Delayed Recovery and Chronic Disability in Patients with Whiplash-Associated Disorders

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Narrative Abstract

Whiplash is a common injury after a motor vehicle collision resulting in significant pain and disability for those injured. The prognosis of these disorders is highly variable and difficult to predict and evidence suggests that both medical and external non-injury related factors are important in determining recovery.

This study is an extensive exploratory analysis investigating the association between a number of personal, clinical, and non-injury related factors and delayed clinical improvement after soft-tissue injuries sustained in a motor vehicle collision. Data were collected shortly after injury ensuring each patient was enrolled in the study at a similar point of recovery, and the outcome was measured with a valid and reliable disability questionnaire. The source of the data was the clinical database from a national network of 48 Canadian physiotherapy and rehabilitation facilities. A cohort of 2185 adult patients from this database was assembled for analysis.

Multivariate logistic regression analysis revealed eight predictors associated with delayed recovery as measured by a minimal clinical improvement: 1) older age, 2) female gender, 3) increasing lagtime between injury date and presentation for treatment, 4) initial pain location, 5) province of injury, 6) higher initial pain intensity, 7) lawyer retention, and 8) work status (currently working). The variable measuring increasing initial pain intensity interacted with both the lawyer retention and the work status variables. A model

predicting early improvement was developed and validated. A secondary cross-sectional analysis of the acute and chronic whiplash population suggests that significant differences between these groups are apparent at 3 months and that the acute patient population should be analyzed separately from the chronic patient population.

Researchers and clinicians in all jurisdictions should be cognizant of the potential for non-injury related factors to delay recovery, and aware of the interaction between the initial intensity of a patient's pain and other covariates when confirming these results.

Table of Contents

List of Tables

List of Figures

Chapter 1 Introduction

Whiplash is defined as an acceleration-deceleration mechanism of energy transfer to the neck, usually occurring during a motor vehicle collision (1). The direction of the impact is usually rear-end or side impact but other mechanisms of collision also generate similar forces. Injuries to the neck or other areas of the body are a common occurrence after such a trauma. The clinical manifestations of these injuries have been termed whiplash-associated disorders (WAD) and the list of reported signs and symptoms includes: neck pain, headache, facial pain, temporo-mandibular joint pain, dysphagia, visual disturbances, vertigo, concentration difficulties, interscapular pain, and upper and lower extremity numbness and pain (1). Low back pain is also commonly reported (2, 3).

The incidence of whiplash claims has proven to be highly variable in different provinces across Canada. For example, incidence rates have varied from 70 claims per 100,000 persons in Quebec (1) to 900 claims per 100,000 in British Columbia (4). In Saskatchewan, the incidence rate ranged from 302 claims per 100,000 persons under a no-fault insurance system to 700 claims per 100,000 under a tort system (2). Insurance policy is thought to be a major determinant for these observed differences among the Canadian provinces; however, both Quebec and Saskatchewan operate under a no-fault system (where pain and suffering are not compensated) suggesting other important policy and/or cultural influences are at work.

The presence and recovery of chronic pain and disability after a motor vehicle collision similarly demonstrates considerable variability. Indeed, depending on the insurance

jurisdiction as few as 2% and as many as 28% of those involved in a crash are still compensated one year after their collision (2, 5). Overall, the natural history of the condition is generally thought to be favourable (1) but recent research has highlighted the unpredictable course of recovery (6). The management of whiplash has proven to be challenging for clinicians, and insurers alike.

Accumulating evidence suggests that WADs are not only a medical issue but also a condition that is influenced by external non-injury related factors. This increasingly substantial body of research has created considerable controversy, and few health care issues have received more emotionally laden attention. Although physical trauma likely has a role in the expression of disability secondary to whiplash, it is becoming increasingly clear that compensation systems and legal factors also contribute in many cases (2, 6-8).

Based on the scientific evidence to date, the Quebec Task Force on Whiplash-Associated Disorders (QTF) (1), and more recently Côté and his colleagues (6) have systematically reviewed the whiplash literature and made a number of recommendations regarding future research. Included in its research agenda, the QTF called for the standardization of data collection, assessment, and treatment procedures, as well as the use of valid and reliable outcome measures, to aid the effective investigation of prognostic factors for the recovery of whiplash (1). Côté et al (6) commented that there is a lack of rigorous investigation of prognostic factors in the primary care settings (physician,

physiotherapist, chiropractor, dentist), and that a further understanding of the legal, compensation and cultural forces on recovery is a priority.

CBI Health (CBI), a national network of physiotherapy and rehabilitation service providers in Canada, offered the unique opportunity of access to their clinical database to the candidate for the study of delayed recovery and chronic disability among whiplash patients. The advantages of using this database were its large size, broad scope of personal, clinical and treatment-related variables, standardized data collection and treatment procedures, as well as, the diverse geographic distribution of the patients. CBI has an established position providing rehabilitation services for patients with WAD across Canada, as such both the acute and more controversial chronic patient populations seek treatment at their clinics, and are available for study.

1.1 Study Purpose

The overall purpose of this study was to investigate which prognostic factors are predictive of a poor response to treatment in the early stages of a whiplash-associated disorder (WAD), and from an extensive exploratory analysis to suggest important risk factors for confirmatory analysis.

1.2 Specific Objectives:

- To update previous systematic reviews of the literature on the prognosis of acute whiplash-associated disorders (WAD) and to synthesize the current literature and evaluate the consistency of reported prognostic factors.

- To investigate which personal, clinical, and treatment related factors are prognostic markers of delayed early recovery in a cohort of patients presenting for treatment at the secondary care physiotherapy setting.
- To investigate in an exploratory manner the effect of legal and compensation issues on the recovery from an acute whiplash injury.
- To develop and validate a prognostic model that identifies patients who are likely to demonstrate meaningful improvements early in the course of their recovery in the clinical setting.
- To describe extensively the differences between the acute and chronic whiplash populations.

1.3 Thesis Overview

Chapter 2 provides a review of the medical literature concerning the prognosis of acute whiplash. This chapter is an update to previous systematic reviews of the whiplash literature and a synthesis of both the recent and previous literature is provided.

Chapter 3 provides background information regarding the clinical database of CBI Health that was used in this study. The data collection procedures are reviewed. In addition, the referral process, assessment procedures, treatment and discharge procedures for patients attending CBI are described.

Chapter 4 describes the study design, materials and methods including: inclusion criteria, the working dataset, methods for handling missing data, the outcome and explanatory

variables and ethics. The primary study and a secondary analysis comparing acute and chronic WAD populations are described.

Chapter 5 describes the statistical analysis methods. A description of the logistic regression modeling strategy, model validation, and methods for choosing a final multivariate model are provided. Statistical methods for the secondary analysis comparing the acute and chronic WAD populations are also described.

Chapter 6 presents descriptive statistics for the study cohort of patients with acute whiplash injuries. Logistic regression modeling and validation results are presented. A secondary descriptive analysis of patients with chronic whiplash injuries is provided.

Chapter 7 contains a discussion of the significant prognostic variables, study strengths and limitations and conclusions.

Chapter 2 Literature Review

2.1 Introduction

There have been two previous systematic reviews of the whiplash literature. The Quebec Task Force (QTF) on Whiplash-Associated Disorders (WAD) provided a "best evidence synthesis" of the pre-1995 literature (1). The QTF commented that the overall quality of evidence available for evidence-based recommendations was poor; nevertheless, they concluded that the prognosis for whiplash-associated disorders was generally favourable (1). The QTF also developed a classification system of whiplash-associated disorders (Appendix A) that was designed to categorize patients according to the severity of their signs and symptoms post-injury. The system was developed to facilitate the evaluation of research and aid in clinical patient management (1). An update of the QTF review was published in 2001 by Côté et al (6). Côté and his colleagues observed that the prognosis for whiplash injuries varies considerably depending on the insurance compensation system and the source population considered (6). They further concluded that older age, female gender, baseline neck pain intensity, baseline headache intensity, and radicular signs and symptoms were associated with delayed recovery (6).

Côté et al additionally proposed a new conceptual framework for future reviews and for the classification of the whiplash prognosis literature. Using their framework, each study is categorized by the methodological quality (internal validity), the target population and generalizability (external validity), and the strength of the evidence (three mutually exclusive categories) (6). They identified four common source populations in the literature: population-based, insurance-based, hospital-based emergency department, and

primary care (physician, physiotherapist, chiropractor) cohorts (6), and suggested that each study be considered relative to the other studies with a common source population. Finally, studies are categorized based on the strength of evidence (exploratory or confirmatory). Three phases of study design (phase I-III) are considered. Phase I studies are exploratory or descriptive studies that generate hypotheses (using univariate analysis) regarding the association of a number of potential prognostic factors and a whiplash recovery outcome (6). Phase II studies are extensive exploratory research that focuses on sets of prognostic factors (using multivariate analysis, thereby controlling for a number of variables simultaneously) and/or attempts to determine which factors are of most prognostic importance (6). Phase III studies are large confirmatory models based on pre-stated hypotheses that investigate the prognostic importance of a particular exposure (6). Phase III studies provide detailed information regarding the independence, strength, and direction of a prognostic factor's association with a whiplash recovery related outcome.

For the present research project, an update of the more recent literature on the prognosis of acute whiplash injuries was conducted.

2.2 Literature Search and Selection of Articles.

Two electronic databases were searched: MEDLINE (1966 to March 2003), and CINAHL (1982 to March 2003). Articles published before January 1, 2000 were excluded because they had been previously reviewed (1, 6). The search was based on the keywords: (whiplash injuries, OR neck injuries, OR neck pain), and (predict, OR prognosis, OR prognostic, OR risk factor). A combination of these two searches using

the Boolean "AND" operator was applied to limit the search. All searches were limited to the English language. An initial screen of the titles and abstracts was conducted to ensure that all articles were studies of acute whiplash injuries, and not opinion letters or narrative reviews. If the primary subject matter was unclear from the abstract the full article was evaluated to ensure the content concerned acute whiplash injuries. After the initial screen, the remaining articles were further evaluated based on criteria established from previous systematic reviews of the whiplash literature (1, 6). Specifically studies were included for further review if the following criteria were met: 1) cohort or case-control studies on the prognosis of acute whiplash (duration less than 3 months), 2) systematic reviews on whiplash-associated disorders, and 4) publication after January 1, 2000. Studies that included injuries not associated with a motor vehicle collision, patients with severe injuries (such as fracture or dislocation), patients younger than 18 years of age, or less than 20 subjects, as well as opinion papers, were not included. An assessment of the methodological quality was completed for the included articles.

2.3 Assessment of Methodological Quality

The candidate reviewed the articles that met the inclusion criteria. A subset of the critical appraisal criteria presented in Appendix B was used to assess each article for scientific admissibility. These criteria have been used by other authors in the systematic review of the whiplash literature to determine "fatal flaws" in methodology and to identify information and selection biases (6). Specifically each article was evaluated in terms of the following: 1) source population identified in terms of time, place and sampling frame, 2) inclusion and exclusion criteria were adequately described and appropriate, 3) the zero time (or start of follow-up) was identified, 4) the prognostic factors were measured in an

appropriate manner, 5) the outcome was adequately defined and appropriately measured, and 6) the overall participation rate was reported to be at least 60% or an analysis of factors associated with participation was conducted. For each of these criteria the study was graded in a yes/no fashion. If any criteria were graded no for a particular study then it was excluded from further review.

The articles that met the evaluation criteria were classified according to a new conceptual framework (study population and phase of study) suggested by Côté et al (6) and were evaluated according to a list of criteria described in Appendix B. These criteria are similar to those used by others in the systematic review of observational studies (6, 9). The following characteristics of each study were further scrutinized: source population, sample size, prognostic factors, follow-up time, primary outcome measure, and risk estimates. The results were qualitatively synthesized and no attempts at statistical pooling were made. The results were judged consistent if at least two studies, or if 75% of the studies reported similar results. When making a judgment about a particular prognostic factor the two previous systematic reviews were also considered in conjunction with the more recent literature. For example, if a predictor from one of the previous reviews was considered inconsistent due to limited study, and this same prognostic factor was evaluated in the current literature the results from both the previous review and current literature will be considered to judge the importance of the prognostic factor.

2.4 Results of Literature Review

Table 2.1 displays the results of the text word search.

Table 2.1 – Number of articles retrieved based on whiplash and prognosis text word search and their combination from a MEDLINE and CINAHL January 2000-March 2003

Database	Whiplash papers	Prognosis papers	Combined (whiplash and prognosis papers)
MEDLINE	1287	65397	108
CINAHL	478	3955	21
Text words:	Whiplash injuries, neck injuries, neck pain	Predict, prognosis, prognostic, risk factor	The Boolean "AND" operator applied to the whiplash and prognosis searches

After excluding duplicate articles the combined search from MEDLINE and CINAHL produced a total of 115 articles. The review of the titles and abstracts of these articles resulted in the further exclusion of: 73 articles with subject matter other than whiplash, 16 opinion letters or narrative reviews, 9 articles other than prognostic studies of acute whiplash, and two articles in a previous review. The full text of the remaining 15 articles was retrieved. An additional 5 articles that initially had unclear subject matter (based on the abstract), were excluded after the full text review as articles with subject matter other than whiplash.

Ten articles were considered for evaluation. Four articles were further rejected because they did not meet one or more of the critical appraisal criteria (Table 2.2).

Table 2.2 - Studies excluded based on critical appraisal review criteria

	Review Criteria*					
First Author	1	2	3	4	5	6
Ovadia (10)	N	N	Y	Y	N	N
Khan (11)	Y	N	N	Y	Y	Y
Miettinen (12)	Y	N	N	N	Y	Y
Soderlund (13)	Y	Y	N	Y	Y	Y

*Evaluation criteria 1) source population identified, 2) inclusion and exclusion criteria described and appropriate, 3) the zero time was identified, 4) the prognostic factors were measured in an appropriate manner, 5) the outcome was adequately described and appropriately measured, and 6) the overall participation rate was reported to be at least 60% or analysis of participation was included.
N=No, Y=Yes.

Studies in table evaluated using criteria based on Côté et al (6).

2.4.1 Classification of Prognosis Studies

Of the 6 papers included in the review, four were cohort studies composed of patients from hospital emergency departments (3, 14-16); however, the study by Sterner et al also included patients from the primary care setting of general practitioners, and two of the studies reported on the same cohort of patients (Table 2.3). General population cohorts were used in two studies (17, 18) (Table 2.3).

Table 2.3 – Classification of the prognostic studies that met the critical appraisal criteria for inclusion in the literature review. Studies classified based on the target population and strength of the evidence (phase of investigation)

PHASES OF INVESTIGATION	TARGET POPULATION			
	Hospital Emergency Department	**Primary Care**	**Insurance**	**General Population**
Phase III – Explanatory study (hypothesis testing)				Côté et al (3)
Phase II – Exploratory study (multi-variable models)	Hartling et al (3, 13), Sterner et al (15), Kyhlback et al (14)			Suissa et al (17)
Phase I – Descriptive Study (univariable statistics)				

Five studies (3, 14-16, 18) used multivariate regression analysis to investigate a set of predictor variables and thus were phase II – exploratory studies. Only one study was a phase III confirmatory or explanatory study (17). In this study Côté et al tested the pre-stated hypothesis that investigated whether neck pain intensity, physical functioning and depressive symptomatology were associated with time-to-claim closure. A summary of the methodological quality and the design characteristics of each included study are presented in Table 2.4 and Table 2.5 respectively.

Table 2.4 – Methodological quality of cohort studies on the prognosis of acute whiplash

	Evaluation Criteria*																			
First Author	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Population-based																				
Côté (17)	Y	Y	Y	Y	Y	Y	n/a	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	n/a
Suissa (18)	Y	Y	Y	Y	Y	n/a	n/a	Y	Y	Y	n/a	Y	Y	S	Y	Y	Y	Y	S	n/a
Hospital-based emergency department																				
Hartling (14)	Y	Y	Y	Y	Y	n/a	N	S	S	Y	n/a	Y	S	S	Y	Y	Y	Y	S	N
Hartling (3)	Y	Y	Y	Y	S	n/a	N	Y	S	Y	n/a	Y	S	S	S	Y	S	Y	S	N
Kyhlback (15)	Y	S	Y	Y	Y	n/a	N	S	S	Y	n/a	Y	S	S	Y	Y	Y	Y	Y	N
Sterner (16)	Y	Y	Y	Y	Y	n/a	N	Y	S	Y	n/a	N	S	Y	N	Y	Y	Y	S	N

*Evaluation Criteria: 1) research question and objective are clearly defined, 2) source population is identified, 3) inclusion and exclusion criteria are described and appropriate 4) the overall participation rate was reported to be at least 60% or analysis of participation was included, 5) follow-up is reported, explained and reasonable, 6) loss to follow-up is equal in both groups, 7) sample size is pre-planned based on the objective of the study, 8) statistical analysis is appropriate for the objective of the study, 9) adjustment is made for important variables, 10) zero time is identified, 11) baseline comparability of various groups is reported, 12) same data collection procedures for all members of the cohort, 13) important baseline variables are measured, valid, and reliable, 14) all aspects of a prognostic factor are measured (dose, level, duration) and done so adequately (previous, baseline, follow-up), 15) Regular follow-up are accomplished, 16) other prognostic factors are measured, 17) duration of follow-up is adequate for the objective of the study , 18) outcome is defined and measurable, 19) outcome is valid, 20) outcome assessment was blind (Appendix B).
N = no, Y = yes, S = substandard, n/a = not applicable

Overall the methodological quality of the studies using population-based cohorts was good (Table 2.4). Both studies had large sample sizes and studied a wide variety of prognostic factors. In their study of Quebec residents, Suissa et al did not adjust adequately for the initial whiplash pain intensity, nor did these authors report on the validity of their outcome (18). All methodological criteria were achieved by Côté and his colleagues (17).

Overall, the methodological quality of the studies using population-based cohorts was better than studies using hospital cohorts. A number of methodological flaws were noted in the emergency department cohorts (Table 2.4). Only the study conducted by Kyhlback et al documented the validity of their outcome measure (15). One of the studies by Hartling and her colleagues (3) as well as the study by Sterner et al (16) failed to regularly follow-up on their subjects. In the study by Hartling et al, a single follow-up at 6 months provided some insight into the early recovery from a whiplash associated

disorder, however this was not the stated objective of this article and a longer follow-up is preferred such that overall long-term outcomes may be observed. Sterner et al, also had only a single follow-up, at 16 ± 2 months. Although the duration of follow-up time is adequate in this study, the lack of regular follow-ups could have resulted in the introduction of bias as subjects attributed unrelated or spontaneous spinal pain episodes to their previous motor vehicle collision. The sample sizes of all the hospital-based cohorts were relatively small and none calculated a priori sample size estimates. All of the studies used multivariate analysis and identified important prognostic factors; however, not all adjusted for previously identified factors (age, gender, baseline neck and headache intensity, radicular signs and symptoms) that are known to be associated with delayed recovery from acute whiplash (6).

Table 2.5 – Summary of design characteristic of prognostic studies of acute whiplash injuries

Study Author	Source Population	Case Definition	Sample Size	Follow-Up	Outcome Measure
Population-based					
Côté et al (17)	Province of Saskatchewan, Canada residents, July 1994-Dec. 1995	Whiplash, 18 yrs or older, report injury to insurance company	5398	670 - 1215 days	Time-to-claim closure
Suissa et al (18)	Province of Quebec, Canada 1997	Motor vehicle collision. ICD-9 code 847.0, report injury to insurance company	2843	12 months	Time on compensation
Hospital-based emergency department					
Hartling et al (3)	Kingston, Ontario, Canada residents, Oct. 1995-Mar. 1998	Whiplash, 18 yrs or older, first visit to emergency department	353	6 months	Presence of WAD*
Hartling et al (14)	Kingston, Ontario residents, Oct. 1995-Mar. 1998	Whiplash, 18 yrs or older, first visit to emergency department	353	6 months	Presence of WAD
Kyhlback et al (15)	Sweden residents, Jan. 1997- May 1998	Whiplash, 18 yrs or older, first visit to emergency department	83	12 months	Symptom intensity, pain disability index
Sterner et al (16)	Umea, Sweden residents, Jan.1997-Feb. 1998	Whiplash, 16-64 yrs, all persons seeking treatment at the hospital emergency department or general practitioner	356	16 months	Presence of disability

*Whiplash-associated disorder

2.4.2 Recovery From Acute Whiplash

There is little consistency in the outcomes used to evaluate recovery or the follow-up duration across studies (Table 2.5). This makes comparison in overall recovery between studies difficult. Two of the studies reviewed (17, 18) used an administrative proxy of the recovery time (time-to-claim closure (17), and time receiving compensation (18)). Although these outcomes are thought to closely parallel the actual recovery time (2, 17) the use of the outcome time-to-claim closure is often criticized for it's administrative nature (19). For example, it is possible that some individuals continue to have significant disability despite closure of their claim. In addition, it is difficult to determine how the time-to-claim closure correlates with a patient's perception of recovery. The remainder of the studies reviewed used self-report from the patient to determine if persistent symptoms or disability remained at follow-up. This outcome may also be difficult to interpret because individuals will have different interpretations and perceptions of recovery. Some patients may consider only the complete absence of pain to indicate improvement, while others may consider the return to their normal routines of daily living or successful readjustment to living with pain and disability to indicate meaningful improvement (20). The differences in primary outcome and the duration of follow up partly explain the considerable variation seen in the overall recovery from whiplash in different jurisdictions. However, differences in prognosis are also to be expected in different insurance jurisdictions. In general individuals from provinces (2) or countries (7) that operate in a no-fault jurisdiction have faster recovery time and suffer less chronic whiplash pain (6); however, considerable variation in recovery time also exists in areas

with similar insurance systems suggesting other factors are at play. For instance, both Saskatchewan and Quebec do not provide pain and suffering compensation payments; however, large differences in recovery time exist for these two jurisdictions (6). To date there is no universally accepted recovery outcome for the study of prognosis of whiplash-associated disorders. The perception of recovery will mean different things to different individuals. Similarly definitions of recovery will vary depending on the stakeholder. An insurer may consider the point at which an individual has reached a maximal medical improvement postcollision, whereas the patient or a clinician may seek the complete resolution of symptoms.

Table 2.6 – Summary of Prognosis of Acute Whiplash Injuries by Target population

Study Author	Primary Outcome
Population-based	
Côté et al (17)	Claim duration: median time to claim closure in tort 433 days (95% CI: 403-457), median time to claim closure in no-fault 198 days (95% CI: 190-206).
Suissa et al (18)	Compensation at 1 year (%). 1.4% WAD I, 1.8% WAD II, 4.8 % WAD III
Hospital-based	
Hartling et al (3)	Presence of WAD at 6 months: 35.3% have symptoms consistent with WAD
Hartling et al (14)	Presence and grade of WAD at 6 months: 10.2% WAD 0, 31.7% WAD I, 57.5 % WADII, 0.6% WAD III
Kyhlback et al (15)	Visual Analogue Scale (VAS) at baseline and 1 year - mean (SD): 47.2 (21.6), 41.9 (27.2) Pain Disability Index (PDI) at baseline and 1 year – mean (SD): 25.2 (16), 21.7 (18.8) Self-Efficacy Scale (SES) at baseline and 1 year – mean (SD): 140.3 (40.6), 146.2 (48.8)
Sterner et al (16)	Presence of Disability at 6 months: 32% (26% symptoms affect work and leisure, but not on sick leave, 4% on sick leave, 2% modified work duties)

2.4.3 Prognostic Factors for the Recovery of Acute Whiplash Injuries

Previous systematic reviews of the whiplash literature (1, 6) have considered all studies published prior to July 2000. The results of these reviews are summarized in Table 2.7. The prognostic factors for the six recent studies are summarized in Table 2.8 and considered below.

