial compensation systems now utilize policies to manage active claims based not only on the impairment and resulting disability but also with a focus on the environment through workplace modification and employer education (e.g. workplace accommodations)[14, 50]. The primary objective for stakeholders is to have the injured worker return to pre-injury work duties[70]. Opportunities for environmental adaptations or workplace accommodations can attend to the biomechanical and psychosocial needs of an injured worker, thereby influencing worker participation and time-loss duration[5, 66]. The goal of these accommodations is to match the worker abilities – despite impairment – with the environmental and/or task demands of the workplace. To this author's knowledge, the relationship between accommodations and time-loss duration following traumatic hand injury has not been studied.

Feuerstein et al.[87] found differences in injured workers with upper extremity cumulative trauma disorders who had not returned to work compared to those who had returned with accommodations. Specifically, those workers who were not accommodated were found to have greater self-perceived functional limitations and pain[87]. Identification of a heightened pain response may indicate challenges with coping mechanisms leading to prolonged absence[12]. This suggests a positive role for collaborative case management to identify and minimize barriers as part of the return-to-work process[87]. For example, ergonomic exposure factors, such as work space redesign, have been identified as key elements of case management evaluation and implementation in the workplace accommodation process [66, 88].

Physical work demands, or the bodily requirements that the worker must complete, are described as influencing time-loss duration, but are referenced in diverse ways[3, 16, 17, 25]. Some are described in broad categories of occupational demands such as "Professional" or "Skilled Trades"[25], while others are portrayed in more descriptive classifications such as "Heavy Manual Labour" or "Office

Employment"[3, 16, 17]. Some physical demands are identified through self-reports of three levels of perceived work-demand: minimal, moderate or intensive hand involvement[17]. While these three levels seem to represent an interesting and relevant measure of physical demand[17], they appear to be a theoretical perspective only, and not validated for use in either research or practice arenas.

Statistics Canada uses the National Occupational Classification Statistics (NOC-S) 2006[89] to identify Canadian job classifications and their descriptors. Each occupation has numerous descriptors including the sub-category of *Physical Activities: Strength*, which specifies one of four levels of strength requirements for each occupation. These include:

1. Level 1 = limited work activities involve handling loads up to 5 kg
2. Level 2 = light work activities involve handling loads of 5 kg but less than 10 kg
3. Level 3 = medium work activities involve handling loads between 10 kg and 20 kg
4. Level 4 = heavy work activities involve handling loads more than 20 kg.

Occupational demands, as related to strength, are supported by Reed[63] as variables influencing time-loss duration for most hand injuries. Although strength is recognized as one component of body function, it may not be the primary or only component impaired following hand and/or wrist injuries, nor might it be the most relevant component[16]. For example, individuals with proximal amputations of the ring and small fingers may be restricted from performing their essential work demands if these demands require forceful and sustained grip, since the ulnar digits contribute to the majority of hand strength[42]. Conversely, amputations of the thumb and index finger may result in greater challenges for those requiring frequent fine motor functions and manipulation but not high demands of strength, since these digits contribute extensively to dexterity and manipulation[42]. The literature does not support a consistent outcome measure for occupational demands, and strength seems to be the most commonly accepted option to link physical demands with physical abilities in research and in practice. As such, using only impairment guidelines following traumatic injury may limit the potential for return-to-work for those workers whose challenges lay outside the realm of physical deficits.

The relationship between receipt of injury compensation and time-loss duration has received considerable attention in the literature. Given the potential influence on time-loss duration, Atlas et al.[75] specifically examined differences between work-related and non-work-related injuries. They challenged the poorer results of health outcomes of work-related disability compared to non-work-related injuries, citing socioeconomic level as a stronger predictive factor than compensation association. Their results were based only on lumbar radiculopathy diagnoses however, and included a heterogeneous group of subjects that were either eligible, approved, pending approval, or planning to apply for workers' compensation benefits[75]. Other authors suggest that individuals receiving workers' compensation claims for hand or wrist injuries have outcomes different than those who do not[1, 2, 15, 17, 20, 24]. Variables such as self-reported pain and disability[15], injury culpability[26], socioeconomic status [12], and occupational demands[17, 72] have been identified as key factors of prolonged disability when comparing subjects injured within and outside the workplace.

Caution is warranted when interpreting time-loss duration research involving cohorts with and without work-related injuries. Compensation status may be overrepresented and perhaps overestimated as a potential predictor in work absence for two reasons: first, Workers' Compensation Board databases are relatively accessible to researchers for a variety of outcome measures; and second, variables such as work demands do not have clear and delineated criteria throughout the literature and as such are difficult to measure[17]. MacDermid et al. [17] postulated that receipt of workers' compensation may actually be a confounder while work demands may be the better predictor of time-loss duration.

These findings support other results that differences in clinical and demographic factors require adequate control to examine relationships between receipt of compensation and time-loss duration[3]. While some studies have shown positive associations of compensation with delayed return- to-work in the back-injured and cumulative trauma population[27, 54, 75], the scant amount of research in this area with the hand-injured population remains controversial[1, 9, 25, 33, 72]. In a Hong Kong study of 124 hand-injured subjects, Wong[1] noted that having a compensation claim was related to work absence, although the type of compensation was not differentiated e.g. workplace versus others. While it is imperative to ensure effective treatment of the clinical impairments and measures of ability following hand and/or wrist injuries, consideration must also be given to the socio-political influences that may impact time-loss duration. This could include attention to the differences in compensation regulations, and return-to-work processes across jurisdictions[17, 75].

Wong[1] found a significant relationship between the number of surgical operations performed and return-to-work. In her study, more than one surgical procedure was associated with longer time-loss duration. Interestingly, Wong's study did not find a statistical difference between no surgery and having one surgical procedure on the return-to-work outcome. Unfortunately her data did not specify the *nature-of-injury* characteristics requiring surgery (e.g. fracture, tendon, amputation), and only alluded to the relationship between more complex injuries and surgical management.

The effect of therapy on return-to-work following hand and/or wrist injuries was explored in three studies[90-92]. Case-Smith[90] noted an 80% return-to-work rate after receipt of occupational therapy, although the subject sample size was small (n=33) and the *nature-of-injury* categories were not clearly delineated as to severity. A Brazilian study[92] of 42 hand-injured workers showed significant differences in physical impairment (e.g. strength, mobility) and client reports of functional abilities after receipt of hand rehabilitation. Only one study[91] compared the use of physiotherapy against occupational therapy in subjects with hand and/or wrist injuries. Clients received either physiotherapy or occupational therapy and completed numerous self-administered outcome measures at admission and discharge, including six functional outcome scales. The findings did not identify differences in client satisfaction or client perception of improvement in functional abilities between the two therapies[91]. Return-to-work and time-loss duration were not evaluated. Changes in health status rarely isolate the use of therapy as a predictor of outcome, with the greater focus on the assessments and interventions used by therapists for injury management[17].

Finally, Young[73] has offered geography as an associated factor of time-loss duration with those living in rural areas having less time off work[73]. However, this isolated evidence was not strongly supported due to the imbalance of urban versus rural subjects and the vague operational definition of "rural"[73]. Nonetheless, geographical location of the injured worker deserves reflection in order to understand accessibility issues for legal, medical and therapeutic interventions, and appreciate ethical differences in personal and work values[73]. This is applicable to many provinces in Canada, such as New Brunswick, where large rural and urban communities co-exist.

Consideration of environmental variables supports a biopsychosocial approach[4, 5], but there is insufficient evidence in the literature that examines realistic expectations of these environmental opportunities among the individual employers[66]. For example, availability of accommodative work can be influenced by external variables, such as seasonal employment[71], or a lack of structured support systems with the return-to-work process[87]. It appears that an array of impairment, personal and environmental factors influence time-loss duration. However, hand- and/or wrist-injured workers represent a unique cohort that may offer variation in their relationship with time-loss duration compared to the diverse injuries that lead the literature in this context.

2.7 Conclusion

Traumatic hand injuries can have significant impact on an individual's ability to participate in meaningful work. Hand and wrist injury claims with WorkSafe-NB appear to represent only a small incidence of their overall lost-time claims compared to reports in the literature[49, 93]. Despite those statistics, few studies identify the nature and distribution of these injuries, or their association with work disability. The literature offers adequate support on the surgical and rehabilitative management of individual hand and/or wrist injuries. While the healing process of these injuries may be completed without complication, secondary challenges all too often arise leading to barriers in functional recovery. Those who remain off work for prolonged time periods require additional examination to appreciate the resulting impairment as well as the impact of specific structural damage. Workers' Compensation Board databases offer extensive detail on the work-injured population in general but little research has been initiated that examines the incidence of and impact from traumatic hand and/or wrist injuries.

Explanatory variables of time-loss duration have been identified by various researchers, but without delineation of the trauma-induced hand and/or wrist injuries, and not within this work-injured population. In the literature reviewed, there were various differences in the study samples, including subject cohort, diagnostic categories, levels of injury, and outcome measures. These differences may account for variation in predicted time-loss duration and limit generalizability across specific traumatic hand and/or wrist injuries[94]. While it appears that age, occupational demands, injury characteristics, and the severity of the injury influence time-loss duration for a variety of work-related injuries, the support is weak and limited for those with hand and/or wrist trauma.

Despite the increasing availability of return-to-work research, minimal information exists to guide health care providers, insurers, and employers on reasonable time-loss duration for traumatic hand and/or wrist injuries. To date, disability duration guidelines are most commonly used to guide insurers but can only provide recommendations pertaining to the physical and uncomplicated recovery of injuries in general terms. These guidelines are very limited with respect to specific hand and wrist injuries, such as tendon and nerve injuries, which can lead to extended time-loss duration. Finally, models focusing only on physical impairment to explain work disability are now less convincing in the literature given the paradigm shift to more inclusive perspectives that include personal and environmental influences, such as the ICF model. It is the intent of this study to better understand the incidence and time-loss duration of specific, traumatic hand injuries with a homogenous cohort of work-injured subjects through this broader perspective.

Chapter 3: METHODOLOGY

3.1 Research Design

The research design for this thesis is a retrospective, exploratory design to identify the incidence and compare the time-loss duration of four traumatic *nature-of-injury* categories that involved two *part-of-body* categories, namely the hand and wrist, and to examine various factors associated with time-loss duration for one combined *nature-of-injury/ part-of-body* category.

3.2 Subjects

3.2.1 Overview

An existing database with WorkSafe-NB provided a sample of convenience. Data was collected on hand and wrist injury claims over a 12-month period (January - December 2006). This time frame allowed for maturity or timely resolution of a claim. Electronic files of the study subjects who met inclusion criteria were accessed and reviewed independently of each other. This was completed through repeated visits by the author to the WorkSafe-NB head office, in Grand Bay, New Brunswick. As each subject's case file was accepted into the study, the file was assigned an identification number on the electronic database at WorkSafe-NB. Respecting confidentiality, the identification number was not copied or taken off–site from the WorkSafe-NB offices. The identification number, injury category, and predictive variables of interest were documented on a customized Excel spreadsheet designed for conversion to SPSS statistical package (version 9.0; Real Stats, SPSS Inc, Chicago, IL). The data collection spreadsheet was pre-formulated by the author to facilitate automatic computation of the following variables: dominant vs. non-dominant injured subjects, length of employment, and total time-loss duration. Unknown entries remained blank on the spreadsheet.

3.2.2 Inclusion Criteria

Phase 1 was designed to identify the incidence of four specific traumatic hand or wrist injuries by *nature-of-injury* and *part-of-body*, and to compare the time-loss duration within these two categories. In addition, Phase 1 was used as a process to establish one combined *nature-of-injury/ part-of-body* category. For example, *amputations* (*nature-of-injury)* combined with the *wrist* (*part-of-body*) category would lead to identification of *wrist amputations* as the combined category for Phase 2. Criteria for inclusion in Phase 1 were: males and females; ages 18-65 years; claims documented with both Anglophone and Francophone information; subjects who had been working at the time of the injury, with either an identified time-loss start date, or no time lost; and, subjects who sustained traumatic hand and/or wrist fractures, amputations, nerve lacerations or tendon lacerations/disruptions. These injuries had occurred distal to the mid-forearm, thus impacting structural integrity and function at or distal to the wrist.

For Phase 2, the purpose was to examine time-loss duration and variables associated with time-loss duration in the combined *nature-of-injury/ part-of-body* category. Inclusion criteria were those subjects with the combined *nature-of-injury/ part-of-body* category identified in Phase 1.

3.2.3 Exclusion Criteria

For both Phases 1 and 2, individuals who had approved claims for gradual onset of injuries or those with non-specific trauma or repetitive/cumulative trauma injuries e.g. cumulative nerve entrapment or tenosynovitis diagnoses, were excluded. Additionally, those who had concomitant injury other than the hand were excluded. This allowed for a more homogenous group to study and removed confounding variables, such as injuries of proximal origin, injuries of non-trauma onset, or unrelated co-morbidities[36].

