AN ABSTRACT OF THE THESIS OF

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This thesis is presented in five chapters. The first and fifth chapters are an introduction and summary. The second chapter, *A Comprehensive Review of the Literature Relating to Chronic Neck Pain and Whiplash Injuries,* reports the results of a review of the relevant literature. In the first section, commonly used terms are reviewed and defined. The subsequent section reports on the literature regarding the nature of traffic accidents in the United States. Next is a section on the epidemiology of non-fatal motor vehicle accident (MVA) induced injuries in the U.S.. The proceeding section presents the methods and results of an estimation of the incident rate of whiplash for 1995. The next section is a review of the literature related to late whiplash. A meta-analysis of this literature yielded an estimated cumulative incidence of late whiplash of 33% of all whiplash-injured individuals at 33 months. The final section is a report of the economic and public health impact of motor vehicle accidents.

The third chapter, *"Whiplash Associated Disorders (WAD) - Redefining Whiplash And Its Management" By The Quebec Task Force: A Critical Evaluation,* presents the results of an examination of a major whiplash publication for methodologic weaknesses.

The current examination of this document revealed five areas of methodologic weakness that tended to weaken or invalidate the conclusions of the authors.

The fourth chapter reports the results of a case/control study of chronic neck pain and motor vehicle accident injuries. For this study, 665 individuals with chronic spine pain were queried regarding the origin of their pain. If their pain began following a MVA, they were surveyed about details of the impact. The results of the survey were used to develop an exposure-odds ratio for whiplash injuries and chronic neck pain. In addition, information regarding the nature of the chronic-injury producing MVA was analyzed to determine if there were any significant risk factors for chronic pain following a MVA. Whiplash injuries were found to be the largest single cause of chronic spine pain in population sample studies. In addition, several risk factors were found to predict chronicity following an acute whiplash injury.

A Study of Chronic Neck Pain Following Whiplash Injury

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CONTRIBUTION OF AUTHORS

Chapter 3, *"Whiplash Associated Disorders (WAD) - Redefining Whiplash And Its Management" By The Quebec Task Force: A Critical Evaluation,* was edited by Arthur C. Croft, D.C., M.S., and Annette M. Rossignol, Sc.D.

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A STUDY OF CHRONIC NECK PAIN FOLLOWING WHIPLASH INJURY

1. OVERVIEW OF THESIS OBJECTIVES

INTRODUCTION

Whiplash injuries resulting from motor vehicle accidents are common in the United States, affecting millions of Americans each year (1). Given the magnitude of the problem, it is surprising how little is known about the epidemiology of whiplash injuries and their sequelae.

There are no widely published estimates of the incidence of whiplash injuries, partially as a result of conflicting estimates of the yearly occurrence of motor vehicle accidents, and partly due to a poor understanding of the relationship between motor vehicle accidents and whiplash injuries. In other words, both the number of individuals who were exposed to the putative cause of whiplash (a motor vehicle accident), and the percentage of the exposed who are likely to have sustained a whiplash injury are difficult to estimate from the literature.

Even less is known about the epidemiology of late whiplash, the chronic sequelae of acute whiplash injuries. The prevalence, and even the existence, of this condition is highly contested in the medical and public health literature, and in the courts, partly because chronic whiplash injuries frequently are litigated. Recent publications that have minimized the severity and public health impact of whiplash injuries, such as those by the Quebec Task Force on Whiplash-Associated Disorders (2), have resulted in highly publicized catch-phrases such as "whiplash is all in the head," and "much whiplash aid

rated worthless." A more thorough understanding of whiplash injuries and these injurie's relation to chronic pain is essential for determining, first, whether chronic pain following whiplash is real, and, second, if it is, how many people have are afflicted with the condition. If the condition is real, then it is reasonable to assume that well publicized statements to the contrary could be harming those with the condition by denying them treatment, credibility, and a rationale for their pain.

There are two primary goals of this thesis. The first goal is to provide an understanding of the currently known nature of whiplash injuries and their chronic sequelae. This goal is accomplished in the second chapter of the thesis. Chapter Two is a literature review and is intended to give the reader a background in the history, terminology, and epidemiology of whiplash and late whiplash (chronic whiplash).