Table 2.7 – Summary of findings of the two previously published systematic reviews of the whiplash literature

Review Study Author	Prognostic Factors Consistently Associated with Delayed Recovery
Côté et al.	Sociodemographic: Older age (2, 5, 21) Female gender (2, 5, 21, 22)} Postcollision Symptoms: Baseline neck pain intensity(2, 23) Baseline headache intensity(2, 23) Radicular signs and symptoms (2, 24) **Consistent evidence was not found for:** Work status, work activities, marital status, education level, number of dependents previous neck pain, previous headache, crash-related factors **Prognostic factors from a single study associated with delayed recovery:** Anxiety before collision, reduced/painful jaw movement, percentage of body in pain, concentration problems, initial health care provider, lawyer involvement, compensation system, not at fault for collision (2), anxiety, fatigue, sleep disturbances, illness/disability worry, forgetfulness, stress, cervical spine osteoarthritis, cranial nerve/brainstem disturbance, visual disturbances (24)
Spitzer et al.	**Prognostic Factors Consistently Associated with Delayed Recovery** Postcollision Signs and Symptoms Severity of initial injury (25, 26) **Prognostic factor from a single study associated with delayed recovery:** Older age, radicular symptoms, self-reported cognitive impairment (25), previous headache (27), musculoskeletal or neurological sign within 3 days of collision (26)

2.4.3.1 Sociodemographic Factors

The two Canadian population-based studies (17, 18) controlled for the risk factors age and gender but did provide risk estimates for these variables (Table 2.8). Suissa et al.

(18) reported in the text that both female gender and older age were associated with delayed recovery. In addition, both of these cohorts have been evaluated previously (2, 5), and older age and female gender were found to be significantly associated with delayed recovery in the previous studies (2, 5).

The authors investigating patients from emergency departments (3, 14-16) reported risk estimates for the sociodemographic factors: age, gender, education, and work status (Table 2.7). Hartling et al. (3) and Kyhlback et al. (15) found that older age was associated with the presence of future symptoms; however, Sterner et al. (16) did not find such an association. Female gender was found to be associated with delayed recovery in two of the three cohorts (15, 16). Using a univariate analysis, Hartling et al. additionally reported that missed time from work and modified work and leisure activities were associated with delayed recovery (3). Only one study investigated the effect of education level. Sterner et al. (16) found that individuals with less than a university education were more likely to have persistent disability at follow-up.

There is consistent evidence in the recent literature and from previous studies that older age and female gender are associated with delayed recovery.

2.4.3.2 Postcollision Signs and Symptoms

In a population-based cohort from Saskatchewan, using an explanatory model to test the hypothesis that initial neck pain intensity, depressive symptomatology and physical functioning after a motor vehicle collision were associated with delayed recovery, Côté et al found that all three of these factors were significant (17) (Table 2.8). In the other population-based cohort from Quebec, Suissa et al (18) reported that neck pain on

Table 2.8 - Summary of prognostic factors for recovery from acute whiplash injuries

Study Author	Significant Prognostic Factors – Risk Estimate (95% CI)		Outcome Measure
Population-based Côté et al (17)	Initial neck pain intensity		Time-to-claim closure
	0-34 days	HRR=1.11 (0.97-1.27)	
	35-115 days	HRR=0.84 (0.77-0.91)	
	116-235 days	HRR=0.76 (0.69-0.84)	
	236-358 days	HRR=0.81 (0.74-0.90)	
	>358 days	HRR=0.87 (0.83-0.92)	
	Functional status	HRR=1.17 (1.12-1.23)	
	Depressive Symptomatology	HRR=0.63 (0.51-0.77)	
Suissa et al (18)	Neck pain on palpation	HRR=0.85 (0.76-0.96)	Time on compensation
	Muscle pain	HRR=0.85 (0.74-0.97)	
	Arm numbness or pain	HRR=0.64 (0.55-0.76)	
	Shoulder numbness or pain	HRR=0.83 (0.71-0.97)	
	Headache postcollision	HRR=0.82 (0.73-0.92)	
	QTF classification		
	WAD II	HRR=0.82 (0.75-0.89)	
	WAD III	HRR=0.61 (0.51-0.73)	
	Nonsignificant tenderness on palpation, decreased neck mobility, neck pain on mobilization, muscle spasm, muscle stiffness, radiation of pain or numbness to back or chest, dizziness, loss of consciousness, visual disturbances, anxiety or insomnia		
Hospital-based Hartling et al (3)	Age group*		Presence of WAD
	18-30	OR=1.00	
	31-50	OR=1.51 (0.86-2.65)	
	51-70	OR=3.78 (1.84-7.75)	
	Number of initial symptoms		
	0-2	OR=1.00	
	3	OR=2.05 (0.64-6.61)	
	4	OR=2.71 (0.91-8.07)	
	5	OR=6.71 (2.39-18.81)	
	6	OR=5.87 (2.01-17.16)	
	7	OR=9.87 (3.24-30.11)	
	8	OR=17.81 (5.80-54.64)	
	9	OR=22.67 (5.21-98.72)	
	Upper back pain	OR=2.91 (1.65-5.12)	
	Arm numbness or weakness	OR=2.18 (1.22-3.87)	
	Vision disturbances	OR=1.96 (1.00-3.86)	
	Nonsignificant: nausea and/or vomiting, neck stiffness, headaches, low back pain, shoulder pain, neck pain		
Hartling et al (14)	QTF classification of WAD		Presence of WAD
	WAD I	OR=0.78 (0.32-1.88)	
	WAD II	OR=1.87 (0.69-5.07)	
	Modified WAD II a	OR=1.17 (0.49-2.77)	
	Modified WAD II b	OR=3.10 (1.18-8.19)	
Kyhlback et al (15)	Self-efficacy scale, QTF classification, and female gender significantly associated with VAS.		Symptom intensity (VAS), Pain Disability Index (PDI)
	Self-efficacy scale, older age, and gender associated with PDI.		
Sterner et al (16)	Female Gender	OR=2.02 (1.13-3.63)	Presence of disability
	Previous neck pain	OR=3.17 (1.34-7.46)	
	QTF classification of WAD		
	WAD II & III	OR=2.03 (1.08-3.88)	
	Educational level (lower)	OR=2.08 (1.09-3.98)	
	Nonsignificant: age, accident type, previous headache, previous back complaints		

*Similar risk estimate for age in the study by Hartling et al (3) reported for two different models. The results from model 1 displayed in this table.

HRR=hazard rate ration, OR=odds ratio

palpation, muscle pain, headache, and radicular signs and symptoms were associated with delayed recovery. In addition this study found that the Quebec Task Force (QTF) classification of whiplash-associated disorders (WAD) was an important prognostic factor. Specifically, that the more severe grades of WAD took longer to recover (18).

In a hospital based cohort from Kingston, Ontario, Hartling et al. (3, 14) found that the number of initial symptoms, as well as the specific symptoms: upper back pain, radicular signs and symptoms, and visual disturbances were associate with the presence of WAD at 6 months. They also reported that a modified version of the QTF classification of WAD (WAD II was subdivided into two categories based on the presence abnormal cervical range of motion) was predictive of delayed recovery (14) (Table 2.8). In addition, using univariate analysis these authors reported that: initial pain intensity, depression, anxiety, concentration difficulty, fatigue, and sleep disturbances were associated with delayed recovery (3). They did not report findings for these variables using multivariate analysis. The other two hospital-based cohorts (15, 16) both found the QTF classification of WAD to be an important prognostic factor. Kyhlback et al. also reported that an individual's self-efficacy (defined as a measure of a patient's confidence in performing daily activities despite pain) was associated with pain and disability at 1-year postcollision (15).

On the basis of four studies, there is consistent evidence that the QTF classification of WAD is associated with delayed recovery (14-16, 18). Two recent studies and the previous whiplash literature provide consistent evidence that initial neck pain intensity (1, 3, 6, 17), and radicular signs and symptoms (3, 6, 18) are associated with delayed

recovery. There is also consistent evidence that depressive symptomatology is associated with delayed recovery (3, 17), but this prognostic factor was not adequately described or analyzed in one of the studies (3), and therefore it is not possible to comment on the consistency of this variable. Similarly, only one study (17) investigated an instrument to measure physical functioning (physical functioning scale of the SF-36), number of initial symptoms (3), and self-efficacy (15); therefore, it is not possible to comment on the consistency of these factors.

2.4.3.3 General Health Before Injury

Two of the hospital-based cohorts examined the importance of general health prior to the collision (Table 2.8). In univariate analysis, Hartling et al reported that previous neck pain was associated with delayed recovery (3). This group did not report the results of a multivariate analysis for this covariate. Similarly, Sterner et al found that previous neck pain was associated with prolonged disability; however, previous back complaints and headaches were not. Two additional studies that investigated the association of previous self-reported neck pain with delayed recovery reported conflicting results (6). Based on the findings of three studies (3, 8, 16) previous neck pain appears to be an important prognostic factor in the recovery of acute whiplash; however, it should be noted that in two of these studies (3, 8) statistical adjustment for other factors was not performed.

2.4.3.4 Legal and Compensation Factors

The Saskatchewan insurance system changed from a tort-compensation system (where claimants received payments for pain and suffering) to a no-fault system (which included no such pain and suffering payments) during the study period of the Côté et al study.

Although it was not the primary objective of this group to investigate the influence of the insurance system, they did find that the median time to claims closure was reduced by 235 days in the no-fault insurance system (17). The effect of the insurance system on recovery for this cohort of patients has been previously reported (2). No other studies investigated the association of insurance system or other legal or compensation issues with a delay in recovery; therefore, it is not possible to comment on the consistency of the evidence for these factors.

2.4.3.5 Crash-Related Factors

Only one study investigated crash-related factors. Hartling et al did not find a significant association for any of the following factors: position in vehicle, road conditions, type of road (location), preparation for crash, head position, direction of collision, seatbelt use, head movements after collision, type of transmission, size of vehicle involved, posted speed limit, or brake light in rear window (3). Similarly, previous reviews of the literature (6) have not found consistent results for the association of crash-related factors with delayed recovery.

2.5 Summary

The quality of evidence to date remains mainly exploratory, and there is still considerable inconsistency in the reported association of various prognostic factors and recovery from WAD (Table 2.9).

Table 2.9 – Established and potential prognostic factors in the recovery from an acute whiplash-associated disorder reported in recent and previous literature and systematic reviews

Prognostic factor	Consistent evidence*	Limited evidence**	Inconsistent evidence
Sociodemographic			
Older age (2, 5, 15, 16, 18, 21)	X		
Female gender (2, 3, 5, 15, 18, 21)	X		
Work status (2, 3, 5, 21)			X
Work activities (2, 3, 24)			X
Education level (2, 16)			X
Marital status (3, 5)			X
Number of dependants (2, 5)			X
Postcollision signs and symptoms / clinical			
Initial pain intensity (1, 2, 14, 17, 23)	X		
Increasing grade of injury (QTF classification) (14-16, 18)	X		
Radicular signs and symptoms (3, 17, 18, 24)	X		
Depressive symtomatology (3, 17)		X	
Physical functioning (17)		X	
Anxiety / stress / worry (3, 24)		X	
Self-efficacy (15)		X	
Fatigue / sleep disturbance (3, 24)		X	
Forgetfulness / concentration difficulties (2, 3)		X	
Cranial nerve/brainstem disturbance (24)		X	
Cervical spine osteroarthritis (24)		X	
Reduced/painful jaw movements (2)		X	
Number of symptoms / percentage of body in pain (2, 3)		X	
Visual disturbances (3, 18, 24)			X
Medical history before injury			
Previous neck pain (3, 8, 16)	X		
Previous back pain (16)		X	
Previous headache (2, 16, 24)			X
Anxiety before collision (2)		X	
Crash-related			
Seat belt use (2, 3, 5, 21, 23)			X
Head position (2, 3, 23, 24)			X
In stationary car during collision (23, 24)			X
Position in vehicle (2, 5)			X
Size of vehicle collided with (3, 5)			X
Initial health care / treatment-related			
Initial health care provider (2)		X	
Legal / Compensation			
Insurance jurisdiction (2)		X	
Lawyer involvement (2)		X	
Not at fault for collision (2)		X	

* Evidence was considered consistent if at least two studies or 75% of all studies reported consistent results on the importance of a specific risk factor.

** Evidence was considered limited if only a single study has investigated a particular risk factor or limited statistical analysis (univariate statistics) prevented comment on the consistency of the evidence.

Some potentially important prognostic factors have been investigated by only a single study (for example, lawyer involvement, insurance jurisdiction, initial health care provider, and physical functioning). In other circumstances confirmation of the potential importance of a particular factor was limited by a univariate statistical analysis. For example, both Côté et al and Hartling et al reported that postcollision depression resulted in delayed recovery; however, the study by Hartling and her colleagues lacked statistical adjustment for other factors when investigating the effect of depression (although this was not the primary objective of this study). Evidence was considered limited when only a single study was available or the statistical analysis was descriptive in nature, the evidence was considered limited. Furthermore, differences in the definition of other prognostic factors across studies, such as psychological variables related to anxiety, stress, and worry, limited the qualitative synthesis of these particular factors. Thus, further exploratory and explanatory work is necessary for confirmation of these (often controversial) findings. In future research particular attention should be made to the clear definition of prognostic factors and the use of multivariate statistical analysis.

Based on the most recent literature and previous studies, there is consistent evidence that female gender (6, 15, 16, 18), older age (3, 6, 15, 18), increasing grade of injury by the Quebec Task Force classification (14-16, 18), initial intensity of neck pain and headache (3, 6, 17), radicular signs and symptoms, and previous neck pain(3, 6, 16)are associated with delayed recovery (Table 2.9). The lack of consistency and limited available information for many potentially important prognostic variables has generated considerable controversy. In particular, further consideration of legal and compensation

factors, the choice of health care provider and other treatment related factors, and psychological variables are necessary.

In contrast to the results reported from previous reviews, the recent literature usually considered the simultaneous effect of many variables (phase II studies) in favour of less sophisticated univariate analysis methods (phase I studies). However, since 2000 there has been only one study considered a phase III explanatory study. Several recent articles studied patients presenting to a hospital emergency department, yet there continues to be limited information from other primary or secondary care clinical settings (physician, physiotherapist, or chiropractor). In addition, although there were two recent population-based studies, both of these cohorts have been previously considered in the literature. The assembly of new large cohorts of whiplash subjects is necessary, particularly in primary care settings other that hospital emergency departments.

Chapter 3 Background of CBI Materials and Methods

3.1 Introduction

This study used the clinical database from the Canadian Back Institute (CBI) Corporate Office. This database contains data from a national network of 48 Canadian physiotherapy and rehabilitation clinics. An understanding of the type of patients CBI typically provides service for, the referral process for these patients, the standard treatments they receive, the clinical course of their condition, and the data collection procedures is necessary and provides the context for the current study.

Prior to a description of the clinical database an overview of how an individual injured in a motor vehicle collision would potentially become a patient at CBI is provided. That is, a description of the how an individual progresses form injury to treatment to recovery.

3.2 Patient Referral Process

Typically, when a patient is injured in a motor vehicle collision in Canada the initial provider of care is a physician (2). The patient may attend an emergency department or a private office. The majority of individuals will present with soft-tissue injuries to the neck (1) or low back (2, 3). The physician will generally decide on one of three possible methods of management: 1) CBI treatment, 2) other non-physician health care professional treatment, or 3) continued management with the family physician. Of those patients referred to CBI, greater than 90% have complaints of neck or low back pain (28). Figure 3.1 shows the flow of patients from initial injury to recovery. A patient may also

directly seek care at CBI or with another health care professional without a previous physician visit. This occurs in a minority of the cases.

Patients that attend CBI become part of the clinical database on the day of their initial assessment day. Each patient typically receives a course of therapy until the point at which either the doctor, therapist, or patient deem themselves sufficiently recovered. If recovery is delayed a further referral or discharge from CBI may follow. A cycle of specialist, physician and other health care worker visits may occur until that point where a patient feels that a maximal recovery has occurred or the patient accepts a settlement from their auto insurance provider. In all provinces, the patient's auto insurance company makes payment for CBI treatment. Claim closure for injuries sustained in motor vehicle accidents varies depending on the insurance jurisdiction, however the majority of claims are closed within 1 to 2 years (6, 29).

3.3 Canadian Back Institute Methods

Figure 3.1 depicts the rehabilitative process for whiplash-associated disorders (WAD) referred to CBI. Upon referral to a CBI clinic, an appointment is made for an initial assessment. During this appointment the patient provides demographic information and completes a patient questionnaire regarding their injuries. A registered physiotherapist with specific training in spinal pain rehabilitation performs a standardized interview and physical examination. After considering historical and examination findings, a diagnosis is rendered and a treatment program designed. Data entry personnel enter the

demographic, initial patient questionnaire and spinal assessment form findings into the computerized clinical database. After a treatment program is complete the patient is discharged or referred elsewhere. Clinical data from all clinics within CBI's national network are downloaded to a central location, the CBI Corporate Office.

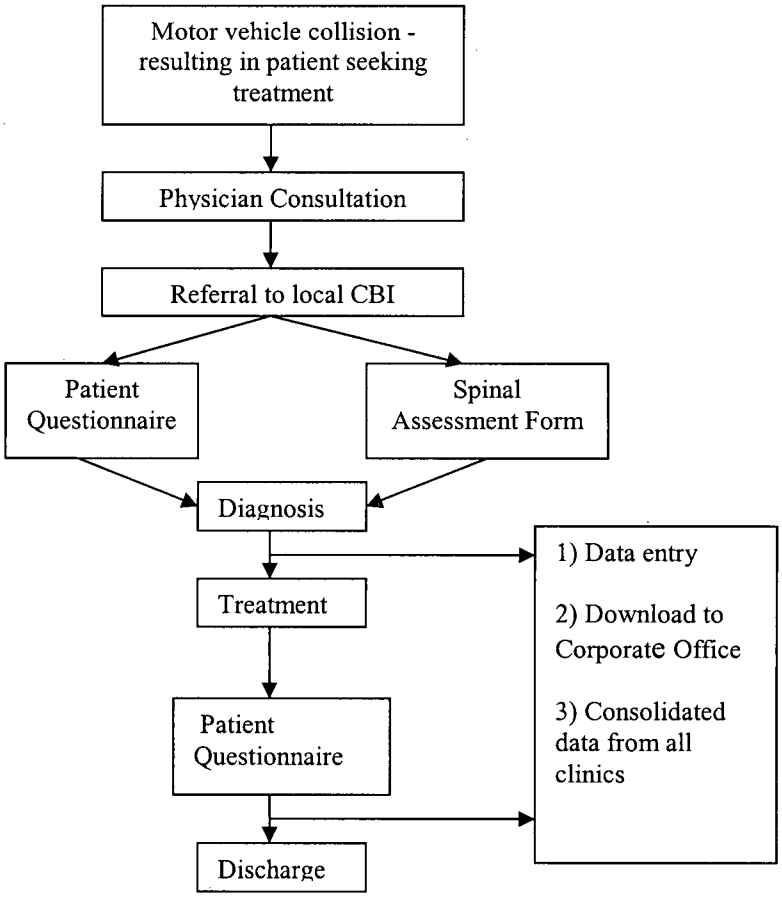


Figure 3.2- Flow chart of patients and data collection procedures through the Canadian Back Institute (CBI) system

3.3.1 Clinical Database

The forms for data entry into the clinical database are the Spinal Assessment Form, Spinal Discharge Form and patient questionnaire (completed twice, once on presentation to the clinic, and once at discharge).

3.3.1.1 Spinal Assessment Form

Prior to the development of the Spinal Assessment Form, the history taking and physical examination process consisted entirely of open-ended questions and free hand writing. In an effort to standardize assessment procedures a step-by-step structured approach consisting of a series of close-ended questions was developed. This new approach captures the essential aspects of the history and physical examination findings and results in an efficient mode for data entry and potential analysis. The Spinal Assessment Form was developed by CBI's Medical Director (an orthopaedic surgeon), the senior physiotherapist, the Teaching and Development staff, and other clinicians of CBI. The Spinal Assessment Form was implemented across the network of clinics in 1992 (Appendix C).

3.3.1.2 Patient Questionnaire

The questionnaire used for this study is based on a previously published instrument, the Low Back Outcome Score (LBOS) (30). This questionnaire has been modified and renamed the Canadian Back Institute Questionnaire (CBIQ) (Appendix D). The CBIQ was designed with consideration of the various potential causes of injury as well as locations of spinal pain. The questionnaire is used for patients with both neck and back pain. With the exception of the first question, the CBIQ does not ask questions regarding the specific anatomical site of the patient's pain; rather the effect of pain (in general terms) on function is the primary focus. The CBIQ includes questions regarding: 1) area

affected 2) cause of injury, 3) onset of pain, 4) length of time in pain, 5) household chores, 6) sport and leisure activities, 7) lawyer involvement, 8) smoking, 9) rest required, 10) doctor visits, 11) pain medication, 12) walking, 13) sitting, 14) standing, 15) lifting, 16) dressing, 17) sleeping, 18) traveling, and 19) working. The CBIQ includes differentially weighted questions to determine an overall score. In a similar scoring system to the LBOS, each response on the CBIQ is scored on a four-point scale. Pain and active daily activities (such as household chores or leisure activities) are weighted more that treatment and rest required, which in turn is weighted more than passive activities (such as sitting or standing). The CBIQ produces two outcome scores. The full questionnaire is scored out of 100, and includes all of the modifications that were made to the LBOS. The second outcome (the function score) is generated from a subset of the full questionnaire. The function score is produced by removing the questions: cause of injury, onset of pain, length of time in pain, and smoking status, thereby more closely resembling the LBOS.

Assessment of validity of self-report scales is made difficult by the lack of a gold standard for which to compare results. However, in a correlation study the CBIQ was compared to the Oswestry Disability Index (ODI)(31). The Pearson correlation coefficient (r) was –0.72 ($p<0.01$), indicating adequate validity to measure function (based on the ODI as an external criterion)(31). In addition the CBIQ demonstrated the ability to predict prognosis and discriminate between low- and high-risk individuals for time on compensation benefits after occupational back injury (32).

3.3.1.3 Spinal Discharge Form

The Spinal Discharge Form includes a second application of the patient questionnaire, four questions regarding patient satisfaction with treatment, and if applicable, therapist recommendations for return to work.