3.3 Procedures

3.3.1 Phase 1: Incidence and Time-loss Duration

To address the objectives for Phase 1 (incidence and time-loss duration for four *nature-of-injury* and two *part-of-body* categories), subject files were accessed from WorkSafe-New Brunswick's database. These files represented the total hand and/or wrist injury claims submitted for the year 2006. A 3-step process was developed to identify the study sample for Phase 1:

1. The total population of work-injured claims were accessed with the goal to identify the annual population with hand and/or wrist injuries with WorkSafe-NB for 2006 (N_{Total})
2. The N_{Total} was reviewed with the goal to identify the annual population with hand and/or wrist injuries that potentially fulfilled the *nature-of-injury* and *part-of-body* categories (N_{Coded}) (Appendix C). Following the Z795-96 Coding of Work Injury or Disease Information standard[14] used at WorkSafe-NB, accepted files included the following coding criteria to identify the subjects of interest:
    a. *Nature-of-injury* codes

       01200 Fractures

       03300 Avulsions

       03100 Amputations, unspecified

       03110 Amputations, fingertips

       03190 Amputations, except fingertips

       03400 Cuts, Lacerations

       08100 Cuts, abrasions, bruises

       08400 Fractures and other injuries

    b. *Part-of-body* Codes

       32000 Wrist(s)

       33000 Hand(s), except fingers(s)

       34000 Finger(s), fingernail(s)

       34001 Thumb or thumb and other fingers(s)

       34002 Fingers, except thumb

34090 Finger(s), fingernail(s), unspecified

38100 Hand(s) and Finger(s)

38200 Hand(s) and wrist(s)

3. From the N_{Coded}, the database files were individually examined (Appendix D). The study sample was named with the goal to identify the sample that fulfilled the total inclusion/exclusion criteria named in sections 3.2.2 and 3.2.3 (n_{Sample}).

Nature-of-injury and *part-of-body* data were identified within the database as both a coded number and a narrative description. For example, “03110” was the code number documented, with its narrative description of “amputations, fingertips”. Both the code numbers and narrative descriptions were collected and verified to ensure discrepancies related to coding were not entered into the sample data set. Where discrepancies were noted, the narrative description of the *nature-of-injury* or *part-of-body* within the file was used. Demographic data were not collected for this phase.

Upon identification of the n_{Sample}, the annual incidence of traumatic fractures, amputations, nerve lacerations and tendon lacerations/disruptions was identified for the specified one year period. Data on each subject in the n_{Sample} included: subject identification number, *nature-of-injury*, *nature-of-injury* code, *part-of-body*, *part-of-body* code. Claim opening and closing dates were collected as continuous data in days to identify time-loss duration. This was not always a continuous duration, and was recorded as a cumulative period of time for all subjects regardless of how many times the claim was closed or re-opened for the same injury. For example, some subjects returned to work - thus “closing a claim” - but stopped working again to undergo a secondary surgical procedure related to the original injury. Their second episode of time off work was then added to the first, giving a cumulative total time-loss duration. The sample data set comprised claims that were both closed and those that remained open on the three dates when data was extracted from WorkSafe New Brunswick (April 30th, May 1st, and May 7th, 2009).

The results of Phase 1 contributed to the identification of the one combined *nature-of-injury/part-of-body* category, namely *hand fractures* that was further studied in Phase 2. An individual analysis of the results of the *nature-of-injury* and *part-of-body* categories was completed on the incidence, time-loss duration, and total time-loss duration (i.e. sum of the time-loss duration for all injured workers in each of the categories). These analyses provided the mechanism by which this decision was made, based on the following guide:

a. If both incidence and time-loss duration were not significantly different, the highest total time-loss duration days was the deciding factor for the selection of the individual category
b. If either the incidence or time-loss duration was significantly different but the other was not, the highest total time-loss duration days was the deciding factor for the selection of the individual category
c. If both incidence and time-loss duration were significantly different, the category with the highest incidence and highest time-loss duration would be the deciding factor for the selection of the individual category. However, if the highest incidence and highest time-loss duration were not in the same category, the highest total time-loss duration days would then be the deciding factor for the selection of the individual category.

3.3.2 Phase 2: Variables Measured

Twelve potential explanatory variables (independent variables) of time-loss duration were identified within the framework of the ICF, representing the impact on activities and participation. These variables included:

Body Function and Structures

1. Injury Characteristic – For fractures, the injury characteristic was collected as the categorical variables of intra-articular or non-intra-articular
2. Medical aid costs – Medical aid costs included physician care, hospital fees, medication, diagnostic procedures, and/or rehabilitation costs

and were expressed as a dollar figure; this category was used as a proxy for hand injury severity, given that injury severity is not routinely entered in the WorkSafe-NB enumeration process. Data were collected as continuous variables

Contextual Factors: Personal

3. Age, in years – Collected as continuous variables
4. Gender (male, female) – Collected as categorical variables
5. Hand injured (dominant, non-dominant) – Collected as categorical variables
6. Length of Employment – Length of employment was identified as the time from date of hire to the first lost time day, and collected in months

Contextual Factors: Environmental

7. Occupational demands – Occupational demands were collected as the "Job Position" within the database files and converted into the level of strength required for this job position, based upon the National Occupational Classification codes. Where a range of strength requirements were noted for an occupational coding, the average strength was accepted. The strength groupings of these ordinal variables were coded as follows:
    - 1 = limited work activities involve handling loads up to 5 kg
    - 2 = light work activities involve handling loads of 5 kg but less than 10 kg
    - 3 = medium work activities involve handling loads between 10 kg and 20 kg
    - 4 = heavy work activities involve handling loads more than 20 kg
8. Therapy intervention – Therapy intervention included the type of therapy interventions received by each subject, collected as categorical variables of none, Occupational Therapy, Physiotherapy, or combined therapies

9. Surgical Intervention – Surgical intervention was collected as categorical data, to indicate the presence, or absence, of a surgical procedure for management of the fracture type
10. Pre-Injury Work Status – Work status prior to injury was indicated in the database as: Permanent Full-Time, Permanent Part-Time, or Casual, and were collected as categorical variables. Distinction was made with work status prior to injury to provide additional insight into the workers' relationship with the pre-injury employer
11. Return-to-Work Position – Return-to-work position was identified in the database as: regular duties, temporary accommodations, permanent accommodations or alternate occupation. Distinction was made in these categorical variables to identify the injured workers' availability and quality of return-to-work
12. Geographical Location – Geographical location was identified as a categorical variable by collecting the second character of each subject's postal code, using Canada Post's method of rural versus urban groupings. As such, the second character in the postal code was "0" for a rural community and "1-9" for an urban community. For example E0A 3G0 is rural, whereas E3B 1A0 is urban.

3.4 Data Analysis

3.4.1 Phase 1

Data points were collected using an Excel spreadsheet and exported into the Statistical Package for the Social Sciences[d] (SPSS) (version 15.0) for analysis. The data were reviewed and compared to the original (Excel) data set to ensure accuracy of the data entry and transfer. The *nature-of-injury and part-of-body* categories were assessed separately. The data from each category were first assessed to determine if normality assumptions were met. The assumptions for normal distributions of data were violated for both. Next, descriptive statistics

[d] SPSS Inc, Chicago, IL 60611

were completed to describe the incidence and time-loss duration for the individual each of the *nature-of-injury* and *part-of-body* categories. This included the count and corresponding percentages, mean, standard deviation, median, range of time-loss duration, 95% confidence interval, and total time-loss duration days as determined by summing the time-loss duration for all injured workers in each of the categories. Given the violations of the normality assumptions, non-parametric tests were chosen to perform further statistical analysis. A Chi Square test of goodness of fit for non-parametric data was completed to evaluate the incidence of the *nature-of-injury* and *part-of-body* groups. The Kruskal-Wallis test for non-parametric data was used to compare the time-loss duration of the four *nature-of-injury* categories and the Mann-Whitney U-Test was used to compare the time-loss duration of the two *part-of-body* categories.

The decision for the establishment of the Phase 2 combined *nature-of-injury/ part-of-body* category was completed through an analysis of both the *nature-of-injury* and *part-of-body* data as per section 3.3.1, including incidence, time-loss duration, and, total time-loss duration per category.

3.4.2 Phase 2

The incidence was identified and time-loss duration was described for the combined *nature-of-injury/ part-of-body* category established from Phase 1. The incidence and incidence rates of this study are based on the subject sample sizes of WorkSafe-NB injured-workers according to the inclusion and exclusion criteria of both Phase 1 (i.e. subjects who had fractures, amputations, nerve lacerations, tendon lacerations/disruptions involving the hand and wrist) and Phase 2 (i.e. one combined *nature-of-injury* and *part-of-body* category) over one year. As such, direct incidence comparisons to the literature were completed by specifying this study's cases per sample and the population on which it is measured. Time-loss duration was described using the mean, median, range and total time-loss duration.

Potential explanatory variables of time-loss duration for the Phase 2 sample were also described. Percentages were used to describe categorical variables (e.g. *n*% of subjects sustained injury to their dominant hand), and continuous data were examined in terms of the mean, standard deviation and range (e.g. mean time-loss duration was x days, with a range of $x_1 – x_2$ days).

A Cox Proportional Hazards regression analysis was completed with the Phase 2 sample to assess the effect of the explanatory variables on the risk of time-loss duration. This type of survival analysis was chosen since time-loss duration (the independent variable) was not normally distributed and, the Cox Proportional Hazards regression analysis makes better use of the "censored" information (i.e. four subjects did not have a finite value of time-loss duration and thus were assigned a censored value of 732 days) compared to other forms of regression such as logistic. A Cox Proportional Hazards model did not make the assumption that the four subjects all went back to work after the maximum days but rather used the information that their time-loss duration was at least the maximum days. Collinearity tests were also performed to assess the stability of the regression model, using Spearman Rank correlations for the continuous data and Chi Square for the categorical data.

The regression was based on two statistical approaches. First, univariate analysis was performed to identify which of the explanatory variables were independently associated with time-loss duration. Next, a backward stepwise procedure was used to assess the association of time-loss duration with the explanatory variables retained in the model, at p=.05.

3.5 Pilot Work Summary

Pilot work was completed by the author in September 2008 with Pam Wasson of WorkSafe-NB and Dr. Anne Fenety, of the School of Physiotherapy, Dalhousie University. In keeping with the Dalhousie University's Research Ethics Guidelines[63], the purpose of this meeting was to ensure due diligence for the proposed methodology. This involved confirmation of availability trends for the intended categories of interest, and familiarization of the software program used for administrative data at the WorkSafe-NB. Data was collected on five subjects injured in 2007, allowing extraction procedures of the injury categories and explanatory variables to be completed. This included those with Francophone documentation. Based on this work, it was anticipated that the author had sufficient working knowledge of the French language, and/or would have on-site assistance for translation from the WorkSafe-NB liaison.

The pilot work data collection was not used as part of the actual study data collection. Appendix E demonstrates an example of one subject in the Data Collection Spreadsheet for this pilot work.

3.6 Ethical Considerations

All efforts were made to recognize the confidentiality of the subject database by extracting the data at the WorkSafe-NB head office and ensuring that the key to linking the extracted data to each file data remained at WorkSafe-NB. Security of all collected paper and electronic data was strictly enforced through storage in a locked room and cabinet at the author's office at Dalhousie University. Electronic data was collected on a flash drive and hard drive of the author's personal laptop, and then burned onto a CD following each episode of data collection. The data on the hard drive was deleted each time after the CD was burned. The pilot work completed was not included in the data collection but discarded as per Dalhousie University's Research ethics guidelines[95]. Given the anonymous pooled data-base information, informed consent was not obtained from individuals. With assistance from the Industry, Liaison and Industry office at Dalhousie University, a "Reciprocal Non-Disclosure Agreement" was developed between the author and WorkSafe-NB and outlines confidentially and proprietorial responsibilities for the collaborating parties (Appendix F). Research Ethics Board approval from Dalhousie University's Faculty of Graduate Studies was obtained prior to any data collection (Appendix G).

Chapter 4: Results

4.1 Phase 1

The results of Phase 1 were identified through examination of the *nature-of-injury* and *part-of-body* categories. First, incidence and time-loss duration were assessed separately for both categories. Second, an analysis of the Phase 1 data was completed to identify the combined *nature-of-injury/ part-of-body* category.

4.1.1 Nature-of-Injury Results

A total of 324 files with hand and/or wrist injuries were identified for 2006 in the New Brunswick work-injured population. Of these, 200 (63%) subjects met the eligibility criteria for *nature-of-injury* categories and were admitted into Phase 1 of this study. Tests showed that the normality assumptions of the *nature-of-injury* categories were violated (Table 4.1). The incidence and time-loss duration for each *nature-of-injury* category is shown in Table 4.2. The incidence of each *nature-of-injury* category was fractures (n=134), amputations (n=41), and tendon lacerations/avulsions (n=25). The majority of tendon injuries were extensor tendons compared to flexor tendons. There were no subjects identified with nerve lacerations.

The average time-loss duration of the three categories was 114 days (SD = 141, median = 70, range = 1-732 days). Total time-loss duration was calculated by summing the total time-loss duration for all injured workers in each of the *nature-of-injury* categories. These values were identified as 15,665, 5052, and 2030 days, for fractures, amputations, and tendon lacerations/disruptions, respectively. Seven claims remained opened at the time of data extraction, thus indicating that return-to-work had not occurred. These subjects did not have a value for time-loss duration but were deemed to have clinical relevance for the analysis. As such, these subjects were assigned a “censored” time-loss duration value[96] of 732 days, which was the maximum value of time-loss duration identified in Phase 1 e.g. 731 days, plus one. Claims remaining open at the time of data collection fell within the categories of fractures (n=6) and amputations (n=1).