The second goal of this thesis is to determine whether chronic symptoms following whiplash are real. This goal is accomplished in the third and fourth chapters. In the third chapter, the hypothesis that chronic neck pain following whiplash injury is *not* real is explored. In this chapter, the publications by the Quebec Task Force on Whiplash-Associated Disorders are examined in order to determine whether flawed methodology could have caused the authors to underestimate the severity and persistence of the condition. If this is the case, then the conclusions reached by the authors may not be valid. If flawed methodology is not present, however, alternative explanations must be explored to explain potential disparities between the findings of the Quebec Task Force and the literature reviewed in Chapter Two. Chapter Four is the report of an original case/control study comparing a sample of subjects with chronic neck pain with a sample of subjects with chronic back pain. The purpose of the study is to establish whether there is a relation

between whiplash injuries and chronic neck pain, and to identify potential risk factors for chronicity following acute whiplash injury.

OVERVIEW OF CHAPTER 2

The second chapter of this thesis is a report of the results of a comprehensive review of the literature relevant to late whiplash. Included in this chapter are definitions of the terms and concepts essential to the understanding of late whiplash, for example; acute whiplash, late whiplash, the biomechanics of whiplash injuries, and others. The obstacles to accurately estimating whiplash injuries also are described, as well as the methods by which these obstacles may be overcome.

The various populations that annually contribute to the subpopulation with late whiplash are described in Chapter Two, starting with the largest population at risk (all individuals who have been involved in a MVA), and becoming more specific (an original estimate of all individuals with acute whiplash injuries). In order to accurately estimate the cumulative incidence, or risk, of late whiplash (the percentage of those with acute whiplash who will develop late whiplash), the results of an original meta-analysis of the relevant literature is presented.

The final section of Chapter Two is a report of the cost of MVA-related injuries, along with an original extrapolation and calculation of the annual cost of whiplash injuries.

OVERVIEW OF CHAPTER 3

The third chapter of the thesis presents the results of a detailed review and critique of a major recent publication on the subject of whiplash injuries and late whiplash,

Whiplash Associated Disorders (WAD)--Redefining Whiplash and its Management by the Quebec Task Force on Whiplash-Associated Disorders (QTF on WAD). The Results and Recommendations sections of this publication included statements such as whiplash injuries are "short-lived," involve "temporary discomfort," that the pain resulting from whiplash is "not harmful," and that whiplash injuries have a "favorable prognosis." Because this document is generally viewed as the authoritative source on the subject of whiplash injuries, because its recommendations currently are being used to determine state-of-the-art treatment and outcome predictions, and because its conclusions regarding the risk of late whiplash were not consistent with the majority of the literature reviewed in Chapter Two of this thesis, the QTF on WAD document was selected for in-depth review and critique. The goal of the review was to gain understanding of the methods used by the QTF, to determine if there may have been systematic bias or other methodologic flaws in their methods, and to judge whether the conclusions and recommendations of the QTF are reliable or valid. This critique has been accepted for publication in the journal *Spine*.

OVERVIEW OF CHAPTER 4

The fourth chapter of this thesis is a report of the methods and results of an original case-control study of chronic neck pain and motor vehicle accidents. This study is unusual in comparison with the existing literature because, to my knowledge, it is the first controlled study of late whiplash to be undertaken in the U.S.. Another unusual feature is the study design; this study is designed to approach the problem from a public health perspective, *i.e.* what percentage of the general population with chronic neck pain has this pain as a result of a MVA, as opposed to a clinical perspective, *i.e.* what percentage of a

group of patients with acute whiplash injuries will develop chronic symptoms. Additionally, in comparison with previous studies, which typically have lacked a comparison group or reference population, or both, the use of the case-control design (in which a group of individuals with the condition in question [cases] are compared with a similar group without the condition [controls] for a history of exposure to the causative agent) allows for greater extrapolation of the results to the general population with chronic spine pain (since this is the population in the study), as well as inferences regarding the magnitude of the problem.