3.3.2 Data Entry and Collection

A data field has been created for each form response in a format that mimicked the actual paper version. Upon completion of the initial assessment and data collection forms, receptionists enter the data verbatim directly into the clinical database at each individual clinic. Upon data entry the questionnaire outcome scores are generated automatically. No coding or interpretation is required. The data is downloaded monthly to a central collection site, the CBI corporate office in Toronto. Here the data is consolidated to one database. The CBI Training and Development team train all staff on the standardization of data collection and data form completion.

Registered physiotherapists at CBI complete two training courses. These courses cover the standardized approach to clinical data collection, assessment form completion, patient interview, treatment strategies, and discharge planning. The curriculum regarding data collection and form completion includes: 1) review of questions and responses, 2) overview of the salient information from the Clinical Forms User's Guide, 3) diagnosis using the CBI classification system, 4) role playing interviews by course participants, and 5) assessing real patients and completing the assessment form as a group. The goal of

these efforts is to standardize data collection, and assessment across therapists within the company. CBI regards 1994 as the operational inception year of the clinical database.

3.3.3 Treatment

The Canadian Back Institute clinics provide active physiotherapy primarily for mechanical spinal pain of musculoskeletal origin. They are secondary care rehabilitation facilities that focus on pain control in acute, sub-acute and chronic ambulatory populations. Rare patients with suspected systemic disease and cases sustaining trauma sufficient to produce severe bony injury or major neurological sequelae are referred elsewhere.

All patients follow a structured CBI protocol of active exercise. The duration of each treatment session and adjunctive physiotherapeutic techniques applied vary by the patient and are left to the discretion of the therapist. Treatment is progressed through three stages of recovery: 1) pain control – approximately ten days of treatment stressing back and neck education and exercises that produce pain reduction, 2) recovery of movement – approximately ten days of treatment emphasizing active exercises through the complete range of motion of the injured area, 3) physical conditioning- approximately four weeks of cardiovascular training via a stationary bike, stair climber or walking program, progressive strengthening of the trunk and extremity musculature using a combination of free weights and machine training, and potentially work conditioning. The number of treatment hours per day in each stage, and the total treatment time are adapted to the individual needs of the patient. Home exercises are additionally given to most patients

early in the treatment regime. The conclusion of the treatment program can occur at any time during its course when normal activities or return to work become possible.

3.4 Database Limitations

Using a clinical database for epidemiological research eliminates many of the potential difficulties associated with administrative data. In addition procedures, such as standardized assessment forms, and training courses in data collection and input, have been implemented at CBI to attempt to improve the completeness of the clinical database and reduce examiner bias. However, an awareness of some possible limitations of the clinical database is necessary. The CBI database included only the sample of patients who perceived that their injuries required treatment. Some individuals with minor injuries and disability will not seek therapy. Others may not have received a referral for physiotherapy services, and may receive treatment with another health care professional. There may be systematic differences between the various groups of patients who seek therapy elsewhere (for example with a massage therapist or chiropractor). In addition, the majority of patients in the CBI clinical database have their treatment costs paid by their auto insurance company. Some individuals whose collision resulted in minor damage to their vehicle or who have had their claims denied for other reasons may not be captured by the database; however, those who opt to pay for their treatment by themselves will be included. Nevertheless some individuals with minor injuries will be excluded.

As with any database there are limits to the quantity, primary focus, and quality of information provided. The CBI database included sociodemographic and clinical information. Limited data on psychological and workplace factors were available. Missing data resulted when certain questions on the Spinal Assessment Form were not completed. The overall response rate for the survey was good; however, due to low response rate for individual survey items, two variables of interest were not included in this study (previous spinal pain and an indicator of constant pain).

3.5 Summary

The clinical database represents the reality of the management of whiplash-associated disorders in Canada. Not all patients injured in motor vehicle collisions will seek professional treatment. Those that perceive that their injuries require some sort of treatment usually initiate therapy with their physician but may additionally see multiple other health care professionals. The database includes individuals either in their first or recurrent motor vehicle collision, who have either immediate or delayed onset of symptoms, and who seek care. The patients presenting to CBI are referred by their physician, other health care professional, other individual involved with their case (for example a claims adjustor, lawyer), or by self-referral. The database consists of many variables of interest (focusing primarily on sociodemographic variables, personal characteristics and clinical information) and is collected in six provinces (British Columbia, Alberta, Saskatchewan, Ontario, Quebec and Nova Scotia) across Canada. The next chapter will focus on additional methodological issues, and a description of the study design.

Chapter 4 Study Design, Materials and Methods

4.1 Overall Study Design

This was a retrospective inception cohort of individuals injured in a motor vehicle collision (MVC) enrolled in rehabilitation programs in 6 provinces in Canada. Data were originally collected by self-report survey and questionnaire, and physiotherapist assessment. All data from patients who presented to one of the Canadian Back Institute Health's (CBI) 48 network clinics, between January 1, 1998 and December 31, 2001 after a MVC were extracted for analysis. The years of the study were selected based on the availability of national, electronic data from CBI. A secondary analysis of all patients presenting after MVC regardless of inception time will be conducted to compare acute and chronic WAD.

4.2 Inclusion Criteria

Table 4.1 lists the subject inclusion criteria.

Table 4.1 – Subject inclusion criteria

1) Injured in a motor vehicle collision. 2) Assessed for primary complaints of neck or low back pain at any one of the 48 CBI locations across Canada. 3) Less than 91 days between reported injury date and first day of treatment at CBI 4) Completion of both the entry and exit patient questionnaires / complete follow-up information. 5) Adults aged 18 to 65 years 6) Less than 91 days between reported injury date and first day of treatment at CBI 7) No previous history of spinal surgery 8) Completed a Visual Analogue Scale (VAS) on the intensity of their current pain.

Inclusion criteria were based on the following rationale. Patients injured in motor vehicle collisions were targeted because treatment of these injuries is a primary focus of CBI. Those individuals who were injured in a motor vehicle collision at work were excluded from the present study because the compensation structure for the injured worker is

different. It was thought that these differences would produce systematic differences in the distribution of the descriptive variables.

Individuals injured in motor vehicle collisions commonly report neck, and/or low-back pain, yet whiplash injuries are typically associated with only neck pain. Therefore, the decision was made to target both locations thereby providing a more comprehensive description of whiplash-associated disorders.

A study investigating the prognosis of any condition requires the construction of an inception cohort (33, 34). This ensures that each individual within the cohort are at a similar stage in the course of recovery. Only individuals with acute and sub-acute neck and back pain (defined as less than 91 days) were included (35, 36). The chronic cases were excluded, as the purpose of the model building exercise was to find predictors of delayed recovery in those individuals prior to chronicity. The inception point for this study was the start date of treatment (which had to occur within 91 days of the motor vehicle collision).

Completion of the patient questionnaire on the first visit at CBI, as well as upon discharge was required to ensure that complete follow-up information was available for all subjects, and thus the primary outcome could be generated.

Patients with prior spine surgery were also excluded from the study population. These patients are rare and not typical of most individuals with soft tissue injuries sustained in a motor vehicle collision.

The intensity of pain on presentation to CBI (as measured by a visual analogue scale) was considered to be an essential variable; therefore, this was included as one of the inclusion criteria.

4.3 Final Data Set

The extraction of data from the clinical database of the 48 Canadian CBI clinic locations produced an initial list of 16,404 records. This represented all patients treated at CBI who were injured in a motor vehicle collision. Of these patients 8,945 (54.5%) presented with acute injuries as defined by less than or equal to 91 days since their injury date. Complete follow-up information was available for 3,472 (38.8%) records. This indicated that both entry and exit questionnaires had been completed. From this population a further 245 (7.1%) records were excluded because of age restrictions, and 15 records (0.5%) due to previous spinal surgery. A further 875 records (28.6%) were excluded with missing intensity of pain data as scored by the VAS, and 123 records (3.8%) with missing or inconsistent age data. A minimal number of other subjects had missing or inconsistent work status or injury dates (see Figure 4.1). In total, of the 8,945 original acute patient records, 5,473 records (61.2%) did not have complete follow-up information, while an additional 1,027 (11.5%) were excluded due to missing or inconsistent data.

4.4 Data Source

This source of data for this study was the clinical database from the Canadian Back Institute (CBI) Corporate Office. A detailed description of the data collecting procedures was provided in Chapter 3. Briefly, upon presentation to one of CBI's rehabilitation clinics each patient completed a questionnaire regarding their current condition and

provided sociodemographic information. A standardized assessment by registered physiotherapist was performed. This examination provided a number of clinical variables of interest. After the treatment period the patient once again completed a questionnaire regarding any changes in their condition. The information from the two patient questionnaires and the spinal assessment form are downloaded to CBI's Corporate Office where the database is analyzed and maintained.

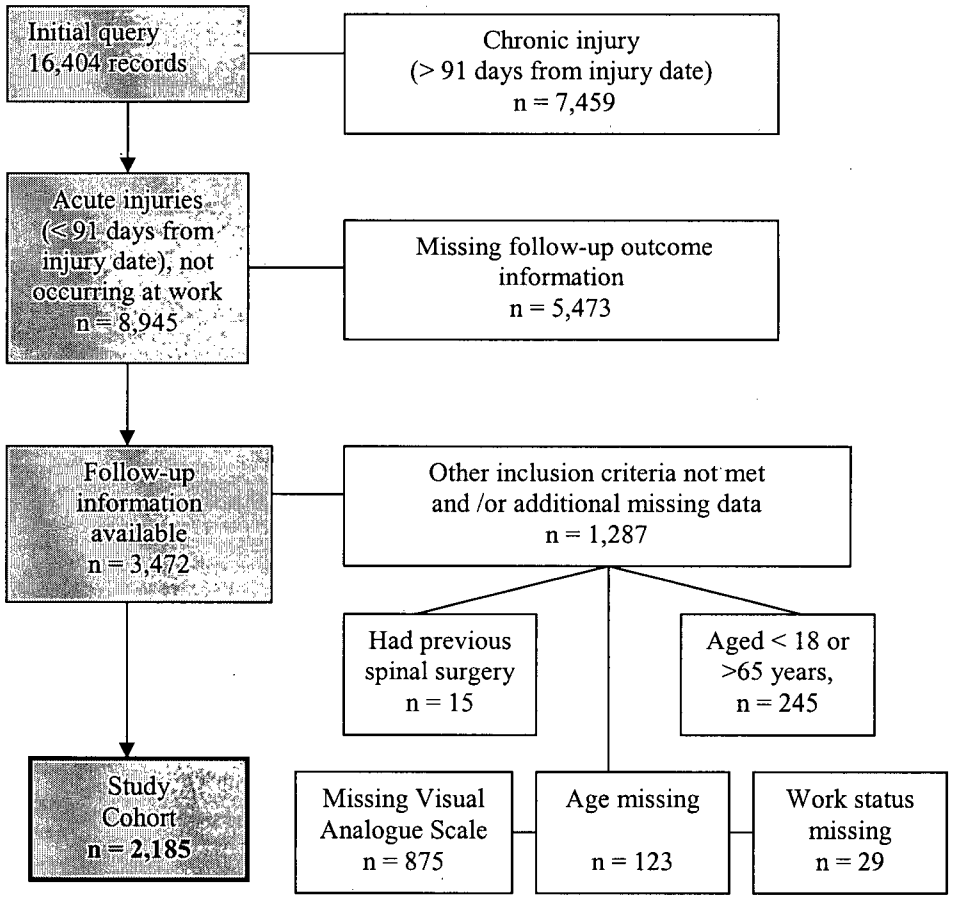


Figure 4.3 - Final working dataset of individuals injured in a motor vehicle collision attending a Canadian Back Institute (CBI) clinic in Canada between 1998-2001

4.4.1 Missing Data

Upon assembly of the dataset (n = 2,185), the data were examined for blank fields, and inconsistent formats (37). The frequency distribution of essential variables was examined. The inclusion criteria for the inception cohort resulted in the removal of a

significant number of records (see Figure 4.1). A total of 5,473 records (61.2%) were excluded because either the entry or exit questionnaire was not completed. This variable was essential for generating the primary outcome variable. A further 878 records (28.7%) with missing data on the visual analogue scale measuring intensity of spinal pain (VAS). This variable was considered an essential variable to control for in the analysis of prognostic factors. Because both the outcome and pain intensity variables were considered essential, imputation techniques were not considered and records missing these data were excluded from the analyses. To examine potential systematic differences between the respondents and non-respondents a comparative analysis was conducted for a number of these key variables.

Alternate methods of analysis were conducted for additional variables of interest (based on previous findings in the literature or clinical suspicion), but with a significant number of missing values. This occurred for three variables of interest (previous episodes of spinal pain, constant versus intermittent pain, and physical demands at work). A total of 1,273 (58.3%) and 1,264 (57.8%) of the records were missing values regarding previous episodes of spinal pain, and constant versus intermittent pain respectively. The proportion of records missing data were considered to large for imputation procedures. To examine the potential association of these two excluded variables with the outcome of interest, a separate analysis using those records with completed information on these variables was conducted. A third variable (physical demands at work) had missing values for 270 records (12.4%). A method of imputation was utilized for adjusting for the smaller proportion of missing values for this variable.

4.4.2 Imputation

There is no ideal method for dealing with missing values in a dataset. For this reason every attempt should be made during the collection of the data to ensure completeness. Nevertheless missing values for some covariates or outcomes are a reality in most epidemiological studies.

A number of methods have been suggested for dealing with these missing values. Perhaps the most common approach is complete subject analysis (38). In this approach only those records with complete information on all variables are included in the analysis (38). Miettinen (39) has stated that this is the only approach that will assure that no bias has been introduced into the data. This declaration, however, assumes that the data that are missing at random. In this scenario the subset of records with complete information are equivalent to a random sample of the entire study population (38). Complete subject analysis is not without difficulty. The precision of the model will be reduced by the reduction in sample size. In addition should a number of different variables have missing values (while at the same time the rest of the record is complete) then this method can be wasteful. Alternative approaches of dealing with missing values include using an imputed variable based on: central tendency, regression estimates, indicator variable or multiple imputation estimates. These approaches are explained further in Appendix E. In simulation models there is not one particular method for handling missing data that produces vastly superior results (38). Methods based on regression estimates, the indicator method or multiple imputation, along with complete subject analysis have

produced similar results (38, 40). As stated previously, in datasets with a small sample size one must consider the loss of precision that results with complete subject analysis.

All of the above methods are common in epidemiological study. Some authors have suggested that the regression and indicator methods have limitations due to the introduction of bias (40). This occurs if the variable with the missing values is a confounder (41). If C% of the confounder is missing then C% of the confounding is potentially uncontrolled (39). The indicator method and the complete subject analysis method have the additional benefit of convenience of application.

For this study the physical demands of work variable was analyzed using two separate methods. The variable was evaluated with both the complete subject analysis and indicator methods. The variable was dropped from later analyses due to lack of significant association with outcome; therefore, the completed information in the records with the missing physical demands variable was available for study without the loss of precision that would have been expected had these records been excluded.

4.5 Research Variables

4.5.1 Outcome Variable

The outcome measure for this study was change in the Canadian Back Institute Questionnaire (CBIQ) score between the initial and discharge visits. The CBIQ is a 19-item survey based on the Low Back Outcome Score (LBOS) (30). Greenough and Fraser (30) concluded that their instrument (LBOS) was more comprehensive and more

discriminating that the Oswestry Disability Score, the Waddell Disability Rating, and the Waddell Physical Impairment Rating. The LBOS had a correlation coefficient of -0.87 ($p<0.001$) with the Oswestry Disability Scale (30). In multivariate regression: age, sex, compensation status, psychiatric disturbance and employment status were all significantly related to questionnaire score (30). Holt et al. (42) further examined the reliability of the LBOS and concluded that this instrument has good internal consistency (cronbach alpha coefficient=0.85), and test-retest reliability (84% agreement at 1 week). Khatri et al. recently reported the minimally clinically important difference in LBOS in a population of low back pain patients (43). Based on an external criterion of the patient's global perception or recovery (no change, a minimal improvement, good-but incomplete recovery, or complete recovery) they found that a 10% change or 7.5 points was the minimal clinically important change.

As noted earlier the questionnaire in this study in a modified version of the LBOS (now called the CBIQ). Additional questions regarding how pain is affecting the ability to sit, stand and lift have been added. In addition, a question regarding contacting a lawyer has been added. This CBIQ correlates well with the Oswestry Disability Index (Pearson correlation coefficient (r) = -0.72), and has demonstrated the ability to predict prognosis (31).

For this study the change in CBIQ was the outcome of interest. The CBIQ was first rescaled to remove the lawyer question from the total score. This was done because this explanatory variable was of interest for analysis. Therefore, it was not appropriate to

investigate this variable while it still contributed to the scoring of the outcome. The CBIQ (function outcome) is scored out of a maximum 70 points. The lawyer question is scored out of a possible 9 points. With this question removed from the rescaled CBIQ has a total possible score of 61 points. For this study the minimally clinically important change in CBIQ score was deemed to be a 10% change or 6.1 points.

Minimum clinically important change in questionnaire score is a common outcome in patients with low back and neck pain (44), however it is important to consider the clinical relevance of the demonstrated change. Statistically significant changes in score may be observed (particularly when a large sample size is used) that have little clinical significance. For this reason, this study used an outcome that considered the clinical significance of the change in CBIQ. Another issue regards the meaning of the change that occurred. Each individual will have different starting scores on the CBIQ, and a change of 6.1 points will have different meaning depending on the individual (20, 45). For example, an individual with significant disability and pain on their initial presentation who achieved the minimally clinical improvement (yet is still significantly disabled), and an individual who presented with relatively minor disability and pain who fully recovered, will both be included in the positive outcome category. The nature of the outcome did not discriminate between two such individuals. However, both individuals described above are demonstrating important improvements in their condition, regardless of their initial state, and the outcome will reflect this change.

4.5.2 Explanatory Variables

A total of 25 explanatory variables were analyzed in the inception cohort. Some of the variables had not been previously demonstrated as prognostic factors in the recovery from whiplash-associated disorders (WAD), however clinical intuition suggested they might be worthy of exploration. The variables were grouped into three clusters: personal characteristics (8 variables), clinical (9 variables) and treatment related (8 variables).

4.5.2.1 Personal Characteristics

The personal characteristics that were examined consisted of: 1) age, 2) gender, 3) lagtime from injury data to treatment date, 4) lawyer involvement with case, 5) physical demands of job, 6) province where injury and treatment occurred, 7) smoking status, and 8) work status.

Age. Patients provided their birth date upon presentation to the clinic.

Gender. This was a categorical variable (0=male, 1=female).

Physical Demands. The physical demand categories were modeled after the taxonomy developed by the U.S. Department of Labour (46). Responses were coded: 1=sedentary, 2=light, 3=medium, 4=heavy. Patients were asked to rate their overall job tasks.

Lagtime. The lagtime between injury and treatment (duration of the current episode) in days was generated by subtracting the injury date from the date of presentation to the clinic.

Lawyer. Each patient in this study was asked on two occasions whether or not they have contacted a lawyer about their injury, once at the initial presentation and once at discharge. The combination of these two variables was use to determine whether a patient had legal representation at or prior to assessment at CBI, or if they retained legal representation at some point after initial presentation by prior to discharge. The two variables were coded 0=no lawyer involvement, and 1=lawyer retained.

Province. Subjects presented to one of a 48 CBI Physiotherapy and Rehabilitation clinics across Canada. Based on the clinic location a province variable was created for analysis. The included provinces were coded as: 1=British Columbia, 2=Alberta, 3=Saskatchewan, 4=Ontario, 5=Quebec, and 6=Nova Scotia. For analysis, British Columbia was chosen as the reference category due to the high incidence of whiplash claims in this province. The incidence of whiplash claims in British Columbia is reported to be higher than all other Western countries (4).

Smoking Status. For analysis this variable was coded 0=non-smoker, 1=current or former smoker

Work Status. On their initial visit to the clinic, patients were asked if they were currently working. For analysis responses were coded: 0=no, 1=yes.

4.5.2.2 Clinical Variables

The list of clinical variables that was examined consisted of: 1) comorbid conditions, 2) headaches, 3) neurological examination results, 4) non-organic signs of pain focused behaviour, 5) number of symptoms on initial presentation, 6) pain radiation to the arm or leg, 7) primary pain location, 8) thoracic (mid back) pain, and 9) Visual Analogue Scale of pain intensity.

Comorbidity. Subjects were asked about their past medical history. Specifically they were queried regarding the presence of coronary artery disease, hypertension, rheumatoid arthritis, diabetes mellitus, malignancy, chronic obstructive pulmonary disease, or other comorbid medical condition. For analysis, comorbidity was recorded as a binary variable: 0=none, 1=any comorbid condition(s).

Headache. The presence of headaches was recorded as a binary variable: 0=no, 1=yes.

Number of Symptoms. A number of symptoms are common to patients with WAD. For analysis, a variable was created that totaled each of these symptoms. For example, each patient was asked about the presence of neck pain, mid back pain, low back pain, upper extremity pain, lower extremity pain, and headache. Depending on the number of body areas where pain was present, each individual received a score from 0 to 6.

Neurological Examination – Bicep Reflex, Anterior Deltoid, Bicep Power, Tricep Reflex, Extensor Digitorum Longus, Tricep Power, Knee Reflex, Ankle Dorsiflexion, Ankle Reflex, Ankle Plantarflexion, and Gluteus Maximus. A physiotherapist's physical examination of the cervical and lumbar spine was performed to rule out any disease states that may require direct attention or referral to a specialist. The clinical database contained the physiotherapists' clinical interpretation of whether these tests were positive or negative. The number of neurological tests performed depends on clinical findings and therapist discretion; therefore, not every patient will get every test. In the dataset this makes it difficult to identify cases where a test was done (but did not need to be performed) from those who were not tested but should have been. To overcome this issue, the conduction tests were categorized into summary variables representing their specific anatomic implications in terms of spinal level of likely neurological involvement: C56 (bicep reflex, anterior deltoid, bicep power), C78 (tricep reflex, extensor digitorum longus, tricep power), L4 (knee reflex, ankle dorsiflexion) and S1 (ankle reflex, ankle plantarflexion, gluteus maximus).

Appendix F presents a summary of which combination of conduction test results comprised positive or negative neurological signs. For analysis this variable was coded with a binary variable (0=normal neurological conduction, 1=abnormal neurological conduction)

Non-organic signs. Using physical examination as a means of identifying illness behaviour in back pain patients has become increasingly popular since the introduction of

Waddell's non-organic signs in 1980 (47). Waddell et al. identified five non-organic signs, each consisting of one or two tests. The tests assess a patient's pain behaviour in response to certain maneuvers (Appendix E). These tests have also been used for patients with a presenting complaint of neck pain (48). A high number of positive non-organic signs in patients with either neck or back pain indicates pain behaviour. For analysis results were recoded into a binary variable: 0=low (0,1,or2 out of 5), 1=high (3,4, or 5 out of 5). A patient with three or more positive non-organic signs was defined as having a clinically significant pattern of non-mechanical, pain focused behaviour (47).

Pain Location. Patients recorded their primary complaint. This categorical variable was coded 1=neck, 2=back, and 3=neck & back.