Table 4.1: One-Sample Kolmogorov-Smirnov Test for Nature-of-Injury

Nature-of-injury (N=200)	**Time-Loss Duration (Days)**
Mean	114
Standard Deviation	141
Kolmogorov-Smirnov Z	3.295
p – value	0.000*

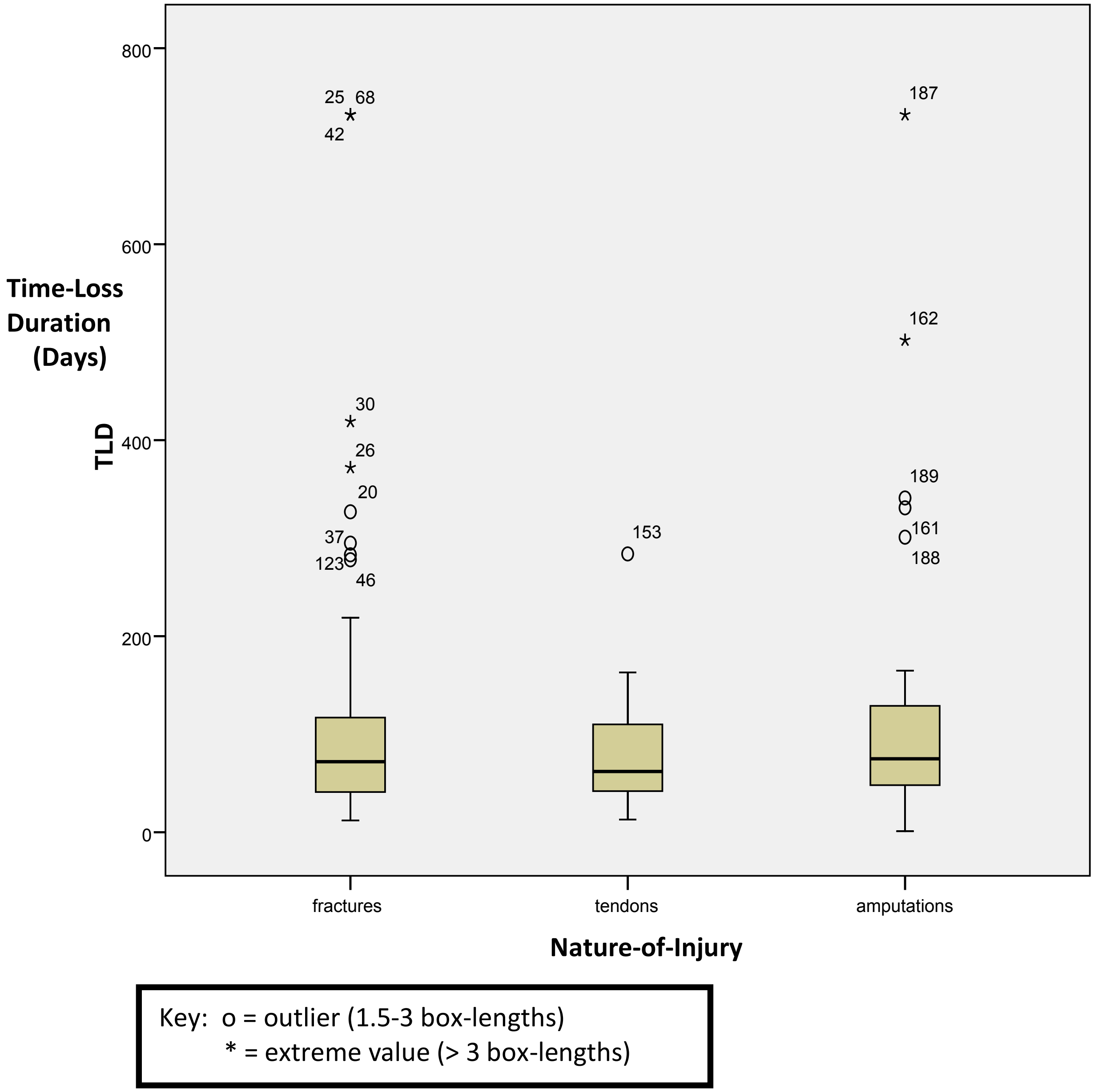
***Test Distribution is Non-Normal**

Table 4.2: Descriptive Statistics for Incidence and Time-Loss Duration (TLD) for Nature-of-Injury Categories

Nature-of-injury	**Incidence N (%)**	**Mean (SD) TLD Days**	**Median Days**	**Range TLD Days**	**95% Confidence Interval**	**Total TLD Days (%)**
Fractures	134 (67%)	117* (152)	72	12-732	91-143	15,665 (69%)
Amputations	41 (20.5%)	123 (139)	75	1-732	79-167	5052 (22%)
Tendon Lacerations	25 (12.5%)	81 (61)	62	13-284	56-107	2030 (9%)
Nerve Lacerations	0	-	-	-	-	-
Total	200 (100%)	114 (141)	70	1-732	94-133	22,747 (100%)

***no significant difference (p< .05)**

Figure 2: Boxplot of average Time-loss Duration (TLD) for three Nature-of- Injury (NOI) categories demonstrating mean (standard deviation), outliers, and extreme values



As seen in Table 4.1 the *nature-of-injury* data were not normally distributed. A goodness of fit test for non-parametric data was completed to evaluate if the incidence of the *nature-of-injury* groups could have been generated at random (Table 4.3). The results show that there is a difference between the incidence rates of the groups, at $p < 0.05$. A non-parametric test was also chosen to examine the differences among each of the *nature-of-injury* categories for time-loss duration using the Kruskal-Wallis non-parametric test. No statistically significant difference was found among the groups' average time-loss duration (p=0.459) for the three *nature-of-injury* categories (Table 4.4).

Table 4.3: Chi Square Goodness of Fit Test for Incidence on Nature-of-Injury Categories (N=200)

Nature-of-injury	Observed N	Expected N	Residual
Fractures	134	66.7	67.3
Tendons	25	66.7	-41.7
Amputations	41	66.7	-25.7

Test Statistics	Nature-of-Injury
Chi-Square	103.930
Df	2
p-value	0.000

p < .0001

Table 4.4: Kruskal-Wallis Test for Time-Loss Duration on Nature-of-Injury Categories (N=200) using Chi Square Statistic

Nature-of-Injury	N	Time-Loss Duration Mean Rank
Fractures	134	99.30
Tendons	25	92.20
Amputations	41	109.48

Test Statistics	Time-Loss Duration
Chi-Square	1.558
Df	2
p-value	0.459

p < .05

In summary, an analysis of the three *nature-of-injury* categories showed significant differences among these categories for incidence, but no significant differences among the time-loss duration results. In keeping with the methodology process from Chapter 3.3.1 (b), the selection of the individual *nature-of-injury* category to study in Phase 2 was based on the highest total time-loss duration, identified as fractures.

4.1.2 Part-of-Body Results

Further analysis was completed to identify the incidence and time-loss duration of traumatic injuries in two *part-of-body* categories, namely: wrist and hand. Of the total 324 files with hand and wrist injuries identified for 2006 in the New Brunswick work-injured population, 200 (63%) subjects met the eligibility criteria for *part-of-body* categories and were also admitted into this portion of Phase 1 of this study. A test to assess the normality assumptions of the *part-of-body* categories showed a non- normal distribution (Table 4.4). The respective incidence and time-loss duration for each *part-of-body* category is shown in Table 4.5. The incidence of each *part-of-body* category was 41 injuries at the wrist and 159 injuries at the hand.

The average time-loss duration of the two *part-of-body* categories was 135 days with a range of 1 - 732 days. Total time-loss duration was calculated by summing the total time-loss duration for all injured workers in each of the *part-of-body* categories. These values were identified as 6976 and 15,771 days, for wrist and hand injuries, respectively. Seven claims remained opened at the time of data extraction, thus indicating that return to work had not occurred. These subjects did not have a value for time-loss duration but were deemed to have clinical relevance for the analysis. As such, these subjects were assigned a "censored" time-loss duration value[96] of 732 days, which was the maximum value of time-loss duration identified in Phase 1 e.g. 731 days, plus one. Of those claims remaining open at the time of data collection, three fell within the wrist category and four within the hand.

Table 4.5: One-Sample Kolmogorov-Smirnov Test for Part-of-Body

Part-of-Body (N=200)	**Time-Loss Duration (Days)**
Mean	114
Standard Deviation	141
Kolmogorov-Smirnov Z	3.4295
p-value (2-tailed)	0.000*

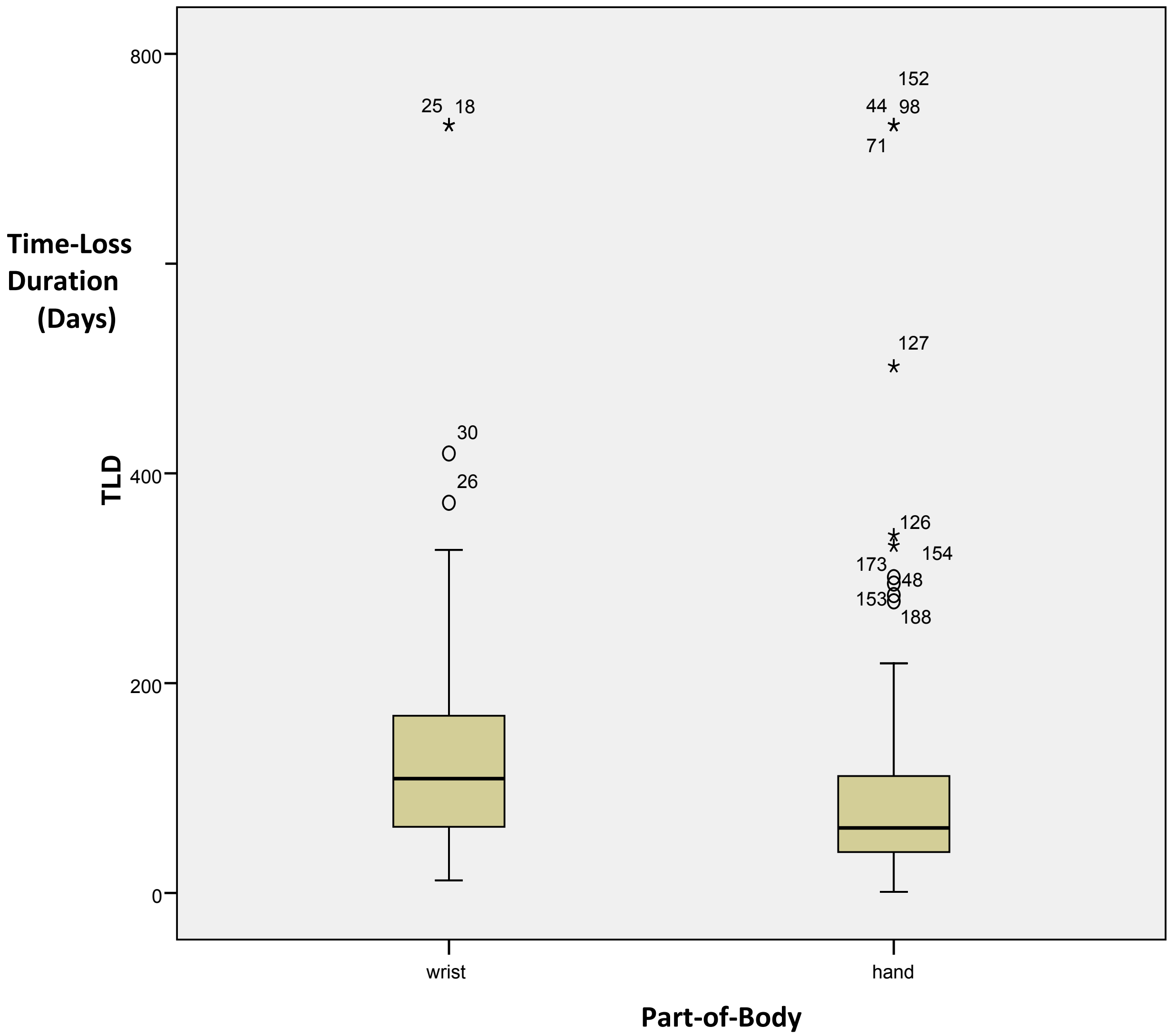
***Test Distribution is non-normal**

Table 4.6: Descriptive Statistics for Incidence and Time-Loss Duration (TLD) for Part-of-Body Categories

POB	**Incidence N (%)**	**Mean (SD) TLD Days**	**Median Days**	**Range TLD Days**	**95% Confidence Interval Days**	**Total Time-Loss Duration Days (%)**
Wrist	41 (21%)	170* (184)	109	12-732	112-228	6976 (31%)
Hand	159 (79%)	99 (124)	62	1-732	80-119	15,771 (69%)
Total	200 (100%)	114 (182)	70	1-732	94-133	22,747 (100%)

*** Significantly different from hand (p< .001)**

Figure 3: Boxplot of average Time-loss Duration (TLD) for two Part-of-Body (POB) categories demonstrating mean (standard deviation), outliers and extreme values



Key: o = outlier (1.5-3 box-lengths)
* = extreme value (> 3 box-lengths)

As seen in Table 4.6, the *part-of-body* category data were not normally distributed. A goodness of fit test for non-parametric data was completed to evaluate if the incidence of the *part-of-body* groups could have been generated at random (Table 4.8). The results show that there is a difference between the incidence rates of the groups, at $p < 0.05$. A non-parametric test was also chosen to examine the difference between the *part-of-body* category groups for time-loss duration using the Mann-Whitney U Test. Results showed that time-loss duration for the two *part-of-body* categories was statistically significantly different, at $p<.001$.