An additional goal of the study described in Chapter Four is to identify risk factors that will help predict which subjects with acute whiplash injuries will become chronic. This analysis is accomplished by examining the responses of subjects who developed chronic pain as a result of a MVA and comparing them with the responses of subjects who sustained an acute injury as a result of a MVA but who did not develop chronic pain as a result of that injury. Of specific interest are responses regarding how the accident happened, and the gender and physical stature of the subjects, among other variables.

The final chapter of this thesis is a summary of the major conclusions of the preceding three chapters, along with recommendations for future research.

REFERENCES

(1) Croft AC. Whiplash: The Master's Program. Module 1. Spine Research Institute of San Diego, San Diego, CA 1996.

(2) Spitzer WO, Skovron ML, Salmi LR, Cassidy JD, Duranceau J, Suissa S, Zeiss E. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. Spine 1995;20(8S):1S-73S.

2. A COMPREHENSIVE REVIEW OF THE LITERATURE RELATIVE TO CHRONIC NECK PAIN AND WHIPLASH INJURIES

INTRODUCTION

The purpose of this chapter is to acquaint the reader with the current literature regarding acute and chronic whiplash injuries, particularly the epidemiology of these injuries.

The first section of the chapter is a review of important terms and concepts relative to whiplash injuries and late whiplash. The remainder of the chapter describes the epidemiology of whiplash injuries and their chronic sequelae (known as late whiplash), beginning with the populations from which these injuries arise. The first part of this section is a selection of statistical data regarding motor vehicle accidents and the injuries that result from these accidents. This information is culled from government sources, such as the National Highway and Transportation Administration (NHTSA), and represents the efforts of many state and national agencies and organizations to accurately characterize the magnitude of traffic accidents in the United States.

By contrast, the subsequent sections of this chapter, the epidemiology of whiplash and late whiplash, is the product of data extrapolation, because, to my knowledge, no accurate estimates of the incidence or risk of either condition exist. The estimate for the risk of late whiplash is the result of a meta-analysis of the literature on the subject. Because the majority of the late whiplash studies are clinically-based, rather than

population-based (as are the estimates from NHTSA), the results of the meta-analysis may have somewhat limited generalizability.

DEFINITIONS

Whiplash

The term whiplash was first introduced by H.E. Crowe in 1928 (1). The original purpose of the term was to describe the indirect traumatic force to the cervical spine which resulted from motor vehicle accidents, but not the actual injury.

The term later was reintroduced by MacNab, in 1964, who defined whiplash as an "extension strain of the cervical spine produced by sudden acceleration (2)." In 1970, States included "any cervical injury caused by indirect violence which does not result in dislocation or fracture (3)."

As recently as 1995, the definition was added to and refined, with the Quebec Task Force on Whiplash Associated Disorders defining whiplash as follows: "Whiplash is an acceleration/deceleration mechanism of energy transfer to the neck. It may result from rear-end or side impact motor vehicle collisions, but can also occur during diving or other mishaps (4)."

Because the term "whiplash" does not describe an injury as much as an injury mechanism, some authors have objected to its use as a diagnostic term (5). However, it has generally come to be accepted as representing both the injury and the manner in which it was sustained (4).

Other authors have adopted terms that more precisely describe the injuries associated with whiplash injuries: Croft first proposed the term Cervical Acceleration/Deceleration (CAD) syndrome (6). the Quebec Task Force on Whiplash Associated Disorders has promulgated the acronym WAD, for Whiplash Associated Disorders (4).

Whiplash Syndrome

The most frequent complaints following whiplash injuries are of neck pain, reported in 100% of acute whiplash cases, and headache, reported in 71% of cases (7). These complaints are most frequently associated with a diagnosis of cervical sprain/strain (ICD-9 code 847.0) (4).

The next most common symptoms accompanying neck and head pain, in decreasing order of frequency, are (8):

interscapular pain;

thoracolumbar and low back pain;

paresthesia (tingling) of the extremities;

extremity pain/weakness;

cognitive difficulties;

dizziness/light-headedness;

facial pain and TMJ related symptoms;

auditory symptoms (loss of hearing, tinnitus, etc);

vertigo;

ocular dysfunction (blurred vision, photophobia); and

dysphagia/hoarseness.