Pain Radiation. The location of the most distal symptom was recorded. This variable was recoded as a binary variable. For subjects with a complaint of neck pain, 0=no radiation to the upper limb, 1=arm, forearm, and/or hand radiation. For subjects with a complaint of back pain, 0=no radiation to the lower limb, 1=thigh, calf, and/or foot radiation.

Thoracic (mid-back) pain. The presence of thoracic spinal pain was recorded during the initial assessment. This variable was recorded as a binary variable: 0=no, 1=yes.

Visual Analogue Scale (VAS). Subjects were asked to rate the intensity of their back or neck pain based on the score on a visual analogue scale. The visual analogue scale, using

a 0 to 10 scale where 0 represents no pain and 10 represents worst possible pain, is widely used for measuring pain and has been shown to be a reproducible method of measuring pain (49, 50).

4.5.2.3 Treatment Variables

The list of treatment variables that was examined consisted of: 1) bed rest, 2) duration of treatment, and number of rehabilitation sessions, 3) concurrent and previous treatment, 4) health care seeking behaviour, and 5) radiographs and other investigations.

Bed Rest. Previous literature suggests that prescribing bed rest may delay recovery from episodes of low back and neck pain (51, 52). This variable was coded separately from the remainder of the previous treatments (0=no bed rest prescribed, 1=bed rest previously prescribed).

Duration of the Treatment Program. A continuous variable; the number of calendar days from the initial presentation to the clinic until discharge. In addition, the number of actual treatment sessions was investigated. Regardless of entry time into the study cohort, data was collected until the patient's discharge date; therefore, the follow up time was not truncated by the end of the study period.

Previous and Concurrent Treatment. Although the initial provider of services was not known for this cohort, patients were asked about their previous investigations and treatment, as well as concurrent treatment. Specifically each patient was asked if

myelography/computed tomography(CT)/magnetic resonance imaging(MRI), bonescan, x-ray, blood work, electrical studies, or no investigations had been previously performed. Patients were also asked if either previous or concurrent manipulation/mobilzation, modalities, active exercise, massage, bed rest, other treatment, or no other treatment had been performed.

For analysis the x-ray variable was coded 0=no x-rays taken, 1=x-rays taken. The other investigations variable was coded 0=no other investigations performed, 1=myelography/CT/MRI, bone scan, blood work, or electrical studies were performed. Two variables were created for the previous investigations (x-rays and other investigations) because in a typical clinical setting, x-rays and the other investigations would not be performed during the same clinical encounter.

It was not known if previous treatment was performed by a single or multiple providers. For analysis a binary variable was created (0=no previous treatment/, 1=any previous treatment.

It was not know if concurrent treatment was performed by a single of multiple providers. For analysis concurrent treatment was a binary variable (0=no concurrent treatment, 1=any concurrent treatment).

Health Care Seeking Behaviour. A variable capturing the health care seeking behaviour of each patient was created. This was a sum of the x-ray, other investigations, previous

treatment, and concurrent treatment variables. A score of 0 to 4 was possible for this variable.

4.6 A Comparison of Acute and Chronic Whiplash Associated Disorders

Using a cohort of all patients who completed both entry and exit questionnaires (n=6,195) a secondary descriptive comparison of acute and chronic WAD was conducted. Further exclusions of this dataset were made based on the injury occurring at work (n=156), age restrictions (n=343), and injury date or work status missing (n=115). This resulted in a working data set of 5581 records. This comparison used an available-case analysis approach. This method included all acute and chronic cases with observed data for a particular variable, for any one specific analysis (but the same number of cases may not be present for other analyses) (53). This method assumes that the missing data are missing at random; that is, that the information available does not differ in any systematic way from the missing information (53). Three groups were compared in a cross-sectional manner: those with an acute presentation (defined as presentation less than or equal to 91 days since injury), early chronic presentation (defined as greater than 91 days but less than 6 months since injury), and chronic presentation (greater than 6 months since injury date).

4.6.1 Additional Research Variables

In addition to the outcome variable and explanatory variables described earlier, additional variables were included for descriptive analysis.

Raw CBIQ entry and exit scores, and CBIQ change score. In addition to the primary outcome based on a minimally clinically important change, a comparison of the average change in CBIQ, as well as, the raw sores on presentation and discharge was conducted.

Work Modifications. Patients were asked about any modification in the hours of work or duties performed at work since their injury. The hours at work variable was coded 0=pre-episode hours, 1=reduced hours. The modified duties variable was coded 0=pre-episode duties, 1=modified duties. For analysis a binary variable of work modifications was coded 0 if hours at work and duties at work were the same as pre-episode, and 1 if either the hours at work or the duties at work had been altered.

Constancy. Patients were asked if their pain was constant or intermittent. Constancy of pain was recorded into a binary variable: 0=intermittent or no pain, 1=constant pain.

Previous Episodes. Patients were asked if they had any previous episodes of back or neck pain. A binary variable was created for previous back pain episodes and previous neck pain episodes (0=no, 1=yes).

Previous Spinal Surgery. A binary variable (0=no, 1=yes).

4.7 Ethics

In 1990, the International Epidemiology Association (54) concluded that:

> It is not feasible to obtain the consent, informed or otherwise, of all individuals whose records have become part of a large database such as a nationwide system of linked records, or the archival records of a general hospital. In these and similar situations, informed consent to use such records for epidemiological study may reasonable be delegated to an ethics review committee.

Consent for access of the clinical database of CBI Health, was received by the candidate from the Medical Director and Research Department Data Steward. It was not feasible to contact the expected 16 000 individuals whose records would be included in the database. To protect the anonymity of the patients within the clinical database the CBI Research Department (Data Stewart, Lynda Wilson) provided a dataset with the unique identifiers removed from each file. In addition CBI clinics are located only in major Canadian centers. This ensured the protection of confidentiality of personal information and records.

In accordance to these guidelines, the Clinical Research Ethics Board at the University of British Columbia approved the ethical issues concerned with this thesis project.

Having documented the materials and methods, the next chapter will focus on the statistical analysis required for the dataset.

Chapter 5 Statistical Analysis Methods

5.1 Inception Cohort

5.1.1 Descriptive Statistics

Preliminary analysis involved descriptive statistics of the assembled study cohort for each variable included in this portion of analysis. Means and percentages were calculated for continuous and categorical study variables to describe the study population. Study population characteristics were described for those with a negative and positive outcome. Additional cross tabulations and correlation coefficients of study variables were computed to investigate possible confounding and to facilitate multivariate model construction.

5.1.2 Logistic Regression Modeling Strategy

For this study, logistic regression modeling was used to evaluate associations between explanatory variables and the dichotomous minimally clinically important change in Canadian Back Institute Questionnaire (CBIQ) outcome. The explanatory variables were grouped into three categories: personal characteristics, clinical, and treatment related variables. The three stage logistic regression modeling strategy employed (55) is described below. Figure 5.1 displays an overview of the model building strategy.

5.1.2.1 Univariable Analysis

Within each category of variables, univariable logistic regression analysis was performed and crude odds ratios and 95% confidence intervals were generated to investigate the association of each explanatory variable with the dichotomous outcome variable. At this

stage the rigid application of a strict 5% significance level for choosing variables was not used. Instead variables with regression coefficient (beta) values for which the P value was less than or equal to 0.10 on the Wald X^2 statistic were retained for a multivariate within category model. For categorical variables with more that two categories, if one or more levels were selected the models were fit using all levels. Due to collinearity, the covariates relating to, number of symptoms, and health seeking behaviour, were not entered into a multivariate model with the two composite covariates that included these items as part of the composite score. All variables in the three category specific models with beta values that maintained a P value of less that or equal to 0.10 were included in a multi-category model.

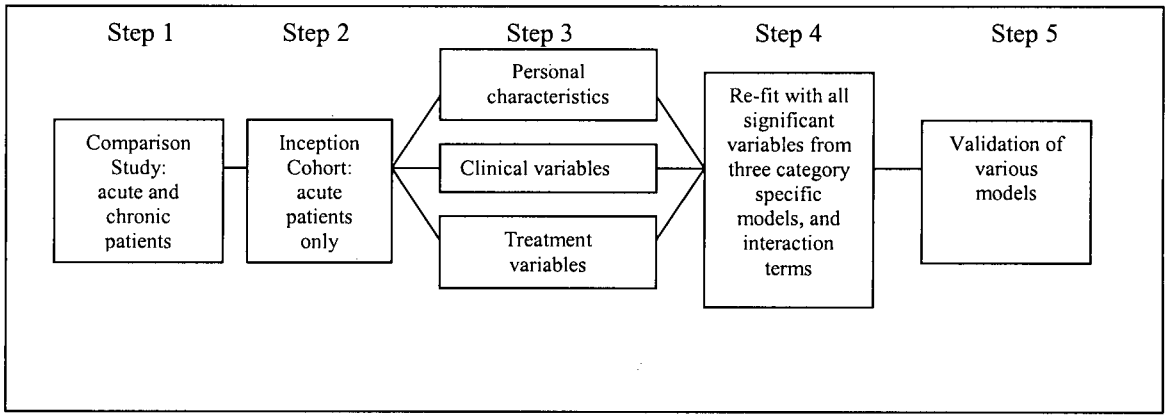
5.1.2.2 Multivariate Analysis

The multivariate models were generated by using all significant variables (P value $\leq$ 0.10) from the three previous category specific models. The provisional multivariate model included variables with coefficient values that demonstrated a significance level of 0.05 or less on the Wald X^2 statistic. In addition, the a priori decision was made to adjust for age, gender and initial pain intensity. Adjusted odds ratios and 95% confidence intervals were generated for the variables of the model.

Bivariate interaction terms were investigated for potential inclusion into the final model. Interaction terms with a P value less than or equal to 0.05 on the Wald X^2 statistic were considered for inclusion in a model. The variables involved in the interaction were also retained in these models. Once a provisional model was constructed using the above strategies, a number of variables that had been previously excluded due to a lack of

significance were reconsidered. A model validation process considered any gains in performance that could be acquired with the inclusion of a specific variable. This model validation process was used to determine the choice of the final most appropriate model.

Figure 5.1– Overview of the logistic regression model building strategy



5.2 Model Validation

In a general sense, model validation provides information that can help one determine if a model indeed does what it intends to do (that the predictions are accurate for the purpose). Model validation usually involves a method of comparison to determine how well the individual predicted probabilities agree with the actual observed responses (56). A number of validation methods are available to predict the accuracy of a model; however, this essential step in the model building process is seldom reported in the literature (57, 58). When validation is performed, forms of internal validation are commonly used. These validation procedures derive estimates based on the same dataset that was used to build the model. In contrast external validation uses an external source of data, such as data from another centre (perhaps collected by other researchers) to validate the model (59). Temporal validation uses subsequent data from the same centre for the purposes of validation. This method is no different than splitting the data into two datasets seen at different time periods (56). Common techniques for internal validation

include: simple sample statistics, split-sample cross validation, and leave-one-out cross validation (Appendix H).

Single sample statistics such as, Akaike's Information Constant (AIC) or Schwarz Bayesian Criterion (SC) may over estimate performance because the same data that was used to build the model is also used for validation (60, 61). Split-sample and the various form of cross validation are methods for obtaining nearly unbiased internal assessments of accuracy (62). Cross validation has the additional advantage of not significantly reducing the sample size of the training sample.

For this study the models that were constructed were validated with leave-one-out cross validation. Cross validation was used as a method for final model section based on the predictive ability of the model in conjunction with other non-statistical criteria. The discriminative accuracy (the model's performance in discriminating outcome) of the competing models was compared by generating Receiver Operator Characteristic (ROC) curves for each model. An ROC curve was constructed using the predicted probabilities generated from the leave-one-out cross validation for each competing provisional model. The model with the largest area under the ROC curve, and thus the best predictive accuracy, was chosen as the final model. The calibration of probability predictions was also analyzed. A comparison of the predicted and the observed responses in deciles of risk was conducted for the final model using the Hosmer and Lemenshow goodness-of-fit statistic (55).

5.4 A Comparison of Acute and Chronic Whiplash Associated Disorders

To illustrate the differences between acute and chronic WAD populations, a secondary descriptive comparison was conducted using the entire cohort of patients who completed both entry and exit questionnaires. Patients presenting with acute injury (defined as 91 days or less since their injury date), were compared to patients with early chronic presentations (greater than 91 days but less than 6 months since their injury date), and to patients with chronic injuries (greater than or equal to 6 months since injury date). An available case analysis approach allowed for an examination of most variables in the database using the information on the cases that provided the information specific to a variable while disregarding those that did not provide information on the same variable. These assessments will be valid if the patients with missing values represent a simple random sample from the cohort (53).

Descriptive statistics (means and percentages) were used to describe the distribution of the various study variables and treatment outcomes using the chi-square test for dichotomous variables and the one-way analysis of variance (ANOVA) test for continuous variables. The results were adjusted for multiple comparisons using the Bonferroni correction. For categorical variables, if the expected frequency count was less than 5 in one of the groups being compared the Fisher's exact test was used.

5.5 Missing Values

Methods to assess the presence of self-selection bias were computed for both the inception cohort and the comparison study. The inclusion of only those patients who

completed both the entry and exit questionnaire and the VAS of pain intensity resulted in the exclusion of a significant number of records. Descriptive statistics to compare the baseline characteristics of participants and non-participants for key variables were assessed. In addition, two variables of interest were excluded from the inception cohort (previous episodes of spinal pain, and presence of constant pain) due to low response rates (> 50 % missing). Separate univariable and multivariate logistic regression models were constructed to investigate the potential influence of these two covariates on the primary outcome (10% change in questionnaire score), among patients with completed data.

All analyses were conducted with SAS System for Windows version 8.2 and S-Plus 2000 for Windows.

Chapter 6 Results

6.1 Cohort Characteristics

6.1.1 Personal Characteristics

A total of 2185 patients who sustained injuries in a motor vehicle collision (MVC) were included in the inception cohort. The mean age of the cohort population was 35.6 years. Fifty-five percent (55.3%) were female, 53.4% were off work due to their MVC, and 38.3% retained a lawyer at some point prior to their discharge from CBI. The mean time between the injury date and the presentation to the clinic was 31.7 days. The majority of the patients were from Ontario (37.6%), British Columbia (29.1%), or Alberta (23.3%). Table 6.1 includes the remaining frequency distributions of the personal, clinical, and treatment related characteristics.

6.1.2 Clinical Characteristics

Almost thirty percent (29.7%) of the patients had a primary complaint of neck pain, 55.9% had complaints of both neck and low back pain, while the remainder (14.4%) reported only low back pain. It was common for other areas of the body to be affected. 28.1 % reported headaches, while 43.9% reported pain in the mid-back. The average initial pain intensity rating was 6.0 (Range 0-10, SD=2.0) (Table 6.1).

6.1.3 Treatment Related Characteristics

Twenty-two percent (22.4%) of the patients received previous treatment prior to presentation to CBI, and 9.9% received concurrent treatment from another health care provider. The average duration of the treatment program at CBI was 72.7 days, and

during this time the patients received an average of 22.9 rehabilitation/treatment sessions (SD=16.5) (Table 6.1).

6.1.4 Outcome Variable

In total 1574 of the 2185 patients (72.0%) demonstrated at least a minimally clinically important improvement (10% change or 6.1 points) as measured by the Canadian Back Institute Questionnaire (CBIQ) between initial visit and discharge. The mean change in raw score on the CBIQ for the entire cohort was 13.5 (SD=11.0, median=13). For those defined with a positive outcome (10% improvement in questionnaire score) the mean change in CBIQ was 18.3 (SD=8.6, median=17.0). For those with a negative outcome the mean change in CBIQ was 0.9 (SD=5.0, median=2.0).

Table 6.1 - Baseline characteristics of 2185 patients with acute presentation after a motor vehicle collision

Variable	Total Population (n = 2185)	Positive Outcome (≥10% change in questionnaire score) (n=1574)	Negative Outcome (<10% change in questionnaire score) (n=611)
Personal Characteristics			
Age			
Mean age – yr (SD)	35.6 (10.6)	35.3 (10.5)	36.4 (10.8)
Gender – no. (%)			
Male	977 (44.7)	731 (46.4)	246 (40.3)
Female	1208 (55.3)	843 (53.6)	365 (59.7)
Lagtime between injury date and clinic presentation			
Mean duration – days (SD)	31.7 (23.7)	30.3 (23.2)	35.4 (24.7)
Median	25.0	23.0	30.0
Work status due to collision – no. (%)			
Off work	1166 (53.4)	904 (57.4)	262 (42.9)
Still working	1019 (46.6)	670 (42.6)	349 (57.1)
Physical demands of work – no. (%)			
Sedentary	363 (16.6)	253 (16.1)	110 (18.0)
Light	370 (16.9)	256 (16.3)	114 (18.7)
Medium	514 (23.5)	373 (23.7)	141 (23.1)
Heavy	668 (30.6)	514 (32.7)	154 (25.2)
Missing	270 (12.4)	178 (11.3)	92 (15.1)

Table 6.1 – Continued baseline characteristics of 2185 patients with acute presentation after a motor vehicle collision.

Retained a lawyer on or before first visit to clinic – no. (%)			
Yes	672 (30.8)	477 (30.3)	195 (31.9)
No	1513 (69.2)	1097 (69.7)	416 (68.1)
Retained a lawyer at some point prior to discharge – no. (%)			
Yes	837 (38.3)	561 (35.6)	276 (45.2)
No	1348 (61.7)	1013 (64.4)	335 (54.8)
Smoking Status – no. (%)			
Current/Former	778 (35.6)	588 (37.4)	190 (31.1)
Non-smoker	1407 (64.4)	986 (62.6)	421 (68.9)
Province – no. (%)			
British Columbia	635 (29.1)	438 (27.8)	197 (32.2)
Alberta	510 (23.3)	335 (21.3)	175 (28.6)
Saskatchewan	72 (3.3)	50 (3.2)	22 (3.6)
Ontario	822 (37.6)	624 (39.6)	198 (32.4)
Quebec	31 (1.4)	25 (1.6)	6 (1.0)
Nova Scotia	115 (5.3)	102 (6.5)	13 (2.1)
Clinical Characteristics			
Location of Pain- no. (%)			
Neck	649 (29.7)	480 (30.5)	169 (27.7)
Neck & Back	1222 (55.9)	850 (54.0)	372 (60.9)
Back	314 (14.4)	244 (15.5)	70 (11.5)
Other Area Affected no. (%)			
Headache	613 (28.1)	441 (28.0)	172 (28.2)
Mid-back	960 (43.9)	696 (44.2)	264 (43.2)
Upper extremity	335 (15.3)	249 (15.8)	86 (14.1)
Lower extremity	274 (12.5)	192 (12.2)	82 (13.4)
Number of Symptoms			
Mean # (SD)	2.6 (1.3)	2.5 (1.3)	2.6 (1.2)
Median	2.0	2.0	2.0
Neurological Tests - no. (%)			
Positive	33 (1.5)	23 (1.5)	10 (5.6)
Negative	2152 (98.5)	1551 (98.5)	601 (94.4)
Non-organic Signs – no. (%)			
3+	127 (5.8)	93 (5.9)	34 (5.6)
Comorbid Conditions – no. (%)			
Yes	256 (11.7)	173 (11.0)	83 (13.6))
No	1929 (88.3)	1401 (89.0)	528 (86.4)
Initial Pain Intensity (range 0-10)			
Mean intensity - VAS (SD)	6.0 (2.0)	6.1 (2.0)	5.9 (2.0)
Median	6.0	6.0	6.0
Treatment Related Characteristics			
Duration of Treatment Program			
Mean duration -days (SD)	72.7 (64.6)	72.6 (65.3)	72.8 (62.8)
Median	56.0	55.0	58.0
Number of Treatment Sessions			
Mean number - # (SD)	22.9 (16.5)	22.9 (16.9)	22.9 (15.4)
Median	20.0	20.0	20.0
Previous Investigations – no. (%)			
X-rays	594 (27.2)	438 (27.7)	156 (25.5)
Other	45 (2.1)	33 (2.1)	12 (2.0)

Table 6.1 – Continued baseline characteristics of 2185 patients with acute presentation after a motor vehicle collision.

Previous Treatment – no. (%)			
Yes	490 (22.4)	332 (21.1)	158 (25.9)
No	1695 (77.6)	1242 (78.9)	453 (74.1)
Concurrent Treatment – no. (%)			
Yes	217 (9.9)	152 (9.7)	65 (10.6)
No	1968 (90.1)	1422 (90.3)	546 (89.4)
Health Care Seeking			
Mean # (SD)	1.6 (0.9)	1.6 (0.9)	1.6 (0.9)
Median	1.0	1.0	1.0

6.2 Univariable and Multivariate (Within Category) Logistic Regression

Table 2, 3, and 4 display the univariable logistic regression coefficient estimates and associated statistics for the explanatory variables by each category of variable (personal, clinical, and treatment related). In addition, the odds ratios (OR) adjusted for each of the other significant variables within the variable category are presented.

6.2.1 Personal Characteristics

The univariable analysis revealed that personal characteristics: older age, female gender, work status (currently working), lawyer retention prior to discharge, province of MVC, less physically demanding work, and lagtime were associated with a negative outcome. All of these variables except for the physical demands at work remained significant while controlling for each other (Table 6.2). The age variable was rescaled to reflect a 10-year increase in age. Similarly, the lagtime (between injury and presentation to the clinic) variable was rescaled to a month lagtime.

Table 6.2 – Crude and adjusted odds ratios for the association of the variables in the personal characteristic category with a negative outcome (< 10% change in questionnaire score)

	UNIVARIABLE ANALYSIS		MULTIVARIATE ANALYSIS	
Personal Characteristics	**Crude OR (95% CI)**	**p-value**	**Adjusted OR (95% CI)**	**p-value**
Age (per decade)	1.10 (1.06-1.20)	0.037	1.14 (1.04-1.25)	<0.0001
Gender				
Male (ref.)				
Female	1.29 (1.06-1.56)	0.009	1.29 (1.06-1.58)	0.0123
Lagtime between injury and presentation to clinic (per month)	1.30 (1.16-1.46)	<0.0001	1.19 (1.05-1.35)	0.0058
Work status				
Off work (ref.)				
Currently working	1.80 (1.49-2.71)	<0.0001	1.84 (1.49-2.28)	<0.0001
Physical demands				
sedentary (ref.)				
light	1.02 (0.75-1.40)	0.8814	1.07 (0.71-1.48)	0.6953
medium	0.87 (0.65-1.17)	0.3543	1.02 (0.75-1.39)	0.9128
heavy	0.69 (0.52-0.92)	0.0111	0.85 (0.62-1.17)	0.3193
missing	1.19 (0.85-1.67)	0.3142	1.19 (0.84-1.71)	0.3299
Layer retention – late				
No (ref)				
Yes	1.49 (1.23-1.80)	<0.0001	1.57 (1.28-1.93)	<0.0001
Province				
British Columbia (ref)				
Alberta	1.16 (0.91-1.49)	0.2376	0.88 (0.67-1.54)	0.3424
Saskatchewan	0.98 (0.58-1.66)	0.9351	0.90 (0.52-1.56)	0.7144
Ontario	0.71 (0.56-0.90)	0.0032	0.69 (0.53-0.89	0.0048
Quebec	0.53 (0.22-1.32)	0.1746	0.63 (0.25-1.58)	0.3230
Nova Scotia	0.28 (0.12-0.52)	<0.0001	0.26 (0.14-0.49)	<0.0001
Lawyer retention - early				
No (ref.)			Not included in	NA
Yes	1.08 (0.89-1.32)	0.4643	multivariate model	
Smoking Status				
No (ref.)			Not included in	NA
Yes	1.17 (0.84-1.63)	0.3439	multivariate model	

NA= not applicable because variable not included in multivariate model

6.2.2 Clinical Characteristics

The clinical variables pain location (pain located simultaneously in the low back and neck), and the presence of comorbid medical conditions were associated with a negative outcome, both at the univariate and multivariate level (Table 6.3).