Table 4.7: Chi Square Goodness of Fit Test for Incidence on Part-of-Body Categories (N=200)

Part-of-body	Observed N	Expected N	Residual
Wrist	41	100.0	-59.0
Hand	159	100.0	59.0

Test Statistics	Part-of-Body
Chi-Square	69.620
Df	1
p-value	0.000

$p < .0001$

Table 4.8: Mann-Whitney *U*-Test for Time-loss Duration on Part-of-Body Categories (N=200)

Part-of-Body	N	Time-Loss Duration Mean Rank
Wrist	41	128
Hand	159	93

Test Statistics	Time-Loss Duration
Mann-Whitney U	2125.500
Z	-3.432
p-value	.001

$p < .001$

In summary, an analysis of the two *part-of-body* categories showed significant differences between these categories for both incidence and time-loss duration results. Since the higher incidence and higher mean time-loss duration identified the hand, and the wrist, respectively (i.e. different categories), the selection of the individual *part-of-body* category to study in Phase 2 was based on the higher total time-loss duration, identified as the *hand*. This was in keeping with the methodology process from Chapter 3.3.1 (c).

4.2 Phase 2

4.2.1 Descriptive Analysis

A total of 95 subjects having *fractures of the hand* met the inclusion criteria for Phase 2. A post hoc power analysis was conducted using an on-line calculator for statistical power determination[e]. The sample size of 95 was used for the statistical power analysis and a 7 explanatory variable equation was used as a baseline. The effect size used for this assessment was medium ($f\,2$ = .15)[97] with alpha level set at p < .05. The post hoc analysis revealed the statistical power for this study was adequate at 0.836 for the detection of a moderate effect size.

Time-loss duration for hand fractures was found to have a mean of 92 days (SD 128, range 12 – 732 days) (Table 4.8). All subjects were noted to have at least twelve days lost from work while four subjects remained off work at the time of data collection.

Table 4.9: Descriptive Statistics: Time-loss Duration (TLD) for Hand Fractures (N=95)

Mean TLD Days (SD)	Median Days	Range TLD Days	Total Time-Loss Duration Days
92 (128)	147	12-732	8765

Explanatory variables for the Phase 2 subject cohort (i.e. *hand fracture*) are described in Table 4.9. The average age of the subjects was 42 years, with the majority of the sample being male. A higher number of subjects were working

[e] (Soper, D.S. (2010) "The Free Statistics Calculators Website", *Online Software*,

full-time at the time of their *hand fracture*. The range of Medical Aid Costs spanned $120-$121,583 and the median was noted at $1946.

Table 4.10: Explanatory Variable Characteristics of Subjects with Hand Fractures (n=95)

Characteristic	Subjects	
Age (yrs)		
Mean (SD)	42 (11)	
Range	19-66	
Gender, n (%)		
Females	13 (14%)	
Males	82 (86%)	
Dominant Hand Injury, n (%)	17 (18%) *missing: 63	
Medical Aid Costs ($)		
Mean (SD)	$4727 ($12,955)	
Range	$120 - $121,583	
Median	$1946	
Occupational Demands, n (%)	Low	High
	34 (31%)	3 (3%)
	14 (13%)	10 (9%)
	27 (25%)	20 (18%)
	18 (16%)	61 (56%)
	*missing 1	
Length of Employment (yrs)		
Mean (SD)	6.2 (7.8)	
Range	0-33 *missing: 10	
Fracture Type		
Intra-articular	18 (19%)	
Extra-articular	28 (30%) *missing: 49	
Type of Therapy Received		
None	44 (46%)	
Physiotherapy	21 (22%)	
Occupational Therapy	18 (19%)	
Combined Therapies	12 (13%)	

Characteristic	Subjects
Surgical Intervention n (%)	
Yes	28%
No	72%
Pre-Injury Work Status	
Full-Time	62 (65%)
Part-Time	31 (33%)
	*missing: 2
Return to Work Position n (%)	
Regular Duties	81(85%)
	*missing: 2
Geography, n (%)	
Urban	95 (100%)
Rural	0 (0%)

4.3 Regression Analysis

4.3.1 Regression Diagnostics

A Cox Proportional Hazards regression analysis was used to assess the strength of the relationships of the explanatory variables for explaining the primary outcome of time-loss duration for those subjects with *hand fractures*. Many challenges were encountered following a preliminary review of the data points, such as missing data, limited distribution of the explanatory variables, or the need to re-evaluate the multi-level status of data collected. The resulting changes involved exclusion of certain variables and the recoding of certain variables.

Missing values were recognized for several variables and thus were excluded in the regression analysis, including the "type of fracture" (intra- vs. extra-articular) and dominant hand injured. These variables had data points missing for 51% and 72%, respectively. Likewise, within "occupational demands", the required strength characteristics were categorized as a range from "lowest" to "highest" given the range of potential strength requirements (i.e. limited, light, medium, heavy) for the identified job descriptions. To illustrate this range, the job position of “Labourer” was identified for 15 subjects in the database. Within the National Occupational Classification system, “Labourer” is classified by 21 different codes, each having a different “strength” requirement ranging from 2 – 4, or limited – heavy. During data collection the lowest rating of strength for Labourer was scored as “2” and the highest as “4”. To link this with the data in Table 4.9, of those workers who had job positions requiring ‘limited strength”, 31% of the subjects had this as their “lowest” rating, while 3% had this as their “highest”. In order to avoid statistical error, the “occupational demands” category was not included in the regression model, as the ranges indicated vague estimates only and inadequate information to accurately identify the true strength required for the job descriptions could not be obtained for this cohort.

Limited distribution of “geography” was identified with 100% of the subjects having urban locales, and thus was disallowed from the overall analysis. In addition, accommodations for the “return to work position” were not definitively stated within the WorkSafe-NB database. Thus, “return to work position” showed poor distribution of responses, such that the majority of subjects all returned to the same position. For example, in some subjects’ files, a physician note indicated approval to return to work on “modified duties” but the database does not specify whether or not the subject did indeed return on modified or accommodated work duties.

Two explanatory variables were re-coded at the time of data collection to ensure accurate representation within the analysis (i.e. to better distribute multi-levelled data points as one- or two-level data points). First, “pre-injury status” was collapsed to collect data as full-time versus part-time. The original intent was to collect data on the various forms of pre-injury status, such as permanent versus temporary full-time, permanent versus temporary part-time, casual, or seasonal. A dichotomous distribution was accepted (i.e. full-time, part-time) to minimize validity concerns for assessment of the “pre-injury status” category. Second, “therapy” received by the subjects was changed for the regression model to reflect the receipt of physiotherapy, and, the receipt of occupational therapy. Although the original intent of data collection on this variable was to ascertain the delivery of hand therapy expertise compared to general therapy practitioners, these professional services are not delineated with WorkSafe-NB[93] as in traditional models of hand therapy[67]. Instead, physiotherapy is most often used for the acute care process for hand therapy management. Occupational therapy is accessed primarily for the return-to-work process, assistive device prescription, and/or the continuum of care process[93], especially when the disability duration exceeds the expected time for recovery.

Consequently, 5 of the 12 variables collected as potential variables were disallowed from the regression analysis , namely: “occupational demands”, “injury characteristics” ,”dominant hand injured”, “return-to-work position”, and “geography”. Type of therapy received was divided into two categories, namely: “receipt of therapyPT” and “receipt of therapyOT”. The remaining variables were accepted for the regression analysis and included: “medical aid”, “age”, “length of employment”, “gender”, “surgery”, “therapyPT”, “therapyOT” and “pre-injury full-time” (Table 4.10).

Table 4.11: ICF Explanatory Variables Collected and Analyzed of subjects with *hand fractures* (n=95). Changes in Variables Collected compared to Variables Analyzed were due to recoding[a] or exclusion due to missing data[b] or limited data distribution[c]

ICF Factors	Variables Collected	Variables Analyzed (Cox Regression
Body Functions / Structures (Impairment)	• Injury Severity (Medical Aid Costs) • Injury Characteristics[b]	• Injury Severity (Medical Aid Costs)
Personal	• Age • Gender • Hand Injured[b] (dominant vs. non-dominant) • Length of Employment	• Age • Gender • Length of Employment
Environmental	• Occupational Demands[c] • Pre-injury Work Status • Return-to-Work Position[c] • Geography[c] • Surgical Intervention • Receipt of TherapyPT[a] • Receipt of Therapy OT[a]	• Pre-injury Work Status • Surgical Intervention • Receipt of TherapyPT • Receipt of Therapy OT

Collinearity tests were used to assess the stability of the explanatory variables in the model. Spearman Rank correlation tests for the continuous data (Table 4.11) demonstrated no significant correlations between “medical aid”, “age”, and “length of employment”. Chi square statistics for the categorical data indicated no significant correlations between “gender”, “surgery”, “therapyPT”, “therapyOT” and “pre-injury full-time” using a cut-off of 0.85[96] (Table 4.12).

Table 4.12: Spearman’s Rank Test of Correlations for Three Explanatory Variables (Continuous Data) demonstrating no significant correlations

	Medical Aid Costs	Age	Length of Employment
Medical Aid Costs	1.000	.284	-.179
Age	.284	1.000	.216
Length of Employment	-.179	.216	1.000

Table 4.13: Chi Square Test of Correlations for Five Explanatory Variables (Categorical Data) demonstrating no significant correlations

	Gender	Surgery	TherapyPT	TherapyOT	Pre- Injury Full-Time
Chi-Square	50.116	16.011	8.853	12.895	1.782

4.3.2 Cox Proportional Hazards Regression

Time-loss duration was modeled first using univariate Kaplan Meier curves or Cox Proportional Hazards curves to examine the association of time-loss duration with the explanatory variables independently. The results show significant effects with the variables medical aid costs, age, receipt of therapyPT and OT, and the receipt of surgery. All variables were then added to a multivariate Cox Proportional Hazards regression, using a backward stepwise procedure to reduce the variables to only those found to be significant. The stepwise process retained the variables Medical Aid costs, Age, and Receipt of Therapy (PT and OT), removing all others (using a likelihood ratio test at p=0.05). In other words, significant effects were noted for Injury Severity, Age, and Receipt of therapyPT and therapyOT. The Medical Aid costs were measured in terms of thousands of dollars, so for every $1000 decrease in medical aid costs, there was a 0.799 times decrease in the risk of staying off work; for every unit decrease in Age, there was a 0.970 times decrease in the risk of staying off work; and for every unit decrease in Therapy PT and Therapy OT, there was a 0.300 and 0.584 times decrease, respectively, in the risk of staying off work.

These results could be interpreted with an inverted perspective to provide more clinical relevance. For example, using the inverted value for Medical Aid costs (1/.799) = 1.25), the interpretation is that for every $1000 increase in Medical Aid costs, there was a 1.25 increase in the risk of longer time-loss duration. For every unit increase in Age, there was a 1.03 times increase in the risk of longer time-loss duration. Finally, for every unit increase in Therapy PT and Therapy OT, there was a 3.33 and 1.7 times increase, respectively, in the risk of longer time-loss duration.

Table 4.14: Univariate and Multivariate Cox Proportional Hazards Regression: Explanatory Variables and Time-Loss Duration for Hand Fractures (n=95)

	Univariate Analysis			**Multivariate Analysis**			
	Beta	**Hazard Ratio (RR)**	**P-value**	**Beta**	**Hazard Ratio (RR)**	**95% CI for RR**	
Medical Aid Costs	-.215	.807	<.001*	-.225	.799	.734	.869
Therapy (PT)	1.017	.362	<.001*	-1.205	.300	.172	.521
Therapy (OT)	-.972	.378	<.001*	-.537	.584	.338	1.010
Pre-injury Full Time	-.393	.675	.088				
Age	-.039	.962	<.001*	-.030	.970	.950	.991
Length of Employment	0	1.00	.865				
Surgery	-.751	.472	<.001*				
Gender	.183	1.201	.555				

*Significant at $p < .05$

Abbreviations: RR =Relative Risk, CI =Confidence Intervals, PT = Physiotherapy, OT = Occupational Therapy

Chapter 5: DISCUSSION

5.1 Overview

This study described the population of New Brunswick workers who sustained hand and/or wrist injuries in a one year cohort study. One purpose of this study was to examine the incidence and time-loss duration of subjects with specific trauma (i.e. fractures, amputations, nerve lacerations, and tendon lacerations/disruptions) involving the hand and/or wrist (Phase 1). Another purpose was to identify the incidence and time-loss duration of subjects with one combined *nature-of-injury/ part-of-body* category, namely *hand fractures* (Phase 2). Explanatory variables of time-loss duration for *hand fractures* were also examined.

The results of Phase 1 indicated that the overall annual incidence rate of hand or wrist trauma involving fractures, amputations, nerve lacerations, and tendon lacerations/disruptions (3.2%) represented only a nominal amount of compensable injuries compared to all lost time claims (n=200/6247) documented at WorkSafe-NB for 2006[93]. In terms of *nature-of-injury*, fractures were identified as having a significant higher incidence compared to amputations and tendons. An analysis of average time-loss duration revealed no significant differences among the *nature-of-injury* categories. Given the inconsistent findings in incidence versus time-loss duration, total time-loss duration was subsequently examined. Fractures were identified with the highest total time-loss duration compared to amputations and tendon lacerations/disruptions.