The Biomechanics of Whiplash

The biomechanical relationship between rear-impact motor vehicle accidents (MVA) and cervical injuries first was explored experimentally by Severy et al. in the early 1950s (9, 10, 11). They used human volunteers and anthropometric dummmies for actual crash tests. Severy et al. reported that both the dummies and the human volunteers experienced greater acceleration at the head than did the struck vehicle, about 2.5 times at impact speeds of up to 10 mph.

Later research by Thomson et al., in 1989 confirmed Severy's earlier findings that the occupants sustain greater accelerative force than the vehicle (12). West et al., in 1993 concurred, reporting occupant:vehicle acceleration ratios ranging from 1.2:1 to 3.8:1 (13).

Severy et al. conjectured that, in a low speed collision with little vehicle damage, a larger proportion of force is transferred to the occupants, the logic being that the energy of the collision absorbed by plastic deformation (crush) of the vehicle was not absorbed by the occupant. Thomson et al. were able to validate Severy et al.'s theory regarding the altered relationship between occupant acceleration and vehicle acceleration in the presence of plastic deformation of the vehicle. They found, during crash testing, that acceleration of the occupant's head and shoulders increased in a linear manner until the vehicle began to sustain crush, at about 8.7 mph. At this point, the slope of the acceleration of the head and

shoulders flattened. This phenomenon may account for the fact that the majority of whiplash injuries have been found to occur at relatively low collision speeds (14, 15).

Late Whiplash

While the acute results of whiplash injuries are of interest, a significant proportion of the literature has focused on the chronic sequelae of these injuries. In 1980, Balla was the first to use the term "late whiplash" to describe symptoms present more than six months after a neck injury caused by a motor vehicle accident (16). While "whiplash" has been to used describe acute injuries resulting from motor vehicle accidents and a variety of other causes, "late whiplash" has been used solely in reference to motor vehicle accident injuries. Late whiplash generally is thought to be a permanent condition, consisting of chronic neck and head pain (8, 17).

The epidemiology of late whiplash has been reported widely in the literature, with estimates of cumulative incidence amongst the population of acute whiplash injured ranging greatly from 12% at 1.5 years post-accident (18) to 86% at 10.8 years post-accident (19). Bogduk estimated the average among the studies at 25%, ± 15% (7).

While the cumulative incidence of late whiplash among whiplash-injured individuals has been the subject of numerous studies, the contribution of late whiplash to chronic neck pain in the general population has not been previously investigated. Following an exhaustive literature search, no studies were found which explored the relationship between late whiplash and prevalence of chronic neck pain.

Some studies have refuted the existence of late whiplash syndrome, most recently Schrader et al., in 1996 (20). However, these studies have tended to suffer from methodologic weaknesses and biases (21).

TRAFFIC ACCIDENTS IN THE UNITED STATES

Data Sources

NHTSA

The U.S. government collects data concerning traffic accidents through the National Highway Transportation and Safety Administration (NHTSA), which is under the purview of the U.S. Department of Transportation (22). Under the NHTSA are several data collection systems:

NASS/CDS

The National Accident Sampling System/Crashworthiness Data System (NASS/CDS) collects detailed information on police-reported, tow-away passenger vehicle crashes (23). Passenger vehicles are defined as automobiles (cars), and light trucks, which consist of pick-up trucks, vans, and sport-utility vehicles. Cars comprise 81% of all passenger vehicles. Excluded from NASS/CDS analysis are the majority of passenger vehicle crashes, because these crashes did not result in a tow-away, and all accidents involving commercial vehicles.

GES

The General Estimates System (GES) also is part of the NASS. The GES collects information concerning all police-reported crashes that occur in the U.S. annually (24). Undercounting crashes due to administrative and paperwork error accounts for an approximately 10-15% underestimation of the police-reported crashes (25). NHTSA estimates that only one-half of all crashes are reported to the police and thus are not recorded by the GES; crashes resulting in the most serious injuries and greatest property damage, however, are the most likely to be reported.

FARS

The Fatal Accident Recording System (FARS) is operated by NHTSA's National Center for Statistics and Analysis (NCSA). FARS collects data on all fatalities that occur as a result of a traffic accident in the U.S. (26). FARS data includes detailed information about the nature of the crash that resulted in the fatality; it does not include data regarding non-fatal accidents or the injuries resulting from them, however.