Table 6. 3 – Crude and adjusted odds ratios for the association of the patient's clinical characteristics with a negative outcome (< 10% change in questionnaire score)

	UNIVARIABLE ANALYSIS		MULTIVARIATE ANALYSIS	
Clinical Characteristics	**Crude OR (95% CI)**	**p value**	**Adjusted OR (95% CI)**	**p value**
Pain Location				
Neck (ref.)				
Neck & Back	1.24 (1.05-1.54)	0.0319	1.24 (1.00-1.53)	0.0334
Back	0.82 (0.59-1.12)	0.18	0.82 (0.59-1.22)	0.2663
Comorbid Conditions				
No (ref.)				
Yes	1.27 (0.96-1.69)	0.0913	1.26 (0.95-1.67)	0.1071
Headache				
No (ref.)			Not included in	NA
Yes	1.01 (0.82-1.24)	0.9505	multivariate model	
Mid-back				
No(ref.)			Not included in	NA
Yes	0.96 (0.78-1.16)	0.6696	multivariate model	
Pain Radiation to Extremity				
No (ref.)			Not included in multivariate model	NA
Yes	1.02 (0.82-1.27)	0.8724		
Number of Symptoms	1.03 (0.96-1.11)	0.3651	Not included in multivariate model	NA
Neurological Testing				
Negative (ref.)			Not included in	NA
Positive	1.12 (0.53-2.37)	0.7630	multivariate model	
Non-Organic Signs (3+)				
No (ref)			Not included in	NA
Yes	0.94 (0.63-1.41)	0.6985	multivariate model	
Initial Pain Intensity	0.97 (0.93-1.01)	0.1733	Not included in multivariate model	NA

NA= not applicable because variable not included in multivariate model

6.2.3 Treatment Related Characteristics

An association between those patients who had received previous treatment and a negative outcome was observed (Table 6.4).

Table 6.4 – Crude and adjusted odds ratios for the association of the treatment related characteristics with a negative outcome (< 10% change in questionnaire score)

	UNIVARIABLE ANALYSIS		MULTIVARIATE ANALYSIS	
Treatment Related Characteristics	**Crude OR (95% CI)**	**p value**	**Adjusted OR (95% CI)**	**p value**
Previous Treatment No (ref.) Yes	1.31 (1.05-1.62)	0.0167	1.31 (1.05-1.62)	0.0167
Bed rest No (ref.) Yes	0.52 (0.06-4.42)	0.5459	Not included in multivariate model	
Duration of treatment (days)	1.00 (1.00-1.00)	0.9429	Not included in multivariate model	NA
Treatment Sessions (no.)	1.00 (0.99-1.00)	0.9820	Not included in multivariate model	NA
Previous x-rays No (ref.) Yes	0.89 (0.72-1.10)	0.2793	Not included in multivariate model	NA
Other investigations No (ref.) Yes	0.94 (0.48-1.83)	0.8469	Not included in multivariate model	NA
Concurrent Treatment No (ref.) Yes	1.11 (0.82-1.51)	0.4911	Not included in multivariate model	NA
Health Seeking Behaviour	1.04 (0.94-1.16)	0.4297	Not included in multivariate model	NA

NA= not applicable because variable not included in multivariate model

Based on these results the following variables from all categories were included in a multivariate model: age, gender, work status, lawyer retention prior to discharge, province, lagtime, pain location, comorbid medical conditions, and previous treatment.

6.3 Multivariate (All Variable Categories) Logistic Regression

At the more stringent 5% significance level, and while controlling for variables from all categories, the following characteristics were associated with a negative outcome: older age, female gender, work status (currently working), lawyer retention prior to discharge, province of MVC, increasing lagtime between injury date and treatment, and pain

location. The parameter estimations and associated statistics are displayed in Table 6.5 This model was additionally adjusted for the initial pain intensity.

Table 6.5 - Adjusted odds ratios for the association of the significant variables from the three category specific models with a negative outcome (< 10% change in questionnaire score)

Variable	Parameter Estimate	SE	OR (95% CI)	p value
Age (per decade)	0.159	0.00498	1.17 (1.06-1.29)	<0.0014
Gender				
Male (ref)				
Female	0.2180	0.1094	1.24 (1.04-1.54)	0.0462
Work status				
Off work (ref)				
Currently working	0.7136	0.1143	2.04 (1.63-2.55)	<0.0001
Lagtime between injury and presentation to clinic (per month)	0.059	0.0023	1.19 (1.04-1.37)	0.0114
Lawyer Prior to Discharge				
No (ref)				
Yes	0.4638	0.1162	1.59 (1.26-2.00)	<0.0001
Pain Location				
Back (ref)				
Neck & Back	0.3983	0.1662	1.49 (1.08-2.01)	0.0165
Neck	0.2390	0.1803	1.27 (0.89-1.81)	0.1849
Province				
British Columbia (ref)				
Alberta	-0.0959	0.1546	0.91 (0.67-1.23)	0.5350
Saskatchewan	0.0736	0.2988	1.08 (0.89-1.81)	0.8053
Ontario	-0.2482	0.1382	0.78 (0.60-1.02)	0.0725
Quebec	-0.2843	0.4755	0.75 (0.30-1.91)	0.5500
Nova Scotia	-1.1201	0.3189	0.33 (0.18-0.61)	0.0004
Initial Pain Intensity	-0.0127	0.0266	0.99 (0.94-1.04)	0.6760

6.4 Model Selection and Validation

A total of 17 different models containing interaction terms and other covariates were compared using cross validation techniques. The areas under the Receiver Operator Characteristic (ROC) curves for these models and the defining characteristics are displayed in Table 6.6. These provisional models were generated, to see if the inclusion of interaction terms or a variable that was previously eliminated due to a lack of significance (during the univariable or multivariate analysis) could improve the predictive ability of the final model.

Table 6.6 - Defining characteristics and area under the ROC curve for the competing models

Competing Models	Model Characteristics	Area under ROC curve
Model 1	Significant variables adjusted for pain intensity – age, gender, work status, lawyer, lagtime, pain location, intensity, province	0.632
Model 2	Model 1 with smoking status	0.634
Model 3	Model 1 with comorbid variable	0.631
Model 4	Model 1 with duration of treatment variable	0.630
Model 5	Model 1 with non-organic signs	0.627
Model 6	Model 1 with smoking status, comorbid, and duration variable	0.631
Model 7	Model 1 with second order interaction terms for province variable	0.615
Model 8	Model 1 with second order interaction terms for intensity variable	0.634
Model 9	Model 1 with second order interaction terms for age variable	0.628
Model 10	Model 1 with second order interaction terms of smoking status variable	0.632
Model 11	Model 1 with second order interaction terms for lawyer variable	0.630
Model 12	Model 1 with second order interaction terms for gender variable	0.629
Model 13	Model 1 with significant interaction terms: intensity*lawyer, intensity*work status	0.636
Model 14	Model 13 with smoke status	0.640
Model 15	Model with all confounding variables and significant interaction terms	0.605
Model 16	Parsimonious model including: age, gender, work status, lawyer, intensity	0.614
Model 17	Parsimonious model including: age, gender, province, intensity	0.591

Many of the models demonstrated similar areas under the ROC curve. The manipulation of a few similar variables produced the models with the best discriminative ability. Generally, models containing the variable smoking status, and/or the interaction terms of initial pain intensity*lawyer and initial pain intensity*work status performed better than models without these terms. Not surprisingly, including a number of non-significant interaction terms or erroneous variables resulted in a reduction in the performance of the model. A number of simple models containing fewer variables (Model 16 and 17 in Table 6) resulted in less discrimination by the model. Model 14 containing the significant interaction terms and the smoking status variable was chosen as the best model based on having the largest area under the ROC curve. The overall agreement between the observed and predicted outcomes at deciles of risk in this model was assessed with the Hosmer-Lemenshow test statistic (55). The test statistic was not significant ($p=0.24$) indicating that the logistic model adequately describes the risk throughout all of the risk groups. Table 6.7 displays the observed and predicted responses for both negative and positive outcome for the 10 risk subgroups.

Table 6.7- Partitions for the Hosmer and Lemeshow test for the model chosen by validation

		Negative Outcome		Positive Outcome	
Risk Group	Total	Observed	Expected	Observed	Expected
1	218	15	23.02	203	194.98
2	218	43	34.79	175	183.21
3	220	39	43.08	181	176.92
4	218	47	49.66	171	168.34
5	220	68	56.77	152	163.23
6	218	59	62.05	159	155.95
7	220	72	68.98	148	151.02
8	218	79	75.90	139	142.10
9	218	81	86.12	137	131.88
10	215	106	108.60	109	106.40

6.5 Final Multivariate Study Model

In the final model: older age, female gender, increased lagtime between injury and presentation to the clinic, and pain location (simultaneous back and neck pain) were associated with a negative outcome. Those patients whose motor vehicle collision occurred in Nova Scotia or Ontario when compared to British Columbia (reference category) were less likely to have a negative outcome (Table 6.8). In addition, interaction terms between initial pain intensity and the retention of a lawyer, and initial pain intensity and work status were significant. The adjusted odds ratios for the variables lawyer retention and work status at three levels of pain intensity (mild, moderate, and severe) are displayed in Table 6.9. The effect of lawyer retention on outcome was stronger for those individuals with less intense pain. Similarly the effect of work status on outcome diminished as the initial pain intensity increased. The smoking status variable was not significantly associated with the outcome; however, the inclusion of this variable led to better predictive ability by the logistic model, and thus it was also included.

Table 6.8 – Adjusted odds ratios for the association of the variables in the final study model and negative outcome (< 10% change in questionnaire score)

Variable	Adjusted Odds Ratio (95% CI)	p value
Age (per decade)	1.14 (1.04-1.25)	0.0038
Gender – Female	1.303 (1.067-1.593)	0.0096
Lagtime (per month)	1.20 (1.06-1.37)	0.0049
Pain Location		
Neck & Back vs. Back	1.423 (1.046-1.934)	0.0246
Neck vs. Back	1.208 (0.866-1.686)	0.2663
Province		
Alberta vs. British Columbia	0.926 (0.704-1.217)	0.5806
Saskatchewan vs. British Columbia	1.012 (0.584-1.755)	0.9664
Ontario vs. British Columbia	0.725 (0.559-0.939)	0.0147
Quebec vs. British Columbia	0.707 (0.280-1.786)	0.4627
Nova Scotia vs. British Columbia	0.279 (0.150-0.517)	<0.0001
Smoking status (current of former smoker)	0.812 (0.658-1.002)	0.0534
Intensity*lawyer retention prior to discharge	See Table6.9	0.0020
Intensity*work status (currently working)	See Table 6.9	0.0460

Table 6.9 – Adjusted odds rations for the association of lawyer retention and work status and negative outcome stratified by initial pain intensity

Variable – Stratification	Odds Ratio (95% CI)
Lawyer retention stratified by pain intensity.	
Mild intensity (VAS 0-4)	2.17 (1.34-3.57)
Moderate intensity (VAS 5-7)	1.57 (1.17-2.11)
Severe intensity (VAS 8-10)	1.26 (0.66-2.41)
Work Status (currently working)	
Mild intensity (VAS 0-4)	3.50 (2.14-5.73)
Moderate intensity (VAS 5-7)	1.91 (1.43-2.54)
Severe intensity (VAS 8-10)	1.03 (0.50-2.13)

6.5.1 Sensitivity and Specificity of Study Model

The area under the ROC curve for this final study model was 0.64. The sensitivity, specificity, and the number of false positives and false negatives varied depending on the choice of cut-point used to classify a predicted outcome as positive or negative based on the subjects predicted probability. A number of different cut-points and the corresponding sensitivity, specificity, false positives, and false negatives were calculated (Table 6.10). Using a cut-point of 0.24 the sensitivity of the final study model to predict those patients with a negative outcome was 0.74, and the specificity was 0.45. This cut-

point is optimal if the objective is minimizing the total number of false positives and false negatives (63).

Table 6.10 – Sensitivity and Specificity of the final study model with varying cut points .

Cut-Point	Sensitivity (%)	Specificity (%)	False positives (%)	False negatives (%)
0.180	94.7	17.0	83.0	5.3
0.200	88.5	26.2	73.8	11.5
0.220	81.4	35.6	64.4	18.6
0.240	74.1	44.9	55.1	25.9
0.260	65.5	53.4	46.6	34.5

6.6 Missing Values

6.6.1 Inception cohort - Differences between study population and excluded records

A total of 3,060 patients were eligible for inclusion in the cohort study to investigate prognostic factors associated with delayed recovery and disability among acute WAD patients. Of these, 875 patients were excluded because they did not complete a Visual Analogue Scale of their initial pain intensity. A comparison of patients with and without the VAS data are displayed in Table 6.11. Those with VAS data were identified by the following characteristics: more likely to have hired a lawyer, less likely to have taken time off work due to their injuries, less likely to have comorbid medical conditions, and less likely to have had previous treatment. The completion of the VAS scale also varied depending on the province of origin. Quebec, Alberta and Saskatchewan had participation rates of 91.2%, 89.0%, and 89.0% respectively, whereas those injured in Nova Scotia, Ontario and British Columbia participated at rates of 78.2%, 68%, and 62.5% respectively. This resulted in differences in the geographic makeup of the study population and the subjects that were excluded. There was not a significant difference in the overall outcome between the two groups or in the following study variables: age,

gender, lagtime, smoking status, or duration of treatment. The differences between individuals who responded to both the entry and exit questionnaires and those who did not are displayed in Table 1 of Appendix I. Those that completed both questionnaires were less likely to smoke or have comorbid medical conditions, and the duration of their treatment programs was longer by ten days; however, most of the observed differences were not considered clinically significant.

Table 6.11 – Missing Data - Characteristics associated with completion of initial pain intensity variable (VAS)

Variable	Study Population (n=2185)	Missing VAS (n=875)	Difference between groups (95% CI)	SE of difference	p value
Positive Outcome (≥10% change in questionnaire score) - %	72.0	73.6	-1.6 (-5.1, 1.8)	0.0177	NS
Age – mean years (SD)	35.6 (10.6)	35.8 (10.1)	0.3 (-1.1, 0.58)	0.4252	NS
Gender - % female	55.3	57.9	-2.6 (-6.5, 1.2)	0.0198	NS
Lagtime – mean days (SD)	31.7 (23.8)	30.5 (22.8)	1.2 (-0.7, 3.0)	0.9429	NS
Duration of treatment – mean days (SD)	72.7 (64.6)	76.6 (70.6)	-3.9 (-9.2, 1.3)	2.6650	NS
Work status - % off work	53.4	63.9	-10.5 (-14.3, -6.7)	0.0194	<0.0001
Lawyer Retention % yes	30.7	27.0	3.7 (0.2, 7.2)	0.0179	0.0036
Smoking Status - % current/former	35.6	34.5	1.1 (-2.6, 4.8)	0.0191	NS
Comorbid Medical Conditions - %	5.5	11.7	-6.2 (-8.5, -3.9)	0.0119	<0.0001
Previous Treatment - % yes	9.1	22.4	-13.3 (-16.3, -10.3)	0.0154	<0.0001
Non-organic signs - % with 3+	3.7	5.8	-2.1 (-3.8, -0.3)	0.0089	0.0152
Geographic Composition - % of group composed of					
British Columbia	29.1	43.5	-14.4 (-18.2, -10.6)	0.0193	<0.0001
Alberta	23.3	7.2	16.1 (13.6, 18.6)	0.0126	<0.0001
Saskatchewan	3.3	1.0	2.3 (1.3, 3.3)	0.0051	0.0004
Ontario	37.6	44.2	-6.6 (-10.5, -2.7)	0.0197	0.0007
Quebec	1.4	0.3	1.1 (0.5, 1.7)	0.0031	0.01
Nova Scotia	5.3	3.7	1.6 (0.0, 3.1)	0.0080	NS

6.6.2 Missing Covariate Values

Two variables (previous spinal pain episodes and the constant vs. intermittent pain variable) were excluded from the model building exercise due to low response rates (> 50% missing values). Separate univariable and multivariate (adjusted for other predictors found to be associated with outcome) logistic regression models were constructed to investigate the potential influence of these two covariates on the primary outcome among

patients with completed data. Among the 912 individuals who provided information regarding previous episodes of spinal pain those who reported previous episodes were less likely to have a negative outcome (p=0.0084). The adjusted odds ratio (95% CI) for this association was 0.653 (0.475-0.897). A significant association between the constant vs. intermittent pain variable was not observed in the 921 individuals who provided this information (adjusted OR (95% CI) = 1.145(0.784-1.674), p=0.48).

6.7 Comparison Study of Acute and Chronic Whiplash Associated Disorders

During the study period a total of 6195 patients who sustained injuries in a motor vehicle collision were identified in the CBI clinical database. Of theses, 5581 of these patients met the inclusion criteria for a comparison study of the acute and chronic patient populations.

6.7.1 Comparison Cohort Characteristics

Of the entire group, 3916 (64.8%) reported a positive outcome, after a mean treatment duration of 73.19 days (SD=63.42, median=57.0 days). During this time period each patient on average attended 22.6 rehabilitation sessions (SD=16.1, median=20).

A comparison of outcomes as well as the personal, clinical and treatment related characteristics between the acute ($\leq$ 91 days since injury date) and chronic ($\geq$ 6 months since injury date) patient populations revealed several significant differences.

6.7.1.1 Personal Characteristics

Table 6.12 provides a summary of the personal characteristics of the acute and chronic populations. Those individuals with chronic pain and disability after a motor vehicle collision were more likely to be female, and to have retained a lawyer. Chronic patients were more likely to have returned to work; however, less physically demanding work was more common in this population. The distribution of chronic patients across the provinces differed from the distribution of acute patients across the provinces. A larger proportion of the chronic population was composed of patients from British Columbia, Alberta, Saskatchewan and Quebec, when compared to the proportion of patients from these provinces in the acute population. The median lagtime between injury and presentation to the clinic for each of the provinces was: British Columbia (88 days), Alberta (136 days), Saskatchewan (138 days), Ontario (21 days), Quebec (148 days), and Nova Scotia (28 days).

Table 6.12 – A comparison of personal characteristics in individuals injured in a motor vehicle collision

Personal Characteristics	Acute (N = 3075)	Chronic (N = 1548)	Difference Acute-Chronic (95% CI)	SE of Difference	p value
Age					
no. of respondents	3075	1548			
Mean age – yr(SD)	35.7 (10.6)	36.2 (10.9)	-0.5 (-1.5, 0.2)	0.3335	0.2876
Female Sex – no./total no. (%)	1719 / 3075 (55.9)	954 / 1548 (61.6)	-5.7 (-8.7, -2.7)	0.0153	0.0002
Lagtime					
no. of respondents	3053	1548			
Mean no. of days (SD)	31.4 (23.5)	434.0 (321.6)	-403 (-414, -391)	5.8503	N/A
Median	25	348			
Off work because of collision					
no. / total no. (%)	1749 / 3075 (56.9)	506 / 1548 (32.7)	24.2 (21.2, 27.1)	0.0149	<0.0001
Physical Demands of Work – no./total no (%)					
Sedentary	447 / 3075(14.5)	239 / 1548(15.4)	-0.9 (-3.0, 1.3)	0.0111	0.4152
Light	480 / 3075 (15.6)	282 / 1548 (18.2)	-2.6 (-4.9, -0.3)	0.0118	0.0024
Medium	682 / 3075 (22.2)	305 / 1548 (19.7)	2.5 (0.0-0.5)	0.0126	0.0525
Heavy	875 / 3075 (28.5)	377 / 1548 (24.4)	4.1 (1.4, 6.8)	0.0136	0.0031
Missing	591 / 3075 (19.2)	345 / 1548 (22.3)	-3.1 (-5.6, -0.6)	0.0127	0.0143
Modified work duties because of collision.					
no. / total no (%)	466 / 1310*(35.6)	279 / 1024*(27.2)	8.4 (4.6, 12.2)	0.0191	<0.0001

Table 6.12 – Continued comparison of personal characteristics in individuals injured in a motor vehicle collision.

Retained a lawyer on or before first visit to clinic no./total no. (%)	913 / 3075 (29.7)	943 / 1548 (60.9)	-31.2 (-34.1, -28.3)	0.0149	<0.0001
Retained a lawyer at some point prior to discharge no./total no. (%)	1127 / 3075 (36.7)	935 / 1548 (60.4)	-23.7 (-26.7, -20.1)	0.0151	<0.0001
Smoking Status – current / former - no./total no. (%)	1054 / 3072*(34.3)	561 / 1547*(36.3)	2.0 (-4.9, 0.9)	0.0149	0.1888
Province – no./total no. (%)					
British Columbia	1020 / 3075 (33.2)	573 / 1548 (37.0)	-3.8 (-6.7, -0.9)	0.0149	0.0094
Alberta	575 / 3075 (18.7)	563 / 1548 (36.4)	-17.7 (-20.5, -14.9)	0.0141	<0.0001
Saskatchewan	81 / 3075 (2.6)	96 / 1548 (6.2)	-3.6 (-4.9, -2.3)	0.0068	<0.0001
Ontario	1216 / 3075 (39.5)	259 / 1548 (16.7)	22.8 (20.2, 25.3)	0.0129	0.0001
Quebec	43 / 3075 (1.1)	36 / 1548 (2.3)	-1.2 (-2.3, -0.3)	0.0042	<0.0001
Nova Scotia	149 / 3075 (4.9)	21 / 1548 (1.4)	3.5 (2.4, 4.4)	0.0050	<0.0001

*Number of respondents for each patient population that answered the survey item

6.7.1.2 Clinical Characteristics

The acute population reported more symptoms on presentation than the chronic population (Table 6.13). Specifically, additional complaints such as simultaneous neck and low back pain, and mid-back pain were more common. The chronic population; however, reported more low back and lower extremity syndromes, and demonstrated pain focused behaviour as determined by Waddel's non-organic signs more often (47). Comorbid medical conditions were also more common in the chronic population. There was a small difference in the initial pain intensity between the two populations.

6.7.1.3 Treatment Related Characteristics

Not surprisingly, the chronic population was more likely to have received previous treatment and investigations prior to their presentation to CBI (Table 6.13). Regarding their rehabilitation programs at CBI, there was no difference in the overall duration of the treatment programs between the two populations; however, the acute population received more treatment sessions.