Regarding *part-of-body*, injuries involving the hand had a significantly higher incidence compared to wrist injuries, and significantly lower time-loss duration compared to the wrist. Based on the statistical analyses of the *nature-of-injury* and *part-of-body* data, *hand fractures* was established as the combined *part-of-body/ nature-of-injury* category to study further in Phase 2. From the author's perspective, the use of this combined category was clinically relevant since *hand fractures* account for a large profile of client injury characteristics, and evidence in the literature is limited related to this category.

This study provided evidence in Phase 2, that in a group of work-injured subjects, *hand fracture* incidence was lower and time-loss duration was higher than expected compared to the literature. Incidence and time-loss duration of *hand fractures* are not readily available in annual reports of Canadian Workers' Compensation Boards, including WorkSafe-NB. Consequently, results cannot be compared to data published by various Canadian Workers' Compensation Boards due to inconsistencies with methods of reporting in annual reports, and differences between the provincial and territorial compensation systems. The results of Phase 2 also show that increasing injury severity, increasing age, and receipt of physiotherapy and occupational therapy were associated with a greater risk of higher time-loss duration.

5.2 Phase 1

Subjects in Phase 1 included all injured workers with WorkSafe-NB in 2006 who had hand or wrist injuries (i.e. *part-of-body)* with fractures, amputations, nerve lacerations, or tendon lacerations/disruptions (i.e. *nature-of-injury)*. Data for the incidence and time-loss duration of the *nature-of-injury* and *part-of-body* categories were collected and analyzed.

5.2.1 Incidence

The incidences of the four *nature-of-injury* categories were identified within WorkSafe-NB's database for 2006. To this author's knowledge, no other Canadian study has published results related to the incidence of hand and wrist injuries involving fractures, amputations, nerve lacerations, and tendon lacerations/disruptions. Overall, the total number of traumatic hand and wrist injuries in the Phase 1 *nature-of-injury* categories (i.e. fractures, amputations, nerve lacerations, and tendon lacerations/disruption) was low, comprising only 3% of all injured workers who lost time from work for 2006 (i.e. 200 hand & wrist injuries / 6247 total injuries). This finding was consistent with expectations of

WorkSafe-NB[93] but inconsistent with that of other authors[13, 31, 44-46] who have reported higher incidences of hand and wrist injuries.

The first hypothesis in this study regarding incidence (*nature-of-injury*) was supported. That is, in terms of *nature-of-injury*, fractures had the highest incidence rate of all injuries in this study's Phase 1 sample (67% or 134/200). Fractures also showed the highest incidence rate in a study reported by Wong (2008)[1] but included both wrist and finger injuries and did not specify a time period for data collection. Likewise Dawson (2007)[98] reported a high incidence (36%) of fractures, but studied only musicians and named both the hand and upper extremity as *part-of-body* categories examined. The difference between this study's incidence rate and the literature might be explained by the exclusion of other *nature-of-injury* or *part-of-body* categories in the current study, such as sprains/strains, or arm injuries. Unfortunately, direct comparison to the literature is extremely challenging because the methods to determine incidence in the literature are unclear or inconsistent among studies. For example, incidence may be reported for: combined *nature-of-injury* categories (e.g. specific trauma and cumulative trauma[13]); one *nature-of injury* category but different *part-of-body* category (e.g. fractures of the leg[3], fractures of the wrist[15, 36]); or, narrowly focused studies (e.g. one occupational setting[31, 45, 48]). In those studies that combined *nature-of-injury* categories, such as sprains/strains and lacerations/contusions, fractures most often followed these categories in incidence[13, 47, 48], with one exception. Dawson[98] reported fractures as having the highest incidence rate (36%) in his study despite inclusion of sprains/strains and lacerations/contusions as diagnostic categories. The challenge here is the lack of ability to compare consistent incidence and incidence rates of similar categories. The current study is based on annual incidence of specific categories while the aforementioned studies use samples of convenience to name incidence and incidence rates.

Another discrepancy among these studies appears to be related to the methodology and/or the parameters of the cohorts studied. In some studies, for example, while the *nature-of-injury* was named (fractures), the *part-of-body* injured was not always limited to the upper extremity[48], or was not specified as to the divisions of the upper extremity e.g. fingers versus hand versus wrist[31, 45, 48]. Furthermore, comparing the results of this study posed challenges given that the literature and Workers' Compensation Boards primarily indicate incidence on the *part-of-body* (i.e. wrist, hand) without further delineation of the *nature-of-injury* categories as described in this study. Still others compared the *nature-of-injury* to the occupational categories in which these injuries occurred (e.g. white-collar, sales)[13]. *Nature-of-injury* incidence was also noted to be varied in the literature that looked only at specific occupational cohorts such as musicians[98], agriculturalists[48] or university employees[31]. This suggests occupational roles influence injury patterns, therefore it is challenging to compare injury incidence across diverse occupational roles. The diversity of *nature-of-injury* categories can have diverse implications for injury management, rehabilitation, and functional outcomes. Thus for those involved in the care and management of these injuries, and those completing research on these injuries, consistency and clarity of the documentation is essential.

The incidences of the *nature-of-injury* categories in this study (i.e. 66% fractures, 21% amputations, 13% tendon lacerations/disruptions, and 0% nerve lacerations) were inconsistent with the few reports in the literature. For example, in one study of agricultural workers [48] amputations were noted as the highest occurring hand injury (45%) but tendon injury rate was much lower (4%). The focus on agricultural trauma may explain the higher incidence of amputations in that study, given amputations' association with farm machine usage[48]. Wong's (2008)[1] study in Hong Kong showed that amputations occurred at a rate of only 6.4%, while tendon injuries were reported at 26%. However, her subjects represented only people who worked in "elementary occupations" (i.e. unskilled paid occupations), and only 61% of the subjects were injured while working.[1]. It is difficult to compare Wong's (2008)[1] results to the current study results because the causes of their non-occupational injuries were unknown and the occupational demands of the work-injured subjects were diverse. Similar to the current study, there were no reports of nerve injuries in Wong's (2008)[1] study. Amputations, tendon and nerve injuries were unspecified in many studies that examined injuries specific to the hand and wrist [13, 31, 45, 47].

Based on the literature and the author's clinical experience, the absence of wrist or hand nerve lacerations in this study was unexpected, given the definite, albeit low, incidence in the literature[16, 52, 61]. New Brunswick's occupational industries are primarily labour-based (e.g. forestry, manufacturing) and these workforce categories account for a high incidence of work-related "lacerations" [13]. Nerve lacerations would be expected as part of the *nature-of-injury* occurring in these industry sectors. Descriptions of nerve trauma (e.g. incidence, injury site) are rarely stated in the literature. For example, Asplund et al.[52] studied peripheral nerve injuries and amputations, and named the wrist and hand as the primary sites of these injuries but without details of specific rates of incidence. In another study[61], median and ulnar nerves were described as common "battle" injuries sustained during war over the last century. However these results were not specified as to the *part-of-body* injured (e.g. elbow, wrist, or hand). A possible explanation for the inconsistencies in the current study compared to the literature and to clinical expectation may be related to the coding methods used by WorkSafe-NB, which do not specifically identify peripheral nerve lacerations[50]. Also the absence of nerve injuries might relate to the stronger emphasis on safety practices and prevention currently enforced in the work place[14, 50]. One safety practice could include protection against laceration of the volar surfaces of the hand and wrist, thus protecting the more vulnerable structures such as the flexor tendons, and the median, ulnar or digital nerves.

Research examining traumatic injuries at the wrist level has been fairly well documented for specific management approaches[17] but poorly documented with respect to incidence and time-loss duration. In this study, the overall incidence rate of wrist and hand trauma (3%) was low compared to findings reported by Workers' Compensation Boards[14], which ranged from 14 – 26% of total compensable injuries for five Canadian districts examined. However, this incidence rate of hand and wrist injuries is representative of only three *nature-of-injury* categories (i.e. fractures, amputations and tendon lacerations/disruptions). Other types of injuries may have occurred (e.g. sprains/strains, cumulative trauma) but did not meet the inclusion criteria for this study.

The first hypothesis in this study regarding incidence (*part-of-body*) was supported. The results of this study show a higher incidence of fractures in the hand (81%) than at the wrist (19%). This is comparable to findings reported by Hill et al. (1998)[47] and Wong (2008)[1] although the latter study did not specify if "finger fractures" included both phalanges and metacarpals. Another study[46] found close to equal incidence of wrist and hand injuries involving fractures. While that study was designed to examine fractures at various *parts-of-body*, it focused on the relationship among age, gender and potential osteoporotic fracture patterns, making it a less valid comparison to the current study, particularly for Phase 2.

In the literature, research examining incidence on upper extremity injuries is minimal, and primarily focuses on cumulative trauma and wrist fractures. Publications by the Canadian Workers' Compensation Boards appear to combine both claims with and without time-loss, and do not delineate the *nature-of-injury* categories with respect to wrist and hand injuries[14]. As a result, it was challenging to compare the incidence findings of this study to both the literature and data from other Workers' Compensation Boards.

5.2.2 Time-loss Duration

The average time-loss duration of subjects (n=200) in Phase 1 (114 days), was consistent with average time-loss duration reports in the literature (i.e. 6-245 days[1,16-19,24-25]). Despite the consistency, challenges were evident in the time-loss duration literature that presented difficulty in comparing the results of this study to the available research. For example, inconsistencies were noted in the literature for baseline characteristics, injury categories and body sites studied, in measurements of return-to-work (e.g. self-reported time-loss duration) and in the levels of severity for the subject data examined.

The first hypothesis in this study regarding time-loss duration (*nature-of-injury*) was not supported. That is, no statistical significance was noted among the time-loss duration of the three *nature-of-injury* categories. This was not anticipated given the differing return-to-work times described in the literature for the *nature-of-injury* categories examined[9, 18, 24].

Regarding time-loss duration (*part-of-body*), the first hypothesis was supported. That is, time-loss duration was significantly higher in the wrist compared to the hand. Looking at results of time-loss duration tests for both categories (i.e. *part-of-body, nature-of-injury),* suggests that for the 2006 cohort of hand and wrist injuries, *part-of-body* was the best indicator of time-loss duration. A wide range of time-loss duration was identified within each *nature-of-injury* and *part-of-body* category. Variability of time-loss duration has been documented across many specific injury categories and there is agreement that it is difficult to accurately predict time-loss duration based on *nature-of-injury* alone[16-18].

Discrepancies were noted in average time-loss duration for both *nature-of-injury* and *part-of-body* data compared to the literature. This study's findings of average time-loss duration (days) for finger fractures (93), wrist fractures (177), and tendon injuries of the hand (85) were more than double those of Wong[5 1] who reported results of 44, 87, and 48 days for finger fractures, distal radius fractures and, tendon injuries, respectively. Given that severity of injury was identified as "relatively mild" in Wong's (2008)[1] study, it may be postulated that the current study investigated subjects with higher levels of injury severity, which could explain the higher time-loss duration averages. However, injury severity was unable to be ascertained from the WorkSafe-NB database. Most Workers' Compensation Boards use the Medical Disability Advisor to predict disability duration by indicating a range of optimum days for sedentary to very heavy work (Table 2.2)[14, 63]. Compared to the Medical Disability Advisor standards, average time-loss duration was surprisingly high in this study. For example, the optimum days following finger amputations, for sedentary to very heavy work, is recommended as 14-42 days in Reed's guidelines[63]. In comparison, this study showed considerably higher average time-loss duration for finger amputations (136 days), even without categorizing the work demands (i.e. sedentary, very heavy).

In the *nature-of-injury* category, the total time-loss duration of fractures (i.e. sum total of time-loss duration for 134 subjects) was the highest. In fact, the total time-loss duration for fractures was more than three times greater than amputations and almost eight times greater than tendon injuries. This data has never been previously reported in the literature. Time-loss duration costs include wage replacement costs, a large proportion of which is typically covered by Workers' Compensation Boards. As such, the large total time-loss duration found in this study would represent a potentially large economic burden to WorkSafe-NB.

Examining both incidence and time-loss duration allows organizations such as WorkSafe-New Brunswick to assess the effect of work-related accidents, particularly with respect to economic impact. The average weekly benefit for injured workers' in 2006 was $387.00 for WorkSafe-NB. Thus, for this study, the annual wage replacement costs for the fractures, tendon lacerations/disruptions and amputations of the hand and wrist accounted for $1,257,750.00 for 2006 (total time-loss duration 3250 weeks or 22,747 days x $387.00/week). Unfortunately, financial implications associated with workplace injuries are not only limited to the direct expenses of a worker's injury, but also to indirect and hidden costs. These might include, but are not limited to: productive time lost by employees and/or supervisors attending the injured worker; time to hire or retrain workers to replace the injured employee; or, costs of increased workers' compensation insurance rates[102]. Therefore, the complete costs are considerably higher than the $1.25 million noted above.

While guidelines for disability duration are useful as a tool to assist those involved with case management, the discrepancies of this study's findings showed that incidence and time-loss duration are highly variable and challenging to compare across studies. This suggests that a multi-levelled approach to injury management and workplace absence is required to minimize time-loss duration. A biopsychosocial approach offers multi-levelled perspectives to ensure that factors in addition to impairment are considered, such as personal and environmental influences.