Report of the Economic Cost of Motor Vehicle Crashes

This report presented the results of a 1995 analysis of motor vehicle crash costs in 1994 by Lawrence J. Blincoe, a senior analyst in the Plans and Policy division of NHTSA (25). The report also includes estimates of the total number of accidents and injuries in 1994, taking into account the estimated effects of unreported crashes.

NSC

The National Safety Council is a nonprofit non-governmental public service organization that was chartered by an act of Congress in order to promote public safety (27). Specifically, the NSC is devoted to:

"educating and influencing society to adopt safety, health, and environmental policies, practices, and procedures that prevent and mitigate human suffering and economic losses arising from preventable causes (28)."

Biannually, the NSC publishes a booklet called "Accident Facts." This text contains detailed information from many government organizations, including NHTSA. It also includes data gathered by the U.S. Public Health Service during its National Health Interview Survey (NHIS). The NHIS is a continuous, personal-interview sampling of households designed to obtain information about the health status of household members.

In 1994, 116,179 individuals in the U.S. participated in the NHIS. The NSC synthesized this information in its 1996 publication of Accident Facts. Because its data are based on the health status and accident history of the general population, rather than on police reports, the NSC data concerning MVA injuries theoretically is less prone to selection bias than the data from the NHTSA. However, in June of 1996, the U.S.Department of Health and Human Service announced that all NHIS motor vehicle accident injury estimates from 1982 through 1994 were incorrect due to a programming error that coded multiple injuries as multiple injury victims. In addition, for each year, only 50-100 of the NHIS participants were found to have been injured in an MVA, making

estimates regarding MVA injury rates susceptible to large random error (25). For this reason, only NSC data which were not collected by the NHIS will be used in this report.

Accident Data

In 1995, there were 6,613,000 police-reported accidents, and 11,822,000 vehicles involved in these crashes (29). There were 17,600,000 licensed drivers involved in reported and unreported MVAs in 1995 (27). Of these licensed drivers, 10,600,000 were females, and 7,000,000 were males.

Including unreported accidents, there were an estimated 27,000,000 vehicles damaged in crashes in 1994 (25). The time period with the greatest single percentage of accidents is Saturday, from noon until 3:59 p.m.; the time period with the smallest percentage of accidents is Tuesday, from midnight until 3:57 a.m. (29). Note: NHTSA typically uses the term "crash" for "accident;" they state that "accident" implies non-preventability, whereas "crash" does not (29). The terms are used interchangeably in this report.

Table 2.1: Reported number of accidents per 100,000 person-years by age for males, 1995

Age (years)	Number of Drivers	Involvement Rate
<16	51,000	na
16-20	1,231,000	19,813
21-24	781,000	11,372
25-34	1,794,000	8,852
35-44	1,392,000	6,997
45-54	952,000	6,487
55-64	492,000	5,036
65-69	181,000	4,172
>69	345,000	4,225
Total:	***7,220,000***	***8,002***

Table 2.2: Reported number of accidents per 100,000 person-years by age for females, 1995

Age (years)	Number of Drivers	Involvement Rate
<16	24,000	na
16-20	769,000	13,613
21-24	514,000	8,005
25-34	1,126,000	5,870
35-44	936,000	4,795
45-54	594,000	4,132
55-64	270,000	2,847
65-69	104,000	2,423
>69	225,000	2,717
Total:	***4,561,000***	***5,230***

Table 2.3: Reported number of accidents per 100,000 person-years by age for the total population, 1995

Age (years)	Number of Drivers	Involvement Rate
<16	75,000	na
16-20	2,000,000	16,861
21-24	1,296,000	9,745
25-34	2,920,000	7,402
35-44	2,328,000	5,906
45-54	1,546,000	5,322
55-64	762,000	3,959
65-69	285,000	3,301
>69	570,000	3,466
Total:	***11,782,000***	***6,640***

Table 2.4: Types of vehicles involved in accidents compared with total vehicle registration (excludes buses, farm equipment, and others) (23)