Table 6.13 – A comparison of clinical and treatment related characteristics in individuals injured in motor vehicle collisions

Clinical Characteristics	Acute Presentation (N = 3075)	Chronic (N = 1548)	Difference Acute-Chronic (95% CI)	SE for Difference	p value
Location of Pain – no./total no. (%)					
Neck	916 / 3075 (29.8)	399 / 1548 (25.8)	4.0 (1.3, 6.7)	0.0138	0.0043
Neck & Back	1764 / 3075 (57.4)	819 / 1548 (52.9)	4.5 (1.4, 7.5)	0.1555	0.0040
Back	395 / 3075 (12.8)	330 / 1548 (21.3)	-8.5 (-10.9, -6.1)	0.0120	<0.0001
Areas Affected – no/total no. (%)					
Headache	772 / 3075 (25.1)	382 / 1548 (24.7)	0.4 (-0.2, 3.0)	0.0135	0.7506
Mid-Back	1227 / 3075 (39.9)	544 / 1548 (35.1)	4.8 (1.9, 7.7)	0.0150	0.0017
Extremity Pain – no./total no. (%)					
Upper Limb	422 / 3075 (13.7)	196 / 1548 (12.7)	1.0 (-1.1, 3.0)	0.0105	0.3166
Lower Limb	331 / 3075 (10.8)	280 / 1548 (18.1)	-7.3 (-9.5, -5.1)	0.0113	<0.0001
Number of Symptoms					
Mean (SD)	2.47 (1.24)	2.43 (1.31)	0.04 (-0.04, 0.11)	0.0394	0.1161
Neurological Testing – no./total no. (% Positive)	39 / 3075 (1.3)	25 / 1548 (1.6)	-0.3 (-1.0, 0.4)	0.0038	0.3410
Non-Organic Signs - no./total no. (%)					
Any	344 / 3075 (11.2)	234 / 1548 (15.1)	-3.9 (-6.0, -1.2)	0.0107	<0.0001
3+	160 / 3075 (5.2)	95 / 1548 (6.1)	-0.9 (-0.2, 0.5)	0.0073	0.1891
Previous Episodes - no./total no. (%)					
Neck Pain	683 / 910 (75.1)	398 / 527 (75.5)	-0.4 (-5.0, 4.2)	0.0236	0.8434
Back Pain	471 / 771 (61.2)	333 / 504 (66.1)	-4.9 (-10.3, 0.4)	0.0274	0.0715
Previous Spinal Surgery - no. /total no. (%)					
Cervical	3 / 3075 (0.1)	5 / 1548 (0.4)	-0.3 (-0.6, 0.0)	0.0017	0.0347
Lumbar	12 / 3075 (0.4)	15 / 1548 (1.0)	-0.6 (-1.1, -0.6)	0.0028	0.0148
Comorbid Conditions no./total no. (%) - Yes	309 / 3075 (10.1)	196 / 1548 (12.7)	-2.6 (-4.6, -0.6)	0.0100	0.0072
Presence of Constant Pain (Yes) no./total no. (%)	918 / 1172 (78.3)	490 / 642 (76.3)	2.0 (-0.6, 4.5)	0.0131	0.3276
Intensity of Pain Intensity					
Mean VAS (SD)	6.0 (2.0)	5.8 (2.1)	0.2 (0.06, 0.34)	0.0729	0.0224
Treatment Characteristics					
Bed rest previously prescribed - no./total no. %	6 / 3075 (0.2)	13 / 1548 (0.8)	-0.6 (-1.1, -0.1)	0.0024	0.0012
Duration or treatment program					
Mean days (SD)	73.8 (66.3)	73.6 (60.0)	0.2 (-3.7, 4.1)	2.0069	0.3891
Number of treatment sessions					
Mean # (SD)	23.7 (17.1)	21.0 (14.5)	2.6 (1.8, 3.8)	0.5066	<0.0001
Treatment Costs ($)					
Mean (SD)	2097 (1779)	1724 (1601)	373 (268, 478)	53.657	<0.0001
Previous Investigations - no../total no. (%)					
X-rays	737 / 3075 (24.0)	572 / 1548 (37.0)	-13 (-15.8, -10.2)	0.0145	<0.0001
Other	58 / 3075 (1.9)	159 / 1548 (10.3)	-8.4 (-10, -6.8)	0.0081	<0.0001
Previous Treatment – no./ total no. (%)					
Yes	579 / 3075 (18.8)	774 / 1548 (50.0)	-31.2 (-34, -28)	0.0145	<0.0001
Concurrent Treatment – no./total no. (%)					
Yes	251 / 3075 (8.2)	248 / 1548 (15.6)	-7.4 (-9.5, -5.3)	0.0105	<0.0001
Health care seeking – no./total no. (%)					
Mean (SD)	1.5 (0.8)	2.1 (1.2)	-0.6 (-0.7, -0.5)	0.0304	<0.0001

6.7.1.4 Outcome Variable

Seventy-two percent (72.3%) of the patients who presented to the clinic in an acute state demonstrated a positive outcome, in comparison to 51.6% of the chronic patients (Table 6.14). Those with a chronic whiplash injury were not only less likely to demonstrate a minimal clinically important improvement in disability, but also demonstrated less overall improvement on the CBIQ.

Table 6.14- Comparison of outcomes in individuals injured in a motor vehicle collision (acute vs. chronic populations)

Outcome	Acute ≤91 days (N = 3075)	Chronic ≥6mos (N = 1548)	Difference Acute–Chronic (95% CI)	SE for Difference	p value
Change in CBIQ – no./total no. - % with positive outcome (≥10% change)	2224 / 3075 (72.3)	806 / 1548 (52.1)	20.2 (17.3, 23.1)	0.0150	<0.0001
Mean Change in CBIQ					
Mean (SD)	13.8 (11.1)	6.8 (8.4)	7.0 (6.4, 7.7)	0.321	<0.0001
Median	13.0	6.0			
CBIQ Raw Score at Presentation*					
Mean (SD0	29.3 (10.5)	32.2 (9.0)	-2.9, (-3.5, -2.3)	0.311	<0.0001
Median	29.0	33.0			
CBIQ Raw Score at Discharge*					
Mean (SD)	43.1 (12.2)	39.0 (10.2)	4.1 (3.4, 4.8)	0.361	<0.0001
Median	43.0	39.0			

* Raw CBIQ scores out of 61. A higher score indicates less disability.

6.7.2 Early Chronic Pain

An additional comparison group was composed of individuals who presented after 91 days but prior to 6 months. A number of differences between the acute population and this early chronic group were evident (see Appendix J, tables 1-4). Most of the differences echoed the findings in the above comparison with the chronic population, although at an earlier time. The early chronic group were more likely to have returned to work, to have retained a lawyer, to have demonstrated pain focused behaviour, to have low back syndromes and to have received previous treatment and investigations. Some trends were apparent in the data with the addition of the early chronic comparison group.

In particular the proportion of individuals who had a positive outcome, who were female and who retained a lawyer increased from acute through early chronic to chronic presentation.

Chapter 7 Discussion

7.1 Introduction

The identification of predictors of early recovery after a motor vehicle collision is an important step in understanding and potentially reducing the burden of illness created by whiplash-associated disorders (WAD). This study has found a number of predictors for poor recovery in the secondary care (physiotherapy) setting, to be considered for further confirmatory evaluation. While adjusting for other covariates, older age, female gender, increasing lagtime between injury date and presentation for treatment, initial pain location, and province of injury were associated with a poor outcome (<10% improvement in disability by questionnaire score over the treatment period). In addition the interaction between work status and initial pain intensity, as well as, lawyer retention and initial pain intensity was found to be associated with a negative outcome, and as such, must be considered for future studies.

7.2 Prognostic Variables from Multivariate Logistic Regression

Age. The odds of a poor outcome following whiplash-associated disorder (WAD) increased with each year increase in age. Older individuals were more likely to demonstrate minimal early improvement in comparison to their younger counterparts. This predictive ability of age has been demonstrated in previous studies (1, 6) investigating whiplash recovery outcomes in both population- and hospital-based cohorts. For example, Cassidy and his colleagues reported that in the province of Saskatchewan there was approximately a 10% decrease in the time-to-claim closure for each decade increase in age (2). Biologically, older individuals may take longer to heal after a

musculoskeletal injury and the related prolonged inactivity (64, 65), or have less ability to compensate for the functional deficiencies that resulted from the motor vehicle collision (MVC). Potentially, this could have resulted in the slower improvements in the early stages of recovery observed in this study. Some have theorized that degenerative changes (24) in older individuals may be related to delayed recovery.

Gender. Several studies, investigating different source populations, have reported the importance of gender as a prognostic factor for recovery (2, 6, 16). This study observed a similar finding. It is unclear why women have a delayed recovery from WAD. Some authors have suggested that women are more vulnerable to musculoskeletal injury due to smaller muscle mass in the neck or smaller cross-sectional area of the muscle fibers (16, 65). Alternatively, some authors have highlighted that women and men experience pain differently (66). Keogh and Herdenfeldt have suggested that women report more pain experiences and more negative responses to pain when compared to men, and demonstrate lower thresholds and tolerance to a variety of noxious stimuli (66). In addition, men and women use different coping strategies when under stress (66). A number of these biologically and psychologically based theories could have explained the gender differences in this study.

Lagtime. The current study found that patients who waited the longest to seek treatment at a CBI clinic following their injury were less likely to demonstrate further meaningful improvement during the follow up period. Each additional month of lagtime was associated with an approximately 20% increase in the odds of a poor outcome. Several

sources (1, 52, 67) support an early, active approach to treatment for WAD. Interventions such as early exercise and advice to return to normal daily activities have been shown to shorten recovery time (67-69). Individuals who presented late to a CBI clinic may not have received the preceding interventions in a timely fashion post injury, resulting in a poor recovery outcome. Alternatively, whiplash-associated disorders are thought to have a favourable natural history in that they tend to resolve with time (1). As such, one might consider that patients with the longest lagtime reap the benefits of the additional healing window. However, at some point after a motor vehicle collision (MVC) the behavioural and psychological consequences of having a WAD become established. This may have occurred in those patients that delayed in their presentation to CBI and/or received a non-active therapeutic approach elsewhere.

Initial Pain Location. In this study injuries to the neck, with or without low back pain, were associated with a poor outcome. Several studies have examined the initial postcollision symptoms and their effect on recovery. Depending on the study, various symptoms, such as neck pain on palpation (18), headache (70), upper back pain (3), low back pain (71), radicular symptoms (6), and number of total symptoms (3) have been associated with delayed recovery or poor outcome. Generally those individuals with more bodily areas affected would likely demonstrate increased disability. It is reasonable to expect that these individuals have a more serious condition and may take longer to heal. In this regard, those patients in the current study with simultaneous neck and back pain were more likely to have a poor outcome. The neck could be considered a more vulnerable area for injury to occur, and this could explain the association of neck pain

and lack of meaningful improvement in comparison to those individuals with low back pain alone. The current study did not find a significant association with headache, mid-back pain and referred extremity pain with the outcome. There is inconsistent evidence in the literature regarding the potential effect of postcollision headache or mid back pain symptoms on recovery; however, radicular signs and symptoms are an established prognostic factor. It is unclear why the referral of pain to the extremity and/or positive neurological testing (radicular symptoms) was not associated with a negative outcome in the current study (although a trend of this nature was apparent during univariable analysis). The CBI focuses on the conservative treatment of mechanical spinal pain of musculoskeletal origin. The physiotherapists are specifically trained in the management of referred extremity pain, and early efforts are made to demystify these symptoms with the patient. Perhaps this approach of patient education and active treatment for these symptoms resulted in the timely alleviation of the anxiety and disability that radicular symptoms may have created in other cohorts.

Province. A higher percentage of patients from Ontario and Nova Scotia demonstrated a positive outcome in comparison to the reference category, British Columbia. It is unclear what effect the province of residence had on determining clinical improvement to a standardized treatment program at the Canadian Back Institute (CBI). The Quebec Task Force on Whiplash-Associated Disorders (QTF) suggested that the insurance jurisdiction where an injury occurred could alter prognosis (1). This effect was subsequently confirmed in the province of Saskatchewan when the introduction of no-fault legislation that eliminated pain and suffering compensation resulted in faster recovery (2). A similar

effect was seen in the Australian state of Victoria, when legislation limiting compensation was introduced (7). In addition, in countries where there is little public notion of chronic symptoms and disability associated with motor vehicle collisions and litigation is limited, the condition follows a more favourable course (8, 72, 73). Previous reports (2, 6) have also highlighted that a large variation in recovery time exists even within jurisdiction with common insurance systems. For example in the provinces of Quebec and Saskatchewan, there is a wide variation in the median recovery time, despite the fact that both provinces use no-fault insurance systems (2, 5). In addition to the compensation system of the province, other policies of the insurance jurisdiction or cultural factors may be important. In the current study, British Columbia, Alberta, Ontario, and Nova Scotia operated under tort insurance systems, where pain and suffering settlements are provided. Alternatively, the provinces of Saskatchewan, and Quebec operated under no-fault insurance systems, where pain and suffering settlements are not provided. Although it is believed that recovery is faster in no-fault jurisdictions, a detailed comparison between those provinces with such insurance systems was complicated by other observed differences between the provinces. For example, in the current study, variation across the provinces existed for the lagtime between injury and presentation to the clinic, the duration and number of treatment sessions, and the cost of the treatment program (see Table 1, Appendix K). Likely, social forces and insurance policy are influencing these differences. It is impossible to determine from this data how the complex interaction of factors determined by insurance policy may have altered the clinical course and prognosis of those injured in a MVC; however, this study found the

province of the compensation system to be an important predictor or recovery, and worthy of further, more detailed investigation in future studies.

Work status. In this study, those individuals who took time off work were more likely to demonstrate a clinically important improvement in disability questionnaire score. While there are conflicting results regarding this variable in the literature, the findings of this study are not consistent with other Canadian reports (2, 5). This is likely due to the differences in outcome measures between the three cohorts. The previous studies used a primary outcome of recovery time (time-to-claims closure, or time on compensation); however, in the present study a minimum clinically important change in recovery by questionnaire score was used as the primary outcome. As such, the time-to-claim closure may have been less in the individuals who remained at work. An examination of the disability scores at discharge revealed that those individuals who remained at work had higher overall function scores (less disability) than individuals who were off work. In addition, the off work group were more disabled on presentation (mean CBIQ score at presentation 25.2 as compared to 35.8 for the working population) and had more physically demanding jobs (49.4 % self-reported heavy labour as compared to 17.9% heavy labour in the working population). The off work individuals in this cohort may have represented a sub-group of patients who benefited from a break from their heavy work duties while remaining active and receiving education about their injuries in the structured environment of CBI. In addition, as these off work individuals were more disabled on presentation than their working counterparts more room for subsequent improvement as measured by the CBIQ was possible.

Lawyer Retention. This study found a similar association between lawyer retention and poor outcome that has been reported previously (2). After a MVC, individuals who have sustained injuries, have taken time off work, had a disruption of their normal daily activities, or are concerned about their recovery, may seek compensation for their injuries. In this sense it is not surprising that legal representation was associated with poor outcome. However, this study controlled for these factors (daily activities, work status, and severity of the initial complaints), and lawyer retention remained significantly associated with poor outcome. Some authors have argued that poor recovery is inevitable when one must repeatedly prove their illness (7, 74). Having a lawyer involved with a case presumes that an individual is seeking compensation for their predicament. In this context an individual will need to prove that the magnitude of their pain, suffering, and disability are grounds for compensation, often in an adversarial environment, in which others will be denying the existence of serious injury. In this regard, the process of seeking compensation and hiring a lawyer may cause an individual to become focused on their symptoms in comparison to one not involved in litigation. This could lead not only to the poor treatment outcome demonstrated in our study, but also the delayed recovery and increased costs associated with lawyer retention reported by others.

Initial Pain Intensity. Several studies have reported that the intensity of the presenting complaints is an important prognostic factor (1, 6, 17). The current study did not observe such an association in multivariate analysis. Using a change in questionnaire score as the primary outcome in this study likely resulted in partial control for the intensity of initial

symptoms. As the CBIQ asks the individual to rate how their pain has affected the various activities of daily life, it reasons that the intensity of the initial pain would also influence these same activities. Indeed a significant correlation ($r = -0.38$, $p<0.0001$) exists between the initial pain intensity and initial CBIQ raw score. Therefore, the intensity of initial pain is at least partially controlled for due to the nature of the outcome. In addition, linear regression modeling revealed that the initial pain intensity was significantly associated with the raw CBIQ exit score while controlling for age and gender ($p<0.0001$). It is important to also note that those individuals with more intense complaints on presentation will have lower initial scores on the CBIQ (i.e. higher disability), thus these individuals have more room for improvement while attending treatment at CBI, and therefore have a better chance of obtaining a minimum clinical improvement. A trend of this sort is apparent in the data. Individuals with mild pain (VAS 0-4) had on average a raw change in CBIQ score of 12.8 points (SD = 10.8), whereas individuals with moderate (VAS 5-7) and severe (VAS 8-10) intensity pain had average changes of 14.0 (SD = 11.0) and 13.9 (SD = 11.3) respectively. Finally, while the individuals with initially more intense pain did have more room for improvement, their overall disability was still greater at discharge. For instance, the average raw CBIQ exit score for those with the most intense pain was 36.8 (SD=12.1), while those with the mild initial pain on average scored 46.2 (SD=11.1) on discharge. In summary, this study did not find a significant association with the intensity of initial pain and poor recovery during multivariate analysis; however, it appears that this is due to the nature of the outcome.

Interaction Terms. The inclusion of the intensity variable revealed two significant interaction terms. The initial pain intensity (VAS) variable was involved in an interaction with both the lawyer retention and work status variables. As the intensity of pain increased, the strength of the association between lawyer retention and work status and delayed recovery diminished. No previous whiplash studies have thoroughly reported the impact of interactions among covariates.

Individuals with mild (VAS 0-4) and moderate (VAS 5-7) intensity pain at initial presentation, this study found that the retention of a lawyer was associated with a lack of meaningful improvement. A similar effect has been described in individuals recovering from a closed head injury (75). In this study Binder and his colleagues reported that the impact of financial incentives on disability and maintenance of symptoms was most pronounced in individuals with minor injuries. Individuals with minor disability and pain may report less improvement, as any medical improvement may impact future compensation that they may receive through litigation. When initial disability and pain are more intense, there is more room for clinical improvement, perhaps without the perception that future compensation will be affected.

It is not clear why the strength of the association between work status and a clinically important improvement increased as the initial pain intensity decreased. This is likely related to the precision of the CBIQ to measure change in individuals with minimal disability (i.e. mild intensity pain and remained at work). In comparison, a patient who was off work and likely received additional lost wages compensation might have

perceived and reported more disability even at low levels of initial pain intensity. In this manner these patients will have more room for improvement in comparison to a working counterpart, and therefore more likely to have demonstrated and reported a clinical improvement.

The prognostic model developed using the variables discussed above (and the smoking status variable) had a sensitivity of 0.74 and a specificity of 0.45. Although this model produced the best predictions of the various models compared, the strict application of this model as a diagnostic tool for use in clinical practice is not recommended. A significant number of patients would be falsely labeled as "destined for chronicity" (false positive rate = 55.1%), and a number of patients who eventually develop chronic symptoms would be incorrectly told that rapid recovery was likely (false negative rate = 25.9%). Neither of these scenarios is desirable. A patient falsely labeled as chronic may receive more intense therapy than they need, and some intensive rehabilitation programs may reinforce sick role behaviour (32). When recovery is uncomplicated the forecasting of a poor outcome may have a negative impact on recovery. Alternatively, overly optimistic predictions of outcome can create disappointment should recovery be delayed. False negatives may be denied necessary rehabilitation and suffer additional pain and disability because they were deemed to be at low risk for developing chronic symptoms (32).

In a qualitative sense the developed prognostic model alerts clinicians of a number of potential factors associated with a poor clinical outcome; however, the utility of the model for identification of patients at risk for delayed recovery is limited.

7.3 Thesis Strengths and Limitations

7.3.1 Strengths

Inception Cohort. An essential component of prognostic research is the assembly of an inception cohort (33, 34). Acute patients at a similar stage of recovery are needed such that the outcome of interest (early recovery or lack of early recovery) has not already occurred (1, 76). In a clinical setting of secondary care, and where the primary outcome of interest is a change in questionnaire score, an appropriate 'zero time' is the treatment start date. The longer the allowable lagtime between injury and treatment the greater the chance of enrolling patients with behavioural and psychological characteristics associated with a chronic pain state. Therefore, this study included only those patients whose lagtime between injury date and treatment start date was under 91 days. This period is prior to the definition of chronic WAD at 6 months post injury highlighted by the Quebec Task Force on Whiplash-Associated Disorders (QTF) (1). The 91-day period will allow for the accumulation of some sub-acute cases; however, with a median lagtime of 25 days (mean=32 days) most patients were still in an acute state. Ninety percent (90%) of the sample had lagtimes of less than 69 days. Having patients enrolled at a similar stage of disease helped to reduce the introduction of bias due to the issues of cohort assembly, and this variable was also controlled for in the analysis.

Outcome Variable. Common outcome measures used in previous prognosis studies of acute whiplash have been the time-to-claim closure or the self-report of the presence of whiplash symptoms (6). Although, time-to-claim closure has been shown to be a good indicator of recovery from WAD (2, 17), it continues to be criticized by some authors

(19). Time-to-claims closure is an administrative proxy of recovery; therefore, it is possible that some individuals continue to have significant disability despite closure of their claim.

Alternatively, self-report whiplash related symptoms are often used in studies; however, in addition to the recall bias introduced when asking one to remember past symptoms, previous studies rarely use a standardized instrument designed to measure pain and/or disability. In addition, the meaning of recovery will vary depending on the patient. Individuals will not only consider the resolution of their symptoms, but also the readjustment and adaptation of daily activities to work around the condition (20). In this regard, Beaton and her colleagues concluded that two individuals may place entirely different meanings on the concept of recovery, such that some individuals may not actually demonstrate a change in disability or function (20). This poses problems for the interpretation of recovery in studies that ask questions regarding the improvement in symptoms and/or improvement in the whiplash-associated disorder.

In the current study, the primary outcome was a change in disability questionnaire score between entry to and exit from a CBI clinic. A clinically important change in score indicated that a patient had demonstrated at least a minimal improvement in their condition. The data was collected in a standardized manner using a valid and reliable instrument. By using a patient centered outcome measure this study has investigated a number of risk factors for delayed recovery, while at the same time addressing the criticism that proxy markers of recovery such as time-to-claim closure may not indicate

actual improvement in the patient. In addition, the current study controlled for the effect described by Beaton et al above by using a change in questionnaire score as the primary outcome. Regardless of the internal meaning an individual placed on "getting better", a change in questionnaire score would reflect meaningful improvements perceived by the patient.