5.2.3 Phase 1 Summary

The results of Phase 1 showed that for hand and wrist trauma, incidence was low for fractures, tendon lacerations/disruptions and amputations. However, incidence and incidence rates were poorly operationalized in literature, which challenged attempts to compare findings. Average time-loss duration was not significantly different among the three *nature-of-injury* categories. However, significant differences were found between the part-of-body categories, thus partially supporting the first hypothesis of the study. These findings suggest that injuries involving the wrist versus the hand may offer insight into time-loss duration while injuries involving fractures, tendon lacerations/disruptions, and amputations may not be as useful to understand time-loss duration. Given the design constraints in data collection for Phase 1 (i.e. incidence and time-loss duration only), there was limited data to speculate on the explanation of these differences in incidence and time-loss duration. This phase examined incidence and time-loss duration for fractures, tendon lacerations/disruptions, and amputations involving the hand and wrist. Given the statistical results of the Phase 1 analysis, the decision was made to establish and study *hand fractures* as the combined *nature-of-injury/part-of-body category* in Phase 2.

5.3 Phase 2

For the category of hand fractures, the incidence was identified and time-loss duration was described in this phase. In addition, the ICF provided a biopsychosocial framework in this study to organize explanatory variables that were examined for their association with time-loss duration. The literature on *hand fractures* is primarily focused on the management of injury characteristics, and outcomes as they relate to impairment[17]. The results of this study support the relationship of impairment, personal and environmental factors on time-loss duration in subjects with *hand fractures.* The challenge of studying certain personal factors (e.g. psychosocial influences) from administrative databases was encountered in this study but is worthy of further investigation based on the literature.

5.3.1 Incidence of Hand Fractures

This study identified a low incidence rate (1.5%) of subjects with time-loss duration following *hand fractures* compared to all workers with injuries who incurred time-loss duration in 2006. In a similar study, Wong (2008) [1] reported that 31% of her hand-injured cohort was related to finger fractures. The scarcity of literature examining incidence of *hand fractures* contributed to the challenges in comparing this study's findings as did the reporting methods used by Canadian Workers' Compensation Boards. That is, this study reported only subjects with a very specific combined *nature-of-injury/ part-of-body* category whereas only one study in the literature identified incidence of fractures within the hand[1] and, reports of incidence with Workers' Compensations Boards often mix no time-loss claims (e.g. less severity), with time-loss claims.

5.3.2 Time-loss Duration of Hand Fractures

Results show that the average time-loss duration for *hand fractures* was 92 days – a result that is higher than comparable findings in the literature. For example, Wong[1] documented an average of 42 days for finger fractures. It was possible that the average time-loss duration in that study was lower due to a reported lower Injury severity. However, it was not possible to confirm the levels of injury severity from the WorkSafe-NB database for comparison. Of particular note are Reed's Disability Duration Guidelines[63], suggesting optimum disability duration for hand fractures as 3-42 days for sedentary to very heavy work demands, respectively. Differences in time-loss duration might be explained by the *nature-of-injury* categories analyzed. For example, fractures may have required more time-loss than that of the excluded *nature-of-injury* categories, such as cumulative trauma or dislocation injuries. Another possible reason for the better outcomes in the international studies may be the institutional and/or social structures guiding workplace absence in European and Chinese countries. For example, upon initiating workplace absence in Hong Kong, referral to hand rehabilitation services is commenced until return-to-work is resumed[1]. Countries or districts without similar systems may risk delays in return-to-work, if rehabilitation services that are essential to injury management and return-to-work are not accessed, or are accessed late.

Variations between the literature and those in the current study may be attributed to differences in injury severity, job demands, and *part-of-body* injured. For example, the majority of subjects in Wong's[1] study presented with a mild (53%) or moderate (33%) severity of injury, using the HISS system. Additionally, only 23% of her subjects were noted to have heavy physical job demands. Regarding *part-of-body* injured, MacDermid et al.[17] examined only subjects with distal radius fractures, citing average time-loss duration as 63 days. Given the unexpected differences and challenges with explaining both incidence and time-loss duration findings of this study, additional exploration of other variables was supported.

The total time-loss duration in this study allowed an examination of the economic impact for this cohort. For example, based on an average wage replacement of $387.00/week for injured workers with WorkSafe-NB, the annual wage replacement costs for the hand fracture subjects accounted for $484,579.00 for 2006 (total time-loss duration 1252 weeks or 8765 days x $387.00/week).Since this finding is representative of only one individual cohort with WorkSafe-NB, the magnitude of this result is challenging to interpret. WorkSafe-NB identified claims costs of $127.2 million of all injured workers in 2006, with claims costs including wage replacement, health care costs and vocational rehabilitation[49]. The wage replacement costs are not clearly delineated to allow direct comparison of this study's findings.

5.3.3 Explanatory Variables

The second hypothesis of this study was supported. That is, explanatory variables of medical aid costs, age, and receipt of therapy were associated with time-loss duration in the *hand fracture* category. Many challenges were encountered during the analysis, such as missing data, limited distribution of the data, or the need to recode explanatory variables. Some of these challenges were associated with the use of pre-existing databases and a retrospective research design. Ultimately two of the four variables hypothesized as having a relationship with time-loss duration (i.e. "occupational demands" and "injury characteristics") were excluded from the regression analysis in Phase 2. In addition, three other variables were disallowed, namely: "return-to-work position", "geography" and "dominant hand injured". Furthermore, data on "injury characteristics" (collected as intra-articular versus extra-articular fractures), and "dominant hand injured" were found to represent only 49% and 18%, respectively, of the total sample. High numbers of missing variables can seriously affect results and increase the risk of drawing conclusions based on invalid results[99]. Likewise having a limited distribution of data, such as the data collected on "return-to-work position" and "geography" can result in similar errors. The solution to these challenges was to recode or exclude the explanatory variables from the Phase 2 analysis.

5.3.3.1 Medical Aid Costs

Hand injury severity, as proxied by medical aid costs, showed a greater risk of higher time-loss duration in those subjects with hand fractures. For example, for every $1000 increase in Medical Aid costs, there was a 1.25 times increase in the risk of longer time-loss duration. This is consistent with Wong's [1] and Urso-Baiarda et al's[25] findings that identified a positive correlation between extent of injury and time off work for a variety of hand injuries. In the latter study, Urso-Baiarda et al.[25] suggested that 40% of those clients with hand/forearm injuries classified as "major" (i.e. as per the MHISS) do not return to work at all, and those who do return have time-loss duration greater than one year. In both studies, a combination of variables – not only injury severity – was suggested as influencing an individual's ability to perform and/or commit to work attendance[25].

While data reflecting injury characteristics, such as fracture type, were considered for this study, less than half of the sample had documentation specific to this fracture characteristic in the database. In clinical practice, case managers using Reed's Disability Duration Guidelines[63] and therapists using clinical reasoning processes[17, 100], may need to address issues beyond the impairment or injury characteristics (e.g. type and extent of fracture displacement) to minimize time-loss duration. These issues could include personal (e.g. age, dominant versus non-dominant hand injured) and environmental factors (e.g. occupational demands, return-to-work position) as described in the ICF model and illustrated with examples from the current study.

Injury severity rating has shown promise in the literature with predicting time-loss duration[1, 25, 32, 35, 78]. Unfortunately the evidence is not as convincing for its use as a predictor of functional outcome. Injury severity rating may best be utilized as a measure of impairment in the early stages of hand fractures to guide those involved in the case management and/or injury management processes. Establishing the severity of an injury would allow early identification of those clients at risk for prolonged time-loss duration. Not only could early intervention be enabled, but also the injured worker and employer could prepare themselves for workplace absence and the economic impact associated with time-loss duration[25].

5.3.3.2 Receipt of Therapy (Physiotherapy, Occupational Therapy)

The relationship between time-loss duration and receipt of therapy (physiotherapy and occupational therapy) was examined in this study. The results showed that having both physiotherapy and occupational therapy increased the risk of longer time-loss duration. More specifically, for every unit increase in Therapy PT and Therapy OT, there was a 3.3 and 1.7 times increase, respectively, in the risk of staying off work. It would be reasonable to expect that more severe injuries would require therapy for longer periods of time, and that the number of therapy visits would be higher. However, neither treatment frequency (i.e. number of visits) nor duration was not collected on subjects who received therapy. Wong (2008)[1] found similar relationships of receipt of therapy and time-loss duration. That is, the length of rehabilitation increased with injury severity as severity ratings increased from *mild* to *severe*. The literature suggests that the use of physiotherapy and occupational therapy has positive associations with functional gains[90-92]. These studies primarily assessed functional improvement through self-reported measures (e.g. Canadian Occupational Performance Measure, DASH) but did not, however, specify time-loss duration as an outcome measure. While worthy of future investigation, the comparative value of therapy with the literature was not possible because the current study did not capture specific levels of injury severity or measure the treatment frequency or duration of therapy involvement or response to therapy.

5.3.3.3 Receipt of Surgery

Surgical intervention as a potential explanatory variable was collected from the database and was hypothesized to influence return-to-work outcomes as part of post-injury management for *hand fractures*. While the univariate analysis supported a possible relationship between surgery and time-loss duration ($p < 0.05$), the presence of surgery was not significant in the multivariate model. This might suggest that in the presence of other variables such as *medical aid costs* and *receipt of therapy*, there is no significant relationship of surgery on time-loss duration. This supports MacDermid et al.'s[17] findings that, for distal radius fractures, alignment and surgical interventions were not associated with time-loss duration. From a clinical perspective, individuals who receive surgery are often followed more closely by their surgeons, particularly in the early period following surgery. For example, dressing changes, suture removal and monitoring for infection is typically part of follow-up protocol post-operatively. It is possible that complications such as decreased joint mobility or pain beyond expectation are recognized early with these individuals and are thus referred earlier for appropriate medical and therapeutic management. This could potentially contribute to the process that addresses early recognition and prevention of extended time-loss duration.

5.3.3.4 Age

The variable of age deserved reflection given the finding that for every unit increase in age, there was a 1.03 times increase in the risk of longer time-loss duration. For fractures, the healing ability of the older client is accepted as less than optimal for quality and healing time compared to a younger counterpart[3, 18]. Consequently, a positive correlation between age and time-loss duration is often reported in the literature. For example, several researchers[3, 18] found younger subjects (aged 18-24) were more likely to return to work than those with similar fracture injuries over age 45. Current results support the hypothesis that age was associated with time-loss duration for subjects with *hand fractures*.

5.3.3.5 Gender

The lack of a significant effect of gender with time-loss duration was not surprising for this cohort. In various studies of fractures, authors[3, 9, 24] have reported similar findings between gender and time-loss duration, with one exception. Seland et al.[18] noted a significant relationship between females and longer time-loss duration following ankle fractures. However, the same relationship was not reported for wrist fractures[18]. The literature supports stronger relationships of both age and gender with sustaining injuries but not with time-loss duration[82].

5.3.3.6 Pre-injury Work Status, Length of Employment

This study did not find a significant effect between time-loss duration and the variables of pre-injury work status and length of employment. It is possible that these variables, as collected, did not adequately capture what was intended regarding employee/employer relationships thus challenging the validity of any conclusions. For instance, both pre-injury work status and length of employment data were gathered as proxies to relate to the quality of the relationship between each subject and the employer. This was in keeping with the literature that used similar variables to explore worker motivation factors[12], worker satisfaction[12, 101], and positive relationships with colleagues[26]. An alternative conclusion regarding the proxied data was that the variables collected did adequately represent the quality of the relationships between employees and employers. In this case, there was no association between time-loss duration and pre-injury work status or length of employment. While this finding is supported by the literature, none of the aforementioned studies used subject cohorts who had *hand fractures*. Consequently, this study's subject cohort may represent a unique group to explore the relationship of psychosocial influences (e.g. in the personal and environment contexts) with time-loss duration.

5.4 Limitations

Limitations of this study are recognized. Clients with hand fractures due to work-related injury may represent typical occupational distributions and as such, generalization of these findings may not be valid. Controversy exists in the literature that time-loss duration is influenced by work place variables, such as occupational demands, availability of accommodations, and the employee's relationship with the employer[101]. This study was unable to adequately capture and study those variables of occupational demands. Further investigation is warranted, given that occupational demands have been positively correlated with time-loss duration in some studies[16-18], and impact clinical decisions regarding return to work.

The current standard to measure ability to return to work (i.e. strength) is inappropriate to use in isolation for the hand-injured population [42]. The essential variable to consider relates to the specific nature of hand function: no other part of the body is required to perform finely skilled dextrous or manipulative movements. As such, mobility, sensation and coordination play a critical role in the hand's performance of all occupational demands, with strength being a complimentary partner. Furthermore, impairment of strength alone does not necessarily suggest limitations or restrictions in activity performance or participation[37]. Despite this knowledge, physical impairment (i.e. decreased strength) continues to exist as the critical benchmark against which return-to-work is assessed.

Many hand-injured clients fear re-injury or inability to perform to their full potential when considering return to work. Self-report disability is valuable as a predictor of return-to-work with the wrist-injured population[17]. When used early in management of hand injuries, disability self-reports can identify those at risk for prolonged time-loss duration due to psychosocial reasons[17]. An inherent limitation of the current study was the inability to identify psychosocial influences on return to work. Challenges existed in extracting or substituting psychosocial data from the available WorkSafe-NB database. The absence of psychosocial data may have impeded comprehensive outcome measurement and interpretation related to time-loss duration in this study.