Vehicle Type	Crash Involved Vehicles (% of total)	Registered Vehicles (% of total)	Vehicle Miles of Travel (% of total)
Passenger car	76	75	71
Light truck/van/utility vehicle	19	20	22
Medium/heavy truck	4	3	7
Motorcycle	1	2	*
Bus	*	*	*
Total:	***100***	***100***	***100***

* less than 0.5%

Table 2.5: Proportions of collision types by initial point of impact (23)

Collision type by Initial Point of Impact	% of Total
front	36.6
left side	15.7
right side	13.3
rear	18.5
with a fixed object	7.8
with other, unfixed object	6.9
noncollision	1.1
Total:	***100.0***

Table 2.6: Year to year trend in number of reported accidents, 1988-1995 (29)

Year	Total Number of Accidents	% Change From Previous Year
1988	6,887,000	na
1989	6,653,000	-3.4
1990	6,471,000	-2.7
1991	6,117,000	-5.5
1992	6,000,000	-1.9
1993	6,105,000	+1.0
1994	6,492,000	+6.3
1995	6.613,000	+1.9

MOTOR VEHICLE ACCIDENT INDUCED NON-FATAL INJURIES IN THE UNITED STATES

Data Sources

NHTSA

NASS/CDS

The Crashworthiness Data Scale gathers and analyzes detailed data from police-reported injuries incurred by passengers of towed passenger vehicles (23). These injuries represent 54% of all police-reported injuries and because they are the most serious accidents, the reported injuries tend to be more severe than the reported accidents which did not require towing from the accident scene. For this reason, these data are biased towards more serious injuries.

The CDS uses the Abbreviated Injury Scale (AIS), a 0-7 ranked scale based on survivability, to denote injury severity. The AIS ranks injuries as follows (23):

0 not injured
1 minor
2 moderate
3 serious
4 severe
5 critical
6 maximum
7 injured, severity unknown

Typically, whiplash injuries are classified as AIS 1, minor severity (8).

GES

The General Estimates System provides estimates based on all police-reported crash and vehicle types. Although the GES collects information on injuries, it is relatively undetailed, with determinations of injury severity made by the police and ranked as "incapacitated," "non-incapacitated," and "possible injury" (24).

Report of Economic Cost of Motor Vehicle Crashes

In this analysis, Blincoe gives estimates of total annual injuries taking into account the effect of undercounting by the GES, estimates of unreported accidents (30, 31, 32) and other, less significant sources of systematic bias (25). His findings are reported under Injury Data, below.

INSURANCE RESEARCH COUNCIL

The IRC is a nonprofit organization that was founded by the property-casualty insurance industry (33). Their 1994 publication, "Paying for Auto Injuries," reports the results of a 1992 random survey of 180,000 U.S. households, with regards to automobile accident injuries. The first survey produced 133,570 responses, a 74% response rate. Of the respondents, 7,096 reported an automobile accident injury within the preceding four years. A second, more detailed survey was sent to 6,745 of the households which reported

an auto accident injury. 5,344 forms were returned, for a response rate of 79%. The results of the survey were used to calculate the injury frequencies reported in Table 2.13.

THE EFFECT ON THE DATA OF UNREPORTED ACCIDENT INJURIES

Police reports typically are filed in accidents in which the police have come to the scene of the accident. In most U.S. cities, the police will respond to a call concerning a traffic accident if there has been either property damage >$200 or injury requiring immediate medical attention, or both (34). Accident injuries that are not recorded by the police are either not reported or do not meet the criteria for response.

Injuries that are not reported to the police most likely to occur in a crash in which the party at fault is injured, and there is fear of police involvement due to lack of insurance or licensure (25). Additionally, when they are called, the police occasionally do not collect information on passengers who may have sustained injury but who are ambulatory and do not express a need for immediate medical attention.

Greenblatt et al. studied unreported accidents by surveying 630 households in which a driver had been injured in a crash. Their objective was to determine the proportion of injuries that had been reported to the police (31). They found that while all of the injuries that required hospitalization had been reported, the less serious injuries were much less likely to be reported. Greenblatt et al. reported a ratio of unreported injuries to reported injuries of 0.2738. A later study found a similar ratio of 0.2854 (35)

THE EFFECT ON THE DATA OF DELAYED ONSET OF SYMPTOMS

Misclassification bias is likely to occur when there is a police report associated with an accident which states that there are no injuries, when in fact there are injuries. This type of error is more likely to occur when an accident-injured occupant is initially asymptomatic, and reports him or herself as uninjured at the accident scene, but later develops symptoms.