One potential limitation of using a change in questionnaire score as the primary outcome is the ability of the questionnaire to measure change in individuals with minimal disability (high initial function scores on the CBIQ). In this study this effect was particularly apparent in patients who presented with initial disability that was more than two standard deviations below the cohort's mean initial disability. These 69 highly functional people (3% of the cohort) demonstrated minimal improvements in CBIQ score (on average 2 points improvement) and therefore would not have been captured as a positive outcome, despite minimal overall disability. Overall, a total of 30 individuals (approximately 1% of the cohort) presented with such minimal initial disability that the primary outcome of minimal clinically important improvement was not measurable (i.e. out of the possible 61 points on the CBIQ these individuals scored greater than 55 points at initial presentation thereby making positive outcome impossible). It is unlikely these 30 highly functional individuals biased the results in anyway because there was so few of them; however it should be recognized that their inclusion with the other patients with a negative outcome might slightly diminish the risk estimates (odds ratios) for the various covariates of interest. Related to this concept is the fact that minimally important difference in change of questionnaire score may vary depending on the baseline score.

This effect has been reported with the use of other condition specific and generic questionnaires (45, 77). For example, Hagg and his colleagues reported smaller minimally important clinical differences in the lower end of the Roland-Morris questionnaire for low back pain (and vice versa at the upper end of the scale) (45).

Finally, when using a change in questionnaire score as an outcome measure, the assumption is made the traits being measured remain stable over time. In the current study, the assumption was made that the concepts of pain and disability remained constant between the two administrations of the CBIQ. The relatively short time between completion of the initial and discharge questionnaires strengthen this assumption.

Ultimately, the goal of treatment at CBI is to improve the quality of life as perceived by the patient. This goal holds true regardless of the baseline score of disability. For this reason the change in questionnaire score is necessary to capture improvements along the initial disability continuum. The current study is one of only a few studies to use a valid and reliable instrument to capture a whiplash recovery related outcome.

Treatment Protocol. The initial treatment that a patient receives after a motor vehicle collision appears to be an important prognostic factor (2). The recommended treatment for an acute patient is an active approach that encourages a return to normal activities as soon as possible (1). In addition, the QTF, as part of their research agenda, has recommended the standardization of assessment procedures such that critical baseline information is collected (1). Assessment procedures, data collection, and treatment at

CBI are standardized across the company treatment centres. Therefore the same information was collected and an active treatment approach was applied for all patients over several Canadian Provinces. In accordance with previous clinical based research (78) and recommendations for the design of a prognostic factor study (79) there was little variation in CBI treatment. This reduced the possibility of confounding by treatment regimen.

Multiple Insurance Jurisdictions. The insurance system where an individual has their claim managed is an important predictor of recovery (2). In addition, large variations in incidence and recovery time for WAD exist for different geographic regions (even when similar insurance systems exist) (1, 6). This study used patient data from six different provinces in Canada. Quebec and Saskatchewan operated under a no-fault system during the study period, while British Columbia, Alberta, Ontario, and Nova Scotia had various forms of a tort system. In addition, three of the provinces (B.C., Sask., and Que.) had sole insurance providers, while the other three provinces (Alta., Ont., N.S.) had multiple insurance companies operating in the jurisdiction. Although the influence of the differences in insurance system was not specifically investigated, this study did show that recovery varied by province, and that while controlling for the province a number of other significant risk factors emerged in both provinces with tort and no-fault systems. Unfortunately the sample of patients from Que. and Sask. was of limited size.

7.3.2 Limitations

Patient Selection. One must consider the selection of patients in this study when interpreting the results. Patients must have sought treatment at CBI in order to be included in the database. Individuals with mild forms of WAD may not seek treatment, and would be excluded from this study. In addition, CBI is dependent on physician referral for patient acquisition. Physicians do not refer all of their patients to this clinic system; therefore, certain types of whiplash injury may gravitate towards other types of treatment. Likely, this selection process eliminated the mild forms of WAD. However, this referral process would also eliminate severe injuries such as fractures, dislocations or head injuries that could bias the results. The effect of these referral patterns would be to increase patient homogeneity thereby narrowing predictor variable distribution, resulting in a bias towards the null (80). Despite this, the pain severity and functional status, the patient population of CBI was found to be similar to other rehabilitation providers in a pilot project by the Institute of Work & Health (81). In addition, the assembly of an inception cohort attempted to include individuals at a similar stage of recovery.

Unmeasured Prognostic Factors. This study investigated the associations of a large variety of personal, clinical, and treatment related factors and clinically important recovery. However, other prognostic factors that may predict poor outcome, such as depressive symptomatology (17), and initial health care provider (2) were not collected. In addition, due to missing values, two variables of interest (previous back or neck pain, and constant vs. intermittent pain) had to be excluded. It is possible that these or other unmeasured factors influenced the described associations.

Missing Values. Despite the overall large sample size of this cohort, 28.6% of the subjects were excluded because they did not complete a Visual Analogue Scale regarding their initial pain intensity. Overall there was no significant difference in outcome between the non-participants (73.6 % positive outcome) when compared to the participants (72.0% positive outcome). In addition, when comparing outcome in the participants and non-participants, an indicator variable of participation in the cohort (i.e. those individuals who completed the VAS) was not associated with outcome, while controlling for other important predictors. Finally, important factors associated with participation (i.e. work status and lawyer retention) were adjusted for in the cohort analysis. Comorbid medical conditions and previous treatment were not included in the final model despite noted differences between those in the study cohort and those excluded, in favour of a more parsimonious model. Even with the exclusion of a significant reduction of a number of records, this study represents one of the largest cohorts assembled investigating the recovery of acute whiplash.

Duration of Follow-Up. Ideally the follow-up questionnaires would have been completed at identical times for each patient. However, the nature of clinical practice results in a variation in the duration that each individual receives treatment (and thus the timing of discharge and completion of the exit questionnaire). The treatment approach at CBI is standardized, however the point at which the doctor, therapist, or patient deem themselves sufficiently recovered will vary. A patient who improves rapidly will have less follow-up time because they will be discharged earlier. Likewise a patient who is

slow to improve will have a longer duration of treatment. Other factors such as insurance settlement or policy, and patient characteristics may also influence the duration of therapy. The median duration of treatment in the study cohort was 56 days. The duration of follow-up was not associated (p=0.94) with a clinically important improvement in the CBIQ (the dichotomous primary outcome) or the overall change in CBIQ (continuous) score (p=0.44); however, the duration of follow-up was mildly correlated (Pearson correlation coefficient) with the raw initial CBIQ score (r = -0.09) and raw discharge CBIQ score (r = -0.07). Those patients who reported higher levels of disability on presentation or discharge were followed up for a slightly longer duration. The magnitude of this difference in follow-up was relatively small, as approximately 97 % of the cohort had median follow-up times within 28 days of each other. This study would have been additionally strengthened by a longer duration of follow-up. Nevertheless, the follow-up time was suitable to monitor early clinical improvement.

7.4 Conclusion

This study has provided valuable insights into the early stages of recovery from whiplash injuries of varying severity, across multiple insurance jurisdictions. This extensive exploratory work investigating the association of a number of personal, clinical and treatment related variables and early improvement of pain and disability after motor vehicle collision in the secondary care physiotherapy setting, has indicated variables that require particular attention in subsequent research. Older age, female gender, increasing lagtime between injury date and presentation for treatment, initial pain location, and province of injury were associated with minimal early improvements in response to

treatment. Lawyer retention and work status while interacting with the initial pain intensity were also associated with less improvement. This study sought to further investigate risk factors for delayed recover in the secondary care setting (an area with minimal previous research) and to explore how legal and compensation issues might influence recovery. Both of these objectives have been accomplished. The current study and one previous study(2) now provide consistent evidence that legal and compensation issues are important. In addition, lawyer retention was an important factor regardless of the specific policies within the insurance systems of six Canadian provinces.

Initial pain intensity has been previously described as an important prognostic factor in the recovery from whiplash (1, 6). However future researchers should consider the interaction that this variable has with the retention of legal services and work status, and consider other potential interactions that might occur based on the intensity of initial complaints. In addition, this study has provided a description of the chronic whiplash population as defined by the Quebec Task Force (QTF) and an early chronic group. A comparison of these two groups with the acute whiplash population was noteworthy because it demonstrated many significant differences between the populations that occurred prior to the six month definition of chronic pain suggested by the QTF (1).

The information provided by this study will also be useful for clinicians in the secondary care setting who are likely to treat a similar patient population. Ideally clinicians should be able to identify those patients that might require special attention and perhaps offer more intensive or alternate treatment. Although some uncertainty will always exist when

determining the prognosis for a particular patient this study has provided a list of factors that will help a clinician identify a patient who will not make a meaningful early recovery. Clinicians must pay particular attention to non-clinical factors, as these external factors and personal characteristics were found to be particularly important, and are not the usual focus of clinical practice.

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Appendices

Appendix A: The Quebec Task Force Classification of Whiplash-Associated Disorders (1)

Grade	Clinical Presentation
0	No complaint about the neck No physical sign(s)
I	Neck complaint of pain, stiffness or tenderness only No physical sign(s)
II	Neck complaint and Musculoskeletal sign*
III	Neck complaint and Neurological sign**
IV	Neck complaint and Fracture or dislocation

* Musculoskeletal signs include decreased range of motion and point tenderness.
** Neurological signs include decreased or absent deep tendon reflexes, weakness and sensory deficits.

Appendix B: Criteria for the Appraisal of the Methodological Quality of Cohort Studies

1) Research question and objective are clearly defined
2) Source population is identified
3) Inclusion and exclusion criteria are described and appropriate
4) Participation rate is reported and appropriate (at least 60%) or a comparative analysis of participants and non-participants
5) Follow-up is reported, explained and reasonable
6) Where applicable loss to follow-up is equal in both groups
7) Sample size is pre-planned based on the objective of the study
8) Statistical analysis is appropriate for the research question and objective of the study
9) Adjustment is made for important variables*
10) Zero time is identified
11) Baseline comparability of various group is reported where applicable
12) Same data collection procedures are conducted for all members of the cohort
13) Important baseline variables are measured, valid, and reliable
14) All aspects of a prognostic factor are measured (dose, level, duration) and done so adequately (previous, baseline, follow-up)
15) Regular follow-up are accomplished
16) Other prognostic factors are measured
17) Duration of follow-up is adequate for the objective of the study **
18) Outcome is defined and measurable
19) Outcome is valid
20) Outcome assessment was blind

*Based on the previous systematic reviews of the whiplash literature (1, 6) the following prognostic factors were considered important for adjustment: age, gender, initial pain intensity (neck and headache), and radicular signs and symptoms.

**Based on the objectives of all studies reviewed, a follow-up duration of at least one year was considered appropriate.

Appendix C: Canadian Back Institute Spinal Assessment Form – page 1

SPINAL ASSESSMENT

CANADIAN BACK INSTITUTE

PATIENT

PATIENT | ASSESSMENT DATE MM / DD / YY | AGE

AREA ASSESSED ☐ BACK ONLY ☐ NECK ONLY ☐ BACK & NECK ☐ RE-ASSESSMENT

TYPE OF ASSESSMENT ☐ CA ☐ CRA ☐ FCE ☐ IA ☐ RA ☐ WA ☐ OTHER ☐ _____

ELEMENTS OF THIS EPISODE

SITE OF DOMINANT PAIN ☐ BACK ☐ LEG ☐ NECK ☐ ARM

SYMPTOM LOCATION ☐ BACK ☐ BUTTOCK ☐ THIGH ☐ CALF ☐ FOOT ☐ NECK ☐ INTER SCAP ☐ TRAP RIDGE ☐ ARM ☐ FOREARM ☐ HAND ☐ H / A

DURATION ☐ DAYS ☐ WEEKS ☐ MONTHS ☐ YEAR(S)

BACK/LEG PAIN ☐ CONSTANT ☐ INTERMITTENT ☐ NONE AT PRESENT

NECK/ARM PAIN ☐ CONSTANT ☐ INTERMITTENT ☐ NONE AT PRESENT

DAY - A.M. ☐ BETTER ☐ WORSE ☐ SAME

DAY - P.M. ☐ BETTER ☐ WORSE ☐ SAME

PAIN DISTURBING SLEEP ☐ YES ☐ NO

BLADDER CONTROL ☐ UNCHANGED ☐ CHANGED

BOWEL CONTROL ☐ UNCHANGED ☐ CHANGED

SIGNIFICANT MED. HISTORY _____

RECENT UNEXPLAINED WEIGHT LOSS ☐ YES ☐ NO

DATE THIS EPISODE STARTED MM / DD / YY

WAS THERE AN EVENT THAT CAUSED THIS EPISODE ? ☐ NO ☐ YES

IF YES, HOW LONG AFTER EVENT DID PAIN START ? ☐ MINUTES ☐ HOURS ☐ DAYS ☐ WEEKS

MECHANISM _____

NO PAIN — WORST PAIN

BACK PAIN 0 1 2 3 4 5 6 7 8 9 10

LEG PAIN 0 1 2 3 4 5 6 7 8 9 10

NECK PAIN 0 1 2 3 4 5 6 7 8 9 10

ARM PAIN 0 1 2 3 4 5 6 7 8 9 10

HEADACHE 0 1 2 3 4 5 6 7 8 9 10

WORK HISTORY

OCCUPATION : _____ ☐ HOMEMAKER ☐ STUDENT ☐ RETIRED

TYPE OF WORK ☐ SEDENTARY / LIGHT ☐ LIGHT ☐ MEDIUM ☐ HEAVY ☐ VERY HEAVY

CURRENTLY WORKING ☐ YES ☐ NO

IF YES, ☐ WORKING WITH SYMPTOMS ☐ WORKING WITHOUT SYMPTOMS ☐ PREVIOUS OCCUPATION ☐ NEW OCCUPATION ☐ FULL HOURS ☐ PARTIAL HOURS ☐ FULL DUTY ☐ MODIFIED DUTY

IF NO, LAST DAY WORKED MM / DD / YY ☐ POSITION AVAILABLE ☐ POSITION TERMINATED ☐ LOOKING FOR WORK ☐ DISABILITY PENSION ☐ NO DIRECTION

LUMBAR

EFFECT ON PAIN

	BETTER	WORSE	SAME	BEST	WORST
FLEXION					
EXTENSION					
SITTING					
RISE FROM SIT					
STANDING					
WALKING					
LYING					

MANAGEMENT OF THIS EPISODE

TREATMENT

INVESTIGATIONS ☐ NONE ☐ X-RAY ☐ MYELO / CT / MRI ☐ BLOODWORK ☐ BONE SCAN ☐ ELECTRICAL STUDIES

PREVIOUS EPISODES

☐ NONE ☐ BACK DOMINANT ☐ LEG DOMINANT

TIME SINCE 1st EPISODE ☐ < 1 YR. ☐ 1 - 5 YRS. ☐ > 5 YRS.

IN THE PAST YEAR FREQ. ☐ INCREASE ☐ DECREASE ☐ SAME ☐ NIL

DUR. ☐ INCREASE ☐ DECREASE ☐ SAME ☐ NIL

SIM. TO PRESENT EPISODE ☐ YES ☐ NO

PREVIOUS BACK SURGERY ☐ NONE ☐ DECOMPRESSION ☐ FUSION ☐ MULTIPLE PROCEDURES

CERVICAL

EFFECT ON PAIN

	BETTER	WORSE	SAME	BEST	WORST
FLEXION					
EXTENSION					
ROTATION					
SITTING					
STANDING					
WALKING					
LYING					

MANAGEMENT OF THIS EPISODE

TREATMENT

INVESTIGATIONS ☐ NONE ☐ X-RAY ☐ MYELO / CT / MRI ☐ BLOODWORK ☐ BONE SCAN ☐ ELECTRICAL STUDIES

PREVIOUS EPISODES

☐ NONE ☐ NECK DOMINANT ☐ ARM DOMINANT

TIME SINCE 1st EPISODE ☐ < 1 YR. ☐ 1 - 5 YRS. ☐ > 5 YRS.

IN THE PAST YEAR FREQ. ☐ INCREASE ☐ DECREASE ☐ SAME ☐ NIL

DUR. ☐ INCREASE ☐ DECREASE ☐ SAME ☐ NIL

SIM. TO PRESENT EPISODE ☐ YES ☐ NO

PREVIOUS NECK SURGERY ☐ NONE ☐ DECOMPRESSION ☐ FUSION ☐ MULTIPLE PROCEDURES

Appendix C: Spinal Assessment Form – page 2

LUMBAR

PHYSICAL EXAMINATION

OBSERVATION
SITTING POSTURE — 1 FLEXED/FLAT | 2 NEUTRAL | 3 LORDOTIC — SHIFT ☐ L ☐ R

STANDING POSTURE — 1 FLEXED/FLAT | 2 NEUTRAL | 3 LORDOTIC — SHIFT ☐ L ☐ R

STRUCTURAL SCOLIOSIS ☐ YES ☐ NO

RANGE OF MOVEMENT (L R)
L/S FLEXION ☐ NORMAL ☐ REDUCED DEVIATION ☐ ☐
EXTENSION ☐ NORMAL ☐ REDUCED DEVIATION ☐ ☐

TEST MOVEMENTS

DISTAL SYMPTOM ☐ BACK ☐ BUTTOCK ☐ THIGH ☐ CALF ☐ FOOT

	BEFORE	B W S	C P NIL	PDM ERP NIL	AFTER
STAND FLEXION	/10				/10
EXTENSION	/10				/10
SHIFT L	/10				/10
SHIFT R	/10				/10
LYING FLEXION	/10				/10
EXTENSION	/10				/10
SHIFT L	/10				/10
SHIFT R	/10				/10

NEW LOCATION OF DISTAL SYMPTOM _____

NEUROLOGICAL EXAMINATION

IRRITATION TESTS		NORMAL	L+	R+
SLR	L4-S2	☐	☐ ____°	☐ ____°
☐ WELL LEG LIFT				
☐ CROSSOVER				
		NORMAL	L+	R+
FST	L2-4	☐	☐	☐

CONDUCTION TESTS		NORMAL	L+	R+
KNEE REFLEX	L3-4	☐	☐	☐
TRENDELENBURG	L5	☐	☐	☐
ANKLE DORSIFLEXION	L4-5	☐	☐	☐
EXT. HAL. LONG.	L5	☐	☐	☐
ANKLE REFLEX	S1	☐	☐	☐
PLANTAR FLEXION	S1	☐	☐	☐
GLUTEUS MAXIMUS	S1	☐	☐	☐
SADDLE SENSATION	S3-5	☐ NORMAL		☐ REDUCED
PLANTAR RESPONSE	CORD	☐	☐	☐

ARE THE PHYSICAL FINDINGS CONSISTENT WITH THE HISTORY ? ☐ YES ☐ NO

OTHER LOCATIONS

HIP JOINTS ☐ NOT TESTED ☐ NORMAL ☐ L+ ☐ R+
S.I. JOINTS ☐ NOT TESTED ☐ NORMAL ☐ L+ ☐ R+

DOMINANT PATTERNS

☐ PATTERN 1 ☐ PATTERN 2 ☐ PATTERN 3 ☐ PATTERN 4 ☐ PATTERN 5

IF PATTERN 3 ☐ LEFT ☐ RIGHT ☐ BILATERAL
IF PATTERN 4 ☐ LEFT ☐ RIGHT ☐ BILATERAL

IF PAT 3 OR 4 COND. LOSS ☐ L 3,4 ☐ L5 ☐ S1

PAT 5 COMBINED WITH ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ NONE

CERVICAL

PHYSICAL EXAMINATION

OBSERVATION
SITTING POSTURE ☐ HEAD FORWARD ☐ EAR OVER SHOULDER
SHIFT ☐ L ☐ R

STANDING POSTURE ☐ HEAD FORWARD ☐ EAR OVER SHOULDER
SHIFT ☐ L ☐ R

RANGE OF MOVEMENT (L R)
C/S FLEXION ☐ NORMAL ☐ REDUCED DEVIATION ☐ ☐
EXTENSION ☐ NORMAL ☐ REDUCED DEVIATION ☐ ☐
SIDE BEND ☐ NORMAL ☐ RESTRICTION ☐ ☐
ROTATION ☐ NORMAL ☐ RESTRICTION ☐ ☐

TEST MOVEMENTS

DISTAL SYMPTOM ☐ NECK ☐ SCAPULA ☐ TRAP ☐ ARM ☐ FOREARM ☐ HAND ☐ H/A

	BEFORE	B W S	C P NIL	PDM ERP NIL	AFTER
SIT FLEXION	/10				/10
PROTRACTION	/10				/10
RETRACTION	/10				/10
EXTENSION	/10				/10
LYING RETRACTION	/10				/10
EXTENSION	/10				/10
SIDE BEND L	/10				/10
SIDE BEND R	/10				/10

NEW LOCATION OF DISTAL SYMPTOM _____

CONDUCTION TESTS		NORMAL	L+	R+
ANT. DELTOID	C6	☐	☐	☐
BICEP REFLEX	C6	☐	☐	☐
BICEP POWER	C6	☐	☐	☐
TRICEP REFLEX	C7	☐	☐	☐
TRICEP POWER	C7	☐	☐	☐
EXT. DIG. LONG.	C7	☐	☐	☐
PLANTAR RESPONSE	CORD	☐	☐	☐

ARE THE PHYSICAL FINDINGS CONSISTENT WITH THE HISTORY ? ☐ YES ☐ NO

OTHER LOCATIONS

SHOULDER JOINTS ☐ NOT TESTED ☐ NORMAL ☐ L+ ☐ R+
BPT ☐ NOT TESTED ☐ NORMAL ☐ L+ ☐ R+
THORACIC SPINE ☐ NOT TESTED ☐ NORMAL ☐ +

DOMINANT PATTERNS

☐ PATTERN 1 ☐ PATTERN 2 ☐ PATTERN 3 ☐ PATTERN 4 ☐ PATTERN 5

IF PATTERN 3 ☐ LEFT ☐ RIGHT ☐ BILATERAL
IF PATTERN 4 ☐ LEFT ☐ RIGHT ☐ BILATERAL

IF PAT 3 OR 4 COND. LOSS ☐ C6 ☐ C7 ☐ OTHER

PAT 5 COMBINED WITH ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ NONE

ALTERNATIVE FINDINGS

☐ NONE ☐ ACUTE CES ☐ SUSPECT SYSTEMIC DISEASE ☐ HIP JOINT(S) ☐ SI JOINT(S)
☐ NON MECHANICAL HEADACHE ☐ THORACIC SPINE ☐ SHOULDER JOINT(S) ☐ BPT

NON ORGANIC / BEHAVIOURAL FINDINGS

☐ NONE
☐ NOT TESTED
☐ POSITIVE

IF POSITIVE, ☐ SUPERFICIAL TEND. ☐ AXIAL LOADING ☐ SLR DISCREPANCY ☐ SENSORY DISTURB. ☐ OVER-REACTION
☐ NON ANATOMIC TEND. ☐ ACETAB. ROTATION ☐ DOUBLE SLR ☐ COG WHEEL

RECOMMENDATIONS

THERAPIST SIGNATURE

Appendix D: Canadian Back Institute Questionnaire (CBIQ)

INFORMATION ON YOUR INJURY

THE FOLLOWING INFORMATION IS NECESSARY TO PROVIDE THE THERAPIST WITH A BETTER UNDERSTANDING OF YOUR INJURY.