5.5 Conclusion

The results of Phase 1 for fractures, tendon lacerations/disruptions and amputations of the hand and wrist showed that the incidence was low, and that time-loss duration was significantly different only for the *part-of-body* categories. This finding thus only partially supports the first hypothesis of the study. High variances in time-loss duration data were postulated as a primary reason for the lack of nature-of-injury differences, and suggest difficulty with predicting time-loss duration for this cohort based on their *nature-of-injury* alone.

In addition, findings showed that *hand fracture* incidence was lower compared to the literature. This may be related to inconsistent methods used to determine and document incidence within the literature. Time-loss duration was higher than anticipated but challenges were encountered to compare this finding to the literature and other published databases (e.g. Workers' Compensation Board reports), given the scarcity of reports of time-loss duration with *hand fractures.* Using a biopsychosocial framework, this study also identified four variables as having a significant effect with time-loss duration in individuals with hand fractures, namely: injury severity, age, and receipt of therapy (PT and OT). Therefore, the second hypothesis of this study was supported, namely that time-loss duration was associated with explanatory variables of impairment of body functions / structures, personal and environmental factors. This finding corroborates other research conclusions with trauma involving other *nature-of-injury* and *part-of-body* categories.

Chapter 6: CONCLUSION

6.1 Summary

This study addressed the time taken to return to work following traumatic hand injuries, and the variables that were associated with time-loss duration in a one year cohort of injured workers insured by WorkSafe-New Brunswick. Chapters one and two presented the thesis structure and rationale for the thesis topic, and a review of the relevant literature. Chapter three provided the methodology including the research design, the subject sample, and procedures used to complete the study. The results and discussion were described in Chapters four and five, respectively.

Two phases of investigation comprised this study. Phase 1 was designed to identify the incidence and average time-loss duration of four specific *nature-of-injury* categories (fractures, tendon lacerations/disruptions, nerve lacerations, and amputations) and two *part-of-body* categories (wrist and hand). The results for both incidence and time-loss duration for all categories were challenging to compare to the literature for a number of reasons. First, this study included only four *nature-of-injury* and two *part-of-body* categories as part of the data collection. Many incidence reports in the literature do not delineate the *nature-of-injury* or part-of-body categories, or report only on one specific category[3,13,15]. Next, incidence is not well-defined in the literature and includes inconsistent reports of time periods on which to base statements of incidence rates[1]. Finally, traumatic injuries of the hand/wrist are often combined with non-traumatic cohorts[31,45,48]. The distinct characteristics and management of traumatic injuries warrants distinct and separate analysis of their incidence and time-loss duration from their non-traumatic counterparts. Results of this study support the available literature that time-loss duration is variable and challenging to accurately predict following traumatic hand and wrist injuries[1, 17, 18, 24]. Phase 1 of this study provided the foundation to establish one combined *nature-of-injury/ part-of-body* category to study in Phase 2.

Identification of the combined category included analysis of the following factors: incidence, time-loss duration, and, total time-loss duration per category as determined by summing the total time-loss duration for all injured workers in each of the categories. As per the decision guide (section 3.3.1), subjects with *hand fractures* were selected as the primary cohort for Phase 2.

Average time-loss duration for *hand fractures* in Phase 2 exceeded time-loss duration found in the literature. Phase 2 also examined the factors associated with time-loss duration. The variables that most influenced time-loss duration in this study were medical aid costs (as a proxy for severity of injury), age, and receipt of therapy. Gender, length of employment, receipt of surgery and pre-injury work status were not found to have significant association with time-loss duration.

6.2 Conclusion

To the author's knowledge, no other North American published study has examined incidence and time-loss duration as per the *nature-of-injury* and *part-of-body* categories as specified in this study for a cohort of work-related subjects. Likewise, the incidence and time-loss duration of hand fractures in the work-injured population, and explanatory variables of time-loss duration for this cohort have not been documented in the literature. The findings of this study contribute to the available literature and can be used to guide various stakeholders, from those who manage acute care injury to those involved in case management.

A number of challenges were noted in the literature which created barriers to compare the results of this study. The current Workers Compensation Board databases are challenging to use for extracting data to identify impairment, personal and environmental factors of the hand and wrist injured worker. This can appreciably influence interpretation of results related to incidence and time-loss duration and the associated factors with time-loss duration. The availability of research on hand fractures was minimal which also contributed to the difficulty in comparing the results of this study. Time-loss duration for hand fractures was only able to be compared to one report in the literature[1] in addition to the predicted values available in Disability Duration Guidelines used by many Workers Compensation Board organizations[63].

The results of this study have several clinical implications. Recognizing the severity and potential for long time-loss duration of hand and wrist injuries is essential. In addition, identification of personal and environmental factors should be used in conjunction with injury severity to prepare and guide those involved in injury and case management for potential longer time-loss duration. This suggests that a proactive and thorough approach should be implemented immediately for those individuals presenting with minor to severe hand fractures. From a clinical perspective, specific hand injury characteristics may be better considered for the individual interventions, particularly in the primary healing stages following injury. Available tools that measure injury severity may best capture the extent of impairment. The MHISS is considered an acceptable measure of severity rating and predictor of time-loss duration in research endeavours. Compared to its usefulness as a research too, its use as an administrative and clinical tool is less supported in the literature but offers merit in these realms. The MHISS could enable adjudication and administrative processes consistent with disability duration guidelines. This would be beneficial in the early stages of hand injury, but would offer little value to prediction of long term functional outcome.

A complimentary, biopsychosocial approach would be advantageous in the assessment and intervention of the impairment, personal, and environmental variables influencing return-to-work. The current use of disability duration guidelines in the work-injured population is concerning since it is limited to impairment only in the context of time-loss duration. Accuracy and complete care is warranted for all categories of hand injury. It is accepted that returning to work as soon as possible after an injury minimizes economic losses for both the employer and the injured worker. Facilitating timely return-to-work for this cohort would promote optimal rehabilitation of an injury with both impairment and psychosocial benefits. Utilizing this biopsychosical approach and philosophy for injury management is consistent with the ICF framework promoted by the World Health Organization[40]. Further research is required to enhance generalizability and corroborate research findings across other Workers' Compensation Boards and across cohorts with non-occupational injuries.

6.3 Recommendations for Future Research

This thesis addressed the topic of hand and wrist injuries from a unique perspective compared to the available literature. Additional areas of research are proposed to further enlighten our understanding of hand and wrist trauma and the concepts influencing return to work. Scholarly and clinical knowledge of these injuries would advance through the following initiatives:

1. Understanding the association of personal and environmental factors on return-to-work was one of the main purposes of this study. However, the data of many of these variables were unavailable or showed limited distribution and were not able to be included in the final analysis. A prospective study is warranted to allow further identification and examination of the relationship of personal and environmental variables on time-loss duration following hand fractures. These could include factors such as dominant hand injured, occupational demands, and availability of workplace accommodations.

2. This study identified an association with the receipt of therapy and time-loss duration. Given that the medical aid costs within this study reflected a combination of physician, hospital, and rehabilitation expenditures, extrapolating and examining the relative value of specific rehabilitation following hand injury is warranted to ensure evidenced based intervention strategies are enabled and are effective for return-to-work.

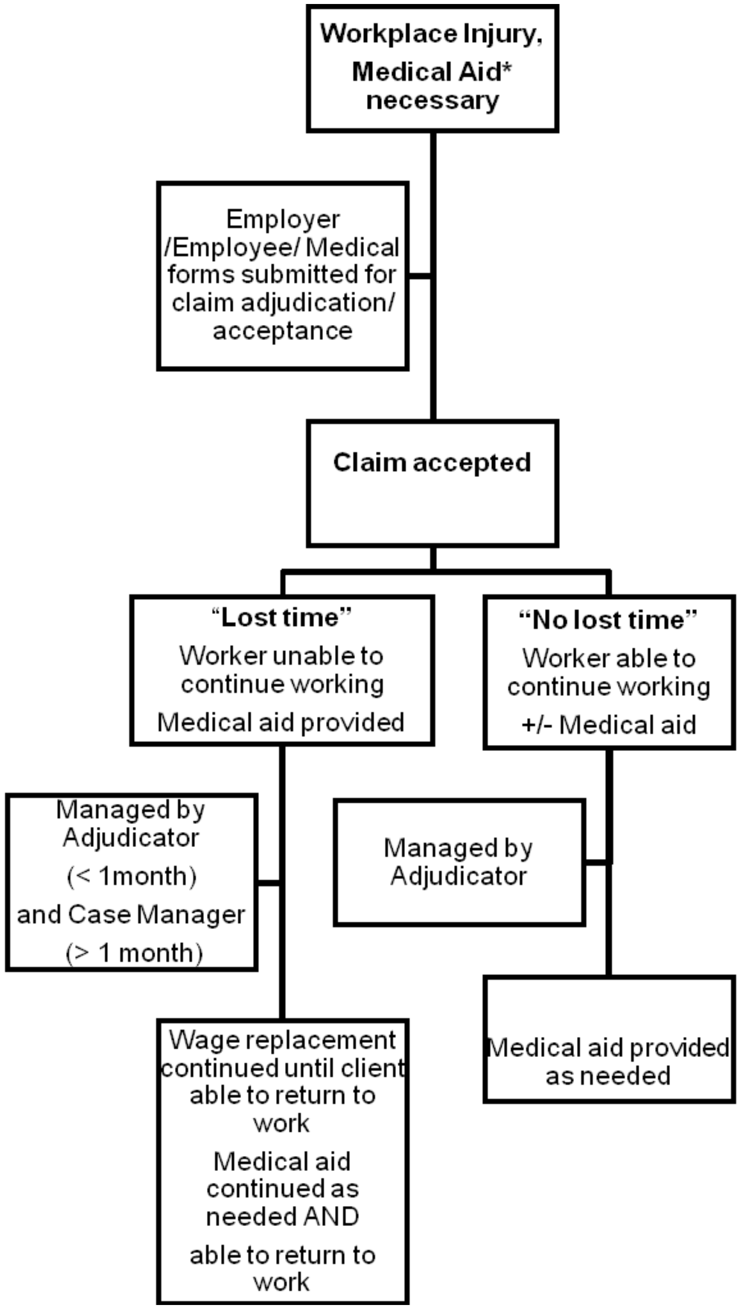
3. The extent of hand injury severity was proxied by the use of medical aid costs for this study. Given the association of medical aid costs with time-loss duration, understanding the true hand injury severity (i.e. not proxied) would strengthen our understanding of this identified relationship. A prospective study to identify levels of hand injury severity for the *nature-of-injury* categories examined in this study is required and could be used

to model other injury categories. The Modified Hand Injury Severity Scale (MHISS) has been introduced in research realms, but minimal focus has been made to identify its applicability in the clinical setting. Exploring the use of the MHISS for its utilility and practicality in clinical practice and case management would guide case managers to ensure appropriate and timely referrals are made, as well as prepare clients and employers for extensive rehabilitation and potential losses associated with workplace absence.

4. Return-to-work following trauma of hand injuries, such as tendon lacerations, amputations or nerve lacerations is a complex process. Disability duration guidelines offer vague parameters to assist case management but little information is available to guide case managers with respect to these specific hand injuries. While the current study explored this theme with fractures of the hand, further research is necessary to examine other categories of hand injuries, including extensor and flexor tendon injuries for all zones, amputations at various levels, and ulnar and median nerve lacerations also at various levels.

APPENDICES

Appendix A: WorkSafe-NB Process: Accepted Claims



*Medical Aid includes physician care, hospital fees, medication, diagnostic procedures, and/or rehabilitation costs

Appendix B: Modified Hand Injury Severity Scale[25]

INTEGUMENT				Points
ABSOLUTE	Skin loss to hand or forearm	Dorsum	< 1 cm^2 > 1 cm^2 > 5 cm^2	5 10 20
		Volar	< 1 cm^2 > 1 cm^2 > 5 cm^2	10 20 40
WEIGHTED (See Weighting Factors)	Skin loss to digit	Dorsum	< 1 cm^2 > 1 cm^2	2 3
		Volar	< 1 cm^2 > 1 cm^2	2 6
		Pulp	< 25% > 25%	3
	Skin Laceration (If extends across more than one ray, include in both ray scores)		< 1 cm^2 > 1 cm^2	1 2
	Nail bed damage			1
If wound crushed, dirty or contaminated: DOUBLE the score				
SKELETAL				
ABSOLUTE	Any forearm fracture			20
WEIGHTED (See Weighting Factors)	Digital Fracture		Simple shaft Comminuted shaft Intra-articular DIPJ Intra-articular MCPJ Intra-articular PIPJ/IPJ of thumb	1 2 3 4 5
		Dislocation	Closed Open	2 4
		Ligament injury	Sprain Rupture/avulsion	2 3
If fracture is open: DOUBLE the score				
MOTOR				
ABSOLUTE	Wrist flexor or extensor (each)			10
WEIGHTED (See Weighting Factors)	Extensor tendon	Proximal to PIPj Distal to PIPj		1 3