Several authors have reported delay of symptoms in whiplash-injured individuals (36, 37, 38, 39). For example, Hildingsson and Toolanen reported the following delay of symptom onset in their cohort of 93 whiplash-injured patients (40): 28 (30%) patients were asymptomatic 1 hour post-accident, 16 (17%) patients were asymptomatic 5 hours post-accident, and 8 (9%) patients were asymptomatic after 15 hours. Other authors have reported similar proportions of symptom delay.

For the purposes of this analysis, police underreporting of whiplash injuries due to symptom delay is conservatively estimated at 25%. The two factors which comprise this estimate are:

an average response time of the police following a summons to an accident scene of 20 minutes (24); and,

a literature based estimate that only two-thirds of the injured occupants have developed symptoms by the time the police arrive at the accident scene.

Injury Data

In 1995, there were 3,386,000 police-reported non-fatal injuries resulting from motor vehicle accidents in the U.S. (29). Of these 3,386,000 injured, 2,161,000 were drivers and 1,071,000 were passengers, yielding a 2:1 ratio of driver injuries to passenger injuries. The remaining 154,000 injuries involved pedestrians, pedalcyclists, and other unidentified individuals.

It is estimated that there were a total of 5.2 million non-fatal injuries in 1994, including unreported injuries, and an additional 3.7 million injury-exposed uninjured occupants, yielding an injury per total occupants per injury-producing crash incidence rate of 58 per 100 person-years (25). This figure differs from the NSC estimate of 17,600,000 total drivers who were operating a vehicle that was involved in any sort of an accident, but who were not necessarily exposed to injury (27), since most of the crashes were not injury-producing. Blincoe estimates that 14% of all occupants who are in crashes will sustain an injury (25).

Table 2.7: Reported number of injuries per 100,000 person-years by age for males, 1995

Age	Number of Drivers	# of injuries/ 100,000
<16	12,000	na
16-20	377,000	6,072
21-24	267,000	3,886
25-34	598,000	2,948
35-44	456,000	2,291
45-54	287,000	1,957
55-64	157,000	1,610
65-69	63,000	1,455
>69	117,000	1,430
Total	***2,334,000***	***2,587***

Table 2.8: Reported number of injuries per 100,000 person-years by age for females, 1995

Age (years)	Number of Drivers	# of injuries/ 100,000
<16	8,000	na
16-20	281,000	4,792
21-24	186,000	2,898
25-34	405,000	2,111
35-44	344,000	1,760
45-54	208,000	1,448
55-64	98,000	1,033
65-69	40,000	933
>69	84,000	1,020
Total	***1,653,000***	***1,896***

Table 2.9: Reported number of injuries per 100,000 person-years by age for the total population, 1995

Age (years)	Number of Drivers	# of injuries/ 100,000
<16	19,000	na
16-20	658,000	5,548
21-24	453,000	3,408
25-34	1,002,000	2,541
35-44	799,000	2,028
45-54	495,000	1,705
55-64	255,000	1,326
65-69	103,000	1,195
>69	201,000	1,224
Total	***3,987,000***	***2,247***

Table 2.10: Types of collisions causing reported non-fatal disabling injuries (29)

Type	Injuries (nonfatal)	All Accidents	Proportion of Type of Accident Causing Injury
With other motor vehicle:	1,800,000	7,830,000	23%
angle collision	640,000	2,730,000	23%
head-on	60,000	220,000	27%
rear-end	730,000	2,830,000	26%
other	370,000	2,050,000	18%
Fixed object	280,000	1,630,000	17%

Note: These data only refer to injuries sustained by the drivers of the vehicles.

* This column gives the relative proportion, expressed as a percentage, of injuries to total accidents, by type of collision. Both head-on and rear-end collisions are more likely to cause injury than the other types of collisions.

Table 2.11: Police Reported Injuries by Year 