1. AREA(S) AFFECTED	☐ NECK	☐ ARM	☐ BACK	☐ LEG	☐ OTHER
2. CURRENT EPISODE CAUSED BY	☐ WORK ACCIDENT	☐ MOTOR VEHICLE ACCIDENT	☐ UNKNOWN	☐ OTHER	
3. ONSET OF PAIN	☐ SUDDEN	☐ GRADUAL			
4. LENGTH OF TIME IN PAIN	☐ 2 WEEKS OR LESS	☐ 3-10 WEEKS	☐ 11 WKS - 6 MO	☐ + 6 MONTHS	
5. ABILITY TO DO DOMESTIC CHORES	☐ NORMAL	☐ MOST BUT SLOWER	☐ FEW	☐ NONE	
6. SPORTS ANDACTIVITIES	☐ NORMAL	☐ LESS	☐ NONE		
7. IS A LAWYER INVOLVED WITH YOUR INJURY ?	☐ NO	☐ YES			
8. SMOKER	☐ NO	☐ YES			
9. NEED FOR REST DURING THE DAY	☐ UNCHANGEDT	☐ REST LESS THAN 1/2 DAY	☐ REST MORE THAN 1/2 DAY		
10. I VISIT MY DOCTOR	☐ NEVER	☐ RARELY	☐ ONCE A MONTH	☐ MORE THAN ONCE A MONTH	
11. NEED FOR PAIN MEDICATION	☐ NEVER	☐ OCCASIONALLY	☐ ONCE A DAY	☐ SEVERAL TIMES / DAY	

PLEASE INDICATE HOW YOUR PAIN HAS AFFECTED THE FOLLOWING ACTIVITIES :

	12. WALK	13. SIT	14. STAND	15. LIFT	16. DRESS	17. WORK	18. TRAVEL	19. SLEEP
NO EFFECT	☐	☐	☐	☐	☐	☐	☐	☐
MILD	☐	☐	☐	☐	☐	☐	☐	☐
DIFFICULT	☐	☐	☐	☐	☐	☐	☐	☐
IMPOSSIBLE	☐	☐	☐	☐	☐	☐	☐	☐

Note that question 1, 2, 3, 4, 7 and 8 are not included in the calculation of questionnaire function score. The result is the 14-item questionnaire similar to the Low Back Outcome Score (30)

Appendix E: Alternate Approaches of Imputation for Missing Data Values

1) *Central Tendency.* One alternate approach uses imputed data to replace the missing values. An overall mean or group-specific (i.e. age or gender specific) mean may be appropriate. The median value could be used for highly skewed data.

2) *Regression.* In this method results are obtained using regression estimates for the missing values based on the other information that is provided within the record (39).

3) *Indicator Method.* Miettnen suggests that a modeling approach using indicator variables for missing values is a suitable alternative (39). In this method for each variable (X) with missing values, a new variable indicating "missing" (M) is created. The M variable would take the value of 1 when the value is missing and 0 other wise. Next the missing values of X are replaced with a constant Finally the regression is conducted with both the original variable with imputed values and the M variable (82). Generally, the constant imputed into the X variable is a product of the X and (1-M). Thus, if the X variable is missing the product of X*(1-M) would be zero. When dealing with categorical variables this method is equivalent to creating a new missing category for the covariate (i.e. commonly coded as 999 or 99) (38).

4) *Multiple Imputation.* More complex statistical procedures have also been developed. Multiple imputation techniques create multiple data sets using a number of plausible imputations for each missing value (83). Each of these datasets area analyzed as if complete, and then the results are combined in a manner that takes into account the variability that was generated (38).

Appendix F: Physical Examination Conduction Tests for Each Anatomical Neurological Area

The dataset contains the physiotherapist's clinical interpretation of whether the neurological examination (conduction tests) was positive or negative. The conduction tests were categorized into summary variables representing their specific neurological areas: C6 (bicep reflex, anterior deltoid, bicep), C8 (triceps reflex, extensor digitorum longus, triceps power), L4 (knee reflex, ankle dorsiflexion), and S1 (ankle reflex, plantar flexion, gluteus maximus). After the tests were categorized, they were further classified as either positive or negative based on the results of the individual conduction tests. For each anatomical area there typically is a deep tendon reflex test and 1 or 2 motor power tests. If both the deep tendon reflex and the motor power tests were positive, the anatomical region was presumed positive. If both the deep tendon reflex and the motor power tests were negative then the anatomical region was considered negative. If either the tendon reflex test or both of the motor power tests were positive then the anatomical region was presumed positive. If the deep tendon reflex was not tested, and discordant results remain among the motor power tests than the anatomical region was presumed negative (i.e. normal).

Note: -ve = normal, +ve = abnormal, nt = not tested

Patients were categorized as negative for C6 based on the following test results:

Bicep reflex	Anterior deltoid	Bicep
-ve	-ve	-ve
-ve	-ve	nt
-ve	nt	-ve
nt	-ve	-ve
-ve	nt	nt
nt	-ve	nt
nt	nt	-ve

No other combinations were observed, and therefore are not listed.

Patients were categorized as positive for C6 based on the following test results:

Bicep reflex	Anterior deltoid	Bicep
+ve	+ve	+ve
+ve	nt	+ve
+ve	nt	nt
+ve	-ve	-ve
+ve	nt	-ve
nt	+ve	+ve
-ve	+ve	+ve
-ve	+ve	nt
-ve	nt	+ve

No other combinations were observed, and therefore are not listed.

Patients were categorized as negative for C8 based on the following test results:

Tricep reflex	Extensor digitorum longus	Tricep
-ve	-ve	-ve
-ve	-ve	nt
-ve	nt	-ve
nt	-ve	-ve
-ve	nt	nt
nt	-ve	nt
nt	nt	-ve
nt	+ve	-ve
nt	-ve	+ve

No other combinations were observed, and therefore are not listed.

Patients were categorized as positive for C8 based on the following test results:

Tricep reflex	Extensor digitorum longus	Tricep
+ve	+ve	+ve
+ve	nt	+ve
+ve	+ve	nt
+ve	nt	nt
+ve	-ve	-ve
+ve	-ve	nt
+ve	nt	-ve
-ve	+ve	nt
-ve	nt	+ve

No other combinations were observed, and therefore are not listed.

Patients were categorized as negative for L4 based on the following test results:

Knee reflex	Ankle dorsiflexion
-ve	-ve
-ve	nt
nt	-ve

No other combinations were observed, and therefore are not listed.

Patients were categorized as positive for L4 based on the following test results:

Knee reflex	Ankle dorsiflexion
+ve	+ve
+ve	-ve
+ve	nt
nt	+ve
-ve	+ve

No other combinations were observed, and therefore are not listed.

Patients were categorized as negative for S1 based on the following test results:

Ankle reflex	Plantar flexion	Gluteus maximus
-ve	-ve	-ve
-ve	-ve	nt
-ve	nt	-ve
nt	-ve	-ve
-ve	+ve	-ve
-ve	-ve	+ve

No other combinations were observed, and therefore are not listed.

Patients were categorized as positive for S1 based on the following test results:

Ankle reflex	Plantar flexion	Gluteus maximus
+ve	+ve	+ve
+ve	-ve	-ve
+ve	-ve	nt
+ve	nt	-ve
nt	nt	+ve
nt	+ve	nt

No other combinations were observed, and therefore are not listed.

Appendix G: Waddell's Non-organic Signs

- Tenderness:
  - ➔Superficial – the patient's skin is tender to light pinch over a wide area of lumbar skin
  - ➔Non-anatomic – deep tenderness felt over a wide area, not localized to one structure

- Simulation Tests:
  - ➔Axial Loading – light vertical loading over patient's skull in the standing position causes typical lumbar pain
  - ➔Acetabular Rotation – back pain is reported when the pelvis and shoulders are passively rotated in the same plane as the patient stands. This is considered to be a positive test if pain is reported in the first 30 degrees.

- Distraction Tests:
  - ➔Straight Leg Raise Discrepancy – marked improvement of straight leg raising on distraction as compared to formal testing
  - ➔Double Leg Raise – when both legs are raised after straight leg raising, the organic response would be a greater degree of double leg raising. Patients with a non-organic component demonstrate significantly less double leg raise as compared to the single leg raise

- Regional Disturbances:
  - ➔Weakness – cogwheeling or giving way of many muscle groups that cannot be explained on a neurological basis
  - ➔Sensory disturbance – diminished sensation fitting a "stocking" rather than a dermatomal pattern

- Overreaction:
  - ➔disproportionate verbalization, facial expression, muscle tension and tremor, collapsing or sweating

Appendix H: Common Techniques of Internal Validation for Logistic Regression

1) Single sample statistics. Statistics such as Akaike's Information Constant (AIC) or Schwarz Bayesian Criterion (SC) provide simple estimators of the generalization error. These methods use the entire sample to generate an estimator. Model validation based on these indices may over estimate performance (60, 61). For instance, if another sample of patients (even when drawn from the same population as the original) is tested with the model, typically the discriminative ability is reduced (61). This is because the same data that was used to build the model and generate parameter estimates is also being used to test the model (60). Several methods have been described to attempt to address this limitation (i.e. split-sample, leave-one-out, or external validation).

2) Split-Sample Cross Validation. A split-sample approach can be employed, in which a percentage (typically ½ or ¾) of the data is randomly selected to build the model (training sample), while the remainder of the data is used for test purposes or validation (55). The test sample is not used in any way during the training. The disadvantage of this approach is that the smaller sample size will result in loss of some precision in the coefficient estimates. In addition this method of validation has shown to underestimate performance in logistic regression models (61).

3) Leave- One-Out Cross Validation. Other methods of cross-validation leave other fractions of the data out for validation purposes. The dataset may be divided into k subsets, of approximately equal size, each of which will be used to both train and test the data. The model is trained k times with one of the subsets left out to compute the error criterion of interest. If k is equal to the entire sample then the validation is termed "leave-one out" cross validation, because each time only one subject is left out for test purposes (62). During this procedure one record is omitted from the data. The regression model is fit with the remaining n-1 records. The parameters of the model are estimated using this analysis dataset and then these parameters are used to estimate the outcome on the single holdout observation. Note that the single holdout observation was not used to generate the parameter estimates. The process is repeated by removing a different observation each time. The accuracy of the model is estimated by comparing the predicted to observed outcome observation in the holdout samples.

Appendix I: Table Comparing the Study Population (in the Comparison Study of Acute vs. Chronic Injury) and Those That Were Excluded Due to Not Responding to Either the Entry or Exit Patient Questionnaire

Table 1 - Characteristics associated with inclusion in comparison study based on completion of both initial and discharge patient questionnaire.

Variable	Respondents (n=3472)	Excluded due to missing questionnaire (n=5473)	p value
Age – mean yrs (SD)	35.1 (11.1)	35.9 (11.4)	0.0088
Gender - % female	55.8	53.8	NS
Work status - % not working	56.0	58.3	0.0326
Lawyer retention - % with lawyer	36.1	35.6	NS
Lagtime – mean no. of days (SD)	30.4 (23.5)	31.6 (24.7)	NS
Smoking status - % current or former	34.4	39.6	<0.0001
Province - %			
British Columbia	31.9	25.8	<0.0001
Alberta	18.5	20.8	0.0079
Saskatchewan	3.0	4.2	0.0048
Ontario	40.8	42.3	NS
Quebec	1.2	2.1	0.0025
Nova Scotia	4.5	4.5	NS
Previous treatment - % Yes	19.6	21.1	NS
Concurrent treatment - % Yes	13.2	11.2	<0.0001
Comorbid medical conditions - % yes	8.3	10.9	0.0241
Non-organic signs			
≥3 positive - %	5.0	6.7	0.0008
CBIQ raw score on presentation			
No. of respondents		7698	
Mean score (SD)	35.6 (11.6)	33.7 (11.7)	<0.0001
Initial pain intensity			
No. of respondents	2500	3907	
Mean score (SD)	5.9 (2.0)	6.0 (2.1)	NS
Median	6.0	6.0	
Duration of treatment program			
Mean days (SD)	72.1 (66.0)	61.7(71.0)	<0.0001

Appendix J: Comparison of the Outcome, Personal, Clinical and Treatment Related Characteristics in Acute, Early Chronic, and Chronic Patient Populations After a Motor Vehicle Collision

Table 1 – Outcome information for 5581 patients presenting with acute, early chronic or chronic injuries following a motor vehicle collision

Outcome	Acute ≤91 days (N = 3075)	Early Chronic >91 days ≤6mos (N = 958)	Chronic > 6 mos (N = 1548)
Clinically Important Change in CBIQ			
Positive Outcome (>10%) – no./total no. (%)	**2224 / 3075 (72.3)**	**588 / 958 (61.4)**	**806 / 1548 (52.1)**
Negative Outcome (<10%)	**681/ 3075 (27.7)**	**370 / 958 (39.6)**	**742 / 1548 (47.9)**
Mean Change in CBIQ			
Mean (SD)	**13.8 (11.1)**	**9.1 (9.4)**	**6.8 (8.4)**
Median	13.0	8.0	6.0
CBIQ Raw Score at Presentation			
Mean (SD0	29.3 (10.5)	**30.1 (9.6)**	**32.2 (9.0)**
Median	29.0	30.0	33.0
CBIQ Raw Score at Discharge			
Mean (SD)	**43.1 (12.2)**	**39.2 (11.0)**	39.0 (10.2)
Median	43.0	39.0	39.0

Bold indicates $p<0.05$ with Bonferroni correction for multiple comparisons applied. Comparisons made between adjacent columns only. If all three columns bold, then both the Acute vs. Early Chronic comparison and Early Chronic vs. Chronic columns were significant.

Appendix J: Comparison of the Outcome, Personal, Clinical and Treatment Related Characteristics in Acute, Early Chronic, and Chronic Patient Populations After a Motor Vehicle Collision Continued

Table 2 - Personal characteristics of 5581 patients presenting with acute, early chronic or chronic injury after a motor vehicle collision

Personal Characteristics	Acute ≤91 days (N = 3075)	Early Chronic >91 days ≤ 6 mos (N = 958)	Chronic > 6mos (N = 1548)
Age			
no. of respondents	3075	958	1548
Mean age – yr(SD)	35.7 (10.6)	36.1 (10.8)	36.2 (10.9)
Female Sex – no./total no. (%)	**1719 / 3075 (55.9)**	**536/ 958 (54.9)**	**954 / 1548 (61.6)**
Lagtime			
no. of respondents	3053	867	1548
Mean no. of days (SD)	31.4 (23.5)	133.6 (26.1)	434.0 (321.6)
Median	25	132	348
Off work because of collision			
no. / total no. (%)	**1749 / 3075 (56.9)**	**506 / 958 (52.8)**	**506 / 1548 (32.7)**
Physical Demands of Work – no./total no (%)			
Sedentary	447 / 2484 (18.0)	133 / 733 (18.1)	239 / 1203 (19.9)
Light	480 / 2484 (19.3)	129 / 733 (17.6)	282 / 1203 (24.4)
Medium	682 / 2484 (27.5)	192 / 733 (26.2)	305 / 1203 (25.4)
Heavy	875 / 2484 (35.2)	279 / 733 (38.1)	377 / 1203 (31.3)
If remained at work has modified work duties because of collision.			
no. / total no (%)	466 / 1310 (35.6)	**187 / 490 (38.2)**	**279 / 1024 (27.2)**
Retained a lawyer on or before first visit to clinic – no./total no. (%)	**913 / 3075 (29.7)**	**453 / 958 (47.3)**	**943 / 1548 (60.9)**
Retained a lawyer at some point prior to discharge – no./total no. (%)	**1127 / 3075 (36.7)**	**474 / 958 (49.5)**	**935 / 1548 (60.4)**
Smoking Status			
current or former - no./total no. (%)	1054 / 3072 (34.3)	336 / 957 (35.2)	561 / 1547 (36.3)
non-smoker - no./total no/ (%)	2018 / 3072 (65.7)	621 / 957 (64.8)	986 / 1547 (63.7)
Province – no./total no. (%)			
British Columbia	**1020 / 3075 (33.2)**	**428 / 958 (44.7)**	**573 / 1548 (37.0)**
Alberta	**575 / 3075 (18.7)**	**261 / 958 (27.2)**	**563 / 1548 (36.4)**
Saskatchewan	**81 / 3075 (2.6)**	**84 / 958 (8.8)**	96 / 1548 (6.2)
Ontario	**1216 / 3075 (39.5)**	**148 / 958 (15.5)**	259 / 1548 (16.7)
Quebec	43 / 3075 (1.1)	15 / 958 (1.6)	36 / 1548 (2.3)
Nova Scotia	149 / 3075 (4.9)	22 / 958 (2.3)	21 / 1548 (1.4)

Bold indicates $p<0.05$ with Bonferroni correction for multiple comparisons applied. Comparisons made between adjacent columns only. If all three columns bold, then both the Acute vs. Early Chronic comparison and Early Chronic vs. Chronic columns were significant. Lagtime statistical significance is not indicated as this was the manner for establishing the three groups.

Appendix J: Comparison of the Outcome, Personal, Clinical and Treatment Related Characteristics in Acute, Early Chronic, and Chronic Patient Populations After a Motor Vehicle Collision Continued

Table 3 – Clinical characteristics of 5581 patients presenting with acute, early chronic or chronic injury after a motor vehicle collision

Clinical Variables	Acute Presentation (N = 3075)	Early Chronic (N = 958)	Chronic (N = 1548)
Location of Pain – no./total no. (%)			
Neck	**916 / 3075 (29.8)**	**228 / 958 (23.8)**	399 / 1548 (25.8)
Neck & Back	1764 / 3075 (57.4)	520 / 958 (54.3)	819 / 1548 (52.9)
Back	**395 / 3075 (12.8)**	**210 / 958 (21.9)**	330 / 1548 (21.3)
Other Areas Affected – no/total no. (%)			
Headache	772 / 3075 (25.1)	219 / 958 (22.9)	382 / 1548 (24.7)
Mid-Back	**1227 / 3075 (39.9)**	**323 / 958 (33.7)**	544 / 1548 (35.1)
Extremity Pain – no./total no. (%)			
Upper Limb	422 / 3075 (13.7)	118 / 958 (12.3)	196 / 1548 (12.7)
Lower Limb	**331 / 3075 (10.8)**	**135 / 958 (14.1)**	**280 / 1548 (18.1)**
Number of Symptoms			
Mean no. (SD)	2.47 (1.24)	2.37 (1.26)	2.43 (1.31)
Median	2.0	2.0	2.0
Neurological Testing – no./total no. (%)			
Positive	39 / 3075 (1.3)	13 / 958 (1.4)	25 / 1548 (1.6)
Non-Organic Signs no./total no. (%)	**344 / 3075 (11.2)**	**139 / 958 (14.5)**	234 / 1548 (15.1)
Any positive	160 / 3075 (5.2)	62 / 958 (6.5)	95 / 1548 (6.1)
≥3 positive			
Previous Episodes no./total no. (%)			
Neck Pain	683 / 910 (75.1)	213 / 289 (73.8)	398 / 527 (75.5)
Back Pain	471 / 771 (61.2)	**159 / 277 (57.4)**	**333 / 504 (66.1)**
Previous Spinal Surgery			
no. /total no. (%)			
Cervical	3 / 3075 (0.1)	1 / 958 (0.1)	5 / 1548 (0.4)
Lumbar	**12 / 3075 (0.4)**	**12 / 958 (1.3)**	15 / 1548 (1.0)
Comorbid Conditions no./total no. (%)			
Yes	309 / 3075 (10.1)	99 / 958 (10.3)	196 / 1548 (12.7)
Presence of Constant Pain (Yes)			
no./total no. (%)	918 / 1172 (78.3)	282 / 379 (74.4)	490 / 642 (76.3)
Intensity of Pain Intensity			
Mean VAS (SD)	6.0 (2.0)	6.0 (2.0)	5.8 (2.1)
Median	6	6	6

Bold indicates $p<0.05$ with Bonferroni correction for multiple comparisons applied. Comparisons made between adjacent columns only. If all three columns bold, then both the Acute vs. Early Chronic comparison and Early Chronic vs. Chronic columns were significant.

Appendix J: Comparison of the Outcome, Personal, Clinical and Treatment Related Characteristics in Acute, Early Chronic, and Chronic Patient Populations After a Motor Vehicle Collision Continued

Table 4 – Treatment Related Characteristics of 5581 patients presenting with acute, early chronic or chronic injury after a motor vehicle collision

Treatment Related Variables	Acute (N = 3075)	Early Chronic (N = 958)	Chronic (N = 1548)
Bed rest previously prescribed - no./total no. %	6 / 3075 (0.2)	**2 / 958 (0.2)**	**13 / 1548 (0.8)**
Duration or treatment program			
Mean days (SD)	73.8 (66.3)	70.6 (60.0)	73.6 (60.0)
Median	56	56	59
Number of treatment sessions			
Mean # (SD)	**23.7 (17.1)**	**22.0 (14.9)**	21.0 (14.5)
Median	20	20	19
Treatment Costs ($)			
Mean (SD)	**2097 (1779)**	**1888 (1843)**	1724 (1601)
Median	1587	1268	1170
Previous Investigations - no../total no. (%)			
X-rays	**737 / 3075 (24.0)**	**315 / 958 (32.9)**	**572 / 1548 (37.0)**
Other	**58 / 3075 (1.9)**	**50 / 958 (5.2)**	**159 / 1548 (10.3)**
Previous Treatment – no./ total no. (%)			
Yes	**579 / 3075 (18.8)**	**407 / 958 (42.5)**	**774 / 1548 (50.0)**
Concurrent Treatment – no./total no. (%)			
Yes	**251 / 3075 (8.2)**	**147 / 958 (15.3)**	248 / 1548 (15.6)
Health care seeking – no./total no. (%)			
Mean (SD)	**1.5 (0.8)**	**2.0 (1.1)**	**2.1 (1.2)**
Median	1	1	2

Bold indicates $p<0.05$ with Bonferroni correction for multiple comparisons applied. Comparisons made between adjacent columns only. If all three columns bold, then both the Acute vs. Early Chronic comparison and Early Chronic vs. Chronic columns were significant.

Appendix K: Provincial Variation in the Management of Whiplash Associated Disorders.

Table 1 – Comparison of Insurance System, Lagtime, Duration of Treatment, Treatment Costs, and Treatment Outcome by Province.

Province	Insurance System	Lagtime–mean days (SD) between injury date and presentation date	Duration of treatment– mean days (SD)	Treatment Costs – mean $ (SD)	% With a clinically important change in CBIQ Score (positive outcome)
British Columbia	Tort	42.0 (23.3)	57.7 (46.3)	1807 (1404)	69.0
Alberta	Tort	32.7 (24.2)	66.8 (53.2)	1304 (852)	65.7
Saskatchewan	No-fault	40.7 (24.9)	76.4 (46.9)	1132 (1294)	69.4
Ontario	Tort	23.0 (20.4)	84.7 (78.5)	2529 (1927)	75.9
Quebec	No-fault	33.7 (22.3)	89.0 (60.1)	2113 (2391)	80.4
Nova Scotia	Tort	26.5 (19.8)	89.0 (76.7)	2402 (2538)	88.7