MOTOR				
	Flexor profundus (incl FPL)	Zone 1 Zone 2 Zone 3 Zone 4, 5, belly		6 6 5 3
	Flexor superficialis	Distal to wrist Proximal to wrist		5 2
	Intrinsic Muscles			2
Crush or avulsion of above : DOUBLE the score				
NEUROVASCULAR				
ABSOLUTE	Nerve	Main median n. Main ulnar n. Motor branch median n. Deep branch ulnar n.		60 60 30 30
	Artery	Radial Artery Ulnar Artery		10 10
WEIGHTED (See Weighting Factors)	Digital nerve	One Both		3 4
	Digital Artery	One Both		3 6
Crush or avulsion of neurovascular bundle: DOUBLE the score				
WEIGHTING FACTORS				
The following apply to weighted scores:				
Thumb x6 Index x2 Middle x3 Ring x3		Little x2 Hand & Forearm x1		

MHISS FINAL SCORE CATEGORIES	
Minor Moderate Severe Major	MHISS < 20 MHISS 20 - 50 MHISS 51 - 100 MHISS > 101

Appendix C: WorkSafe New Brunswick Hand Injury Population – Total

*printed with permission from Pam Wasson, WorkSafe-NB

NOI code	Nature-of-injury	POB code	Part-of-body	2006	2007
01100	Dislocations	32000	WRIST(S)		1
01100	Dislocations	34001	THUMB OR THUMB AND OTHER FINGER(S)		1
01100	Dislocations	34002	FINGERS, EXCEPT THUMB		3
01200	Fractures	32000	WRIST(S)	36	49
01200	Fractures	33000	HAND(S), EXCEPT FINGER(S)	15	11
01200	Fractures	34000	FINGER(S), FINGERNAIL(S)	1	
01200	Fractures	34001	THUMB OR THUMB AND OTHER FINGER(S)	17	9
01200	Fractures	34002	FINGERS, EXCEPT THUMB	31	32
01200	Fractures	34090	FINGER(S), FINGERNAIL(S), UNSPECIFIED	3	1
01200	Fractures	38100	HAND(S) AND FINGER(S)		1
02100	Sprains, strains, tears	32000	WRIST(S)	11	21
02100	Sprains, strains, tears	33000	HAND(S), EXCEPT FINGER(S)	2	3
02100	Sprains, strains, tears	34001	THUMB OR THUMB AND OTHER FINGER(S)	8	3
02100	Sprains, strains, tears	34002	FINGERS, EXCEPT THUMB		4
02100	Sprains, strains, tears	38100	HAND(S) AND FINGER(S)		2
02100	Sprains, strains, tears	38200	HAND(S) AND WRIST(S)	2	3
03100	Amputations, unspecified	34001	THUMB OR THUMB AND OTHER FINGER(S)	1	1
03100	Amputations, unspecified	34002	FINGERS, EXCEPT THUMB	3	5
03110	Amputations, fingertip	34000	FINGER(S), FINGERNAIL(S)	2	
03110	Amputations, fingertip	34001	THUMB OR THUMB AND OTHER FINGER(S)	6	3
03110	Amputations, fingertip	34002	FINGERS, EXCEPT THUMB	7	12
03110	Amputations, fingertip	34090	FINGER(S), FINGERNAIL(S), UNSPECIFIED	2	

NOI code	Nature-of-injury	POB code	Part-of-body	2006	2007
03190	Amputations, except fingertip	34001	THUMB OR THUMB AND OTHER FINGER(S)	2	4
03190	Amputations, except fingertip	34002	FINGERS, EXCEPT THUMB	19	4
03190	Amputations, except fingertip	38100	HAND(S) AND FINGER(S)		2
03300	Avulsions	34001	THUMB OR THUMB AND OTHER FINGER(S)		2
03300	Avulsions	34002	FINGERS, EXCEPT THUMB	5	5
03300	Avulsions	34090	FINGER(S), FINGERNAIL(S), UNSPECIFIED	1	
03400	Cuts, lacerations	32000	WRIST(S)	2	6
03400	Cuts, lacerations	33000	HAND(S), EXCEPT FINGER(S)	12	9
03400	Cuts, lacerations	34000	FINGER(S), FINGERNAIL(S)	1	1
03400	Cuts, lacerations	34001	THUMB OR THUMB AND OTHER FINGER(S)	19	16
03400	Cuts, lacerations	34002	FINGERS, EXCEPT THUMB	43	43
03400	Cuts, lacerations	34090	FINGER(S), FINGERNAIL(S), UNSPECIFIED	1	
03400	Cuts, lacerations	38100	HAND(S) AND FINGER(S)	8	6
03400	Cuts, lacerations	38200	HAND(S) AND WRIST(S)		1
03700	Punctures, except bites	33000	HAND(S), EXCEPT FINGER(S)	2	2
03700	Punctures, except bites	34000	FINGER(S), FINGERNAIL(S)	1	
03700	Punctures, except bites	34001	THUMB OR THUMB AND OTHER FINGER(S)		1
03700	Punctures, except bites	34002	FINGERS, EXCEPT THUMB	4	3
03700	Punctures, except bites	38100	HAND(S) AND FINGER(S)	1	
04000	Surface wounds and bruises, uns	34002	FINGERS, EXCEPT THUMB	1	
04100	Abrasions, scratches	34090	FINGER(S), FINGERNAIL(S), UNSPECIFIED		1
04300	Bruises, contusions	32000	WRIST(S)	5	
04300	Bruises, contusions	33000	HAND(S), EXCEPT FINGER(S)	4	6

NOI code	Nature-of-injury	POB code	Part-of-body	2006	2007
04300	Bruises, contusions	34001	THUMB OR THUMB AND OTHER FINGER(S)	2	1
04300	Bruises, contusions	34002	FINGERS, EXCEPT THUMB	1	3
04300	Bruises, contusions	38100	HAND(S) AND FINGER(S)	4	3
04300	Bruises, contusions	38200	HAND(S) AND WRIST(S)	1	3
04400	Foreign bodies (superficial splinters, chips)	33000	HAND(S), EXCEPT FINGER(S)	1	1
04400	Foreign bodies (superficial splinters, chips)	38100	HAND(S) AND FINGER(S)		1
05100	Chemical burns, uns	32000	WRIST(S)		1
05100	Chemical burns, uns	33000	HAND(S), EXCEPT FINGER(S)		1
05101	First-degree chemical burns	38100	HAND(S) AND FINGER(S)		1
05200	Electrical burns, uns	34002	FINGERS, EXCEPT THUMB		1
05300	Heat burns, scalds, uns	38100	HAND(S) AND FINGER(S)	1	1
05301	First-degree heat burns, scalds	32000	WRIST(S)		1
05301	First-degree heat burns, scalds	38100	HAND(S) AND FINGER(S)	1	
05302	Second-degree heat burns, scalds	32000	WRIST(S)	1	
05302	Second-degree heat burns, scalds	33000	HAND(S), EXCEPT FINGER(S)	2	1
05302	Second-degree heat burns, scalds	34002	FINGERS, EXCEPT THUMB	1	1
05302	Second-degree heat burns, scalds	38100	HAND(S) AND FINGER(S)	1	2
05302	Second-degree heat burns, scalds	38200	HAND(S) AND WRIST(S)	1	1
08100	Cuts, abrasions, bruises	34002	FINGERS, EXCEPT THUMB	1	1

NOI code	Nature-of-injury	POB code	Part-of-body	2006	2007
08100	Cuts, abrasions, bruises	38200	HAND(S) AND WRIST(S)	1	
08200	Sprains and bruises	32000	WRIST(S)	1	2
08200	Sprains and bruises	34002	FINGERS, EXCEPT THUMB	1	1
08400	Fractures and other injuries	34000	FINGER(S), FINGERNAIL(S)	1	
08400	Fractures and other injuries	34001	THUMB OR THUMB AND OTHER FINGER(S)	3	2
08400	Fractures and other injuries	34002	FINGERS, EXCEPT THUMB	8	9
08400	Fractures and other injuries	38100	HAND(S) AND FINGER(S)	4	1
09710	Crushing injuries	32000	WRIST(S)		1
09710	Crushing injuries	33000	HAND(S), EXCEPT FINGER(S)	1	5
09710	Crushing injuries	34001	THUMB OR THUMB AND OTHER FINGER(S)	6	8
09710	Crushing injuries	34002	FINGERS, EXCEPT THUMB	16	27
09710	Crushing injuries	38100	HAND(S) AND FINGER(S)	9	6
09710	Crushing injuries	38200	HAND(S) AND WRIST(S)	2	1
				349	364

Appendix D: **WorkSafe New Brunswick Hand Injury Population – Coded**

NOI code	Nature-of-injury	POB code	Part-of-body	2006	2007
01200	Fractures	32000	WRIST(S)	36	49
01200	Fractures	33000	HAND(S), EXCEPT FINGER(S)	15	11
01200	Fractures	34000	FINGER(S), FINGERNAIL(S)	1	
01200	Fractures	34001	THUMB OR THUMB AND OTHER FINGER(S)	17	9
01200	Fractures	34002	FINGERS, EXCEPT THUMB	31	32
01200	Fractures	34090	FINGER(S), FINGERNAIL(S), UNSPECIFIED	3	1
01200	Fractures	38100	HAND(S) AND FINGER(S)		1
03100	Amputations, unspecified	34001	THUMB OR THUMB AND OTHER FINGER(S)	1	1
03100	Amputations, unspecified	34002	FINGERS, EXCEPT THUMB	3	5
03110	Amputations, fingertip	34000	FINGER(S), FINGERNAIL(S)	2	
03110	Amputations, fingertip	34001	THUMB OR THUMB AND OTHER FINGER(S)	6	3
03110	Amputations, fingertip	34002	FINGERS, EXCEPT THUMB	7	12
03110	Amputations, fingertip	34090	FINGER(S), FINGERNAIL(S), UNSPECIFIED	2	
03190	Amputations, except fingertip	34001	THUMB OR THUMB AND OTHER FINGER(S)	2	4
03190	Amputations, except fingertip	34002	FINGERS, EXCEPT THUMB	19	4
03190	Amputations, except fingertip	38100	HAND(S) AND FINGER(S)		2
03400	Cuts, lacerations	32000	WRIST(S)	2	6
03400	Cuts, lacerations	33000	HAND(S), EXCEPT FINGER(S)	12	9

NOI code	Nature-of-injury	POB code	Part-of-body	2006	2007
03400	Cuts, lacerations	34000	FINGER(S), FINGERNAIL(S)	1	1
03400	Cuts, lacerations	34001	THUMB OR THUMB AND OTHER FINGER(S)	19	16
03400	Cuts, lacerations	34002	FINGERS, EXCEPT THUMB	43	43
03400	Cuts, lacerations	34090	FINGER(S), FINGERNAIL(S), UNSPECIFIED	1	
03400	Cuts, lacerations	38100	HAND(S) AND FINGER(S)	8	6
03400	Cuts, lacerations	38200	HAND(S) AND WRIST(S)		1
08100	Cuts, abrasions, bruises	34002	FINGERS, EXCEPT THUMB	1	1
08100	Cuts, abrasions, bruises	38200	HAND(S) AND WRIST(S)	1	
08400	Fractures and other injuries	34000	FINGER(S), FINGERNAIL(S)	1	
08400	Fractures and other injuries	34001	THUMB OR THUMB AND OTHER FINGER(S)	3	2
08400	Fractures and other injuries	34002	FINGERS, EXCEPT THUMB	8	9
08400	Fractures and other injuries	38100	HAND(S) AND FINGER(S)	4	1
				249	229

Appendix E: Data Collection Spreadsheet

Identification Number (Subjects)	**1***	**2**	**3**	**∞**
Injury Type 1=wrist frac, 2=hand frac, 3=amp, 4= nerve lac, 5=tendon lac/disruption)	2			
Age (years)	53			
Gender M=1, F=2	1			
Dominance R=1, L=2, U=3	1			
Hand Injured R=1, L=2, U=3	1			
Job Description	Alarm installer			
Geographical location (PC-2nd digit) urban=1, rural=2	1			
Work status PPT=1, PFT=2, Cas=3	2			
RTW position reg duties=1, temp accom=2, perm accom=3, alt occ=4	1			
Date of hire(d/m/y)	12Feb00			
Type of injury 1=median, 2=ulnar, 3=flexor, 4=extensor, 5=IA, 6=non-IA				
Level of injury 1= forearm-wrist, 2=wrist-mc heads, 3=distal to mc heads				
Therapy intervention none=1, OT=2, PT=3, HT=4, Comb therapy=5	3			
Medical Aid ($)	1072.5			
Date of 1st lost-time day (d/m/y)	12Dec07			
Date of Initial RTW (d/m/y)	17Mar08			

*Subject #1 is shown as an example of data extracted, obtained during pilot work, September 16, 2008

Appendix F: Reciprocal Non-Disclosure Agreement

To comply with the Canadian Privacy Act the National Library of Canada has requested that the following page be removed from this copy of the thesis: "Reciprocal Non-Disclosure Agreement".

Appendix G: Ethics Approval

To comply with the Canadian Privacy Act the National Library of Canada has requested that the following page be removed from this copy of the thesis: "Ethics Approval".

Appendix H: Tests for Homogeneity of Variances for Nature-of-Injury and Part-of-Body Categories for Phase 1 Data

	Levene Statistic	**df1**	**df2**	**Significance**
Nature-of-Injury	1.506	2	197	.224*
Part-of-Body	8.011	1	198	.005**

*Group variances of the *nature-of-injury* categories were similar, or homogenous, given the non-significance of the Levene Statistic at 0.224 ($p < .05$)

**Group variances of the *part-of-body* categories were dissimilar, given the significance of the Levene statistic at 0.005 ($p < .05$)

Abbreviations: df = degrees of freedom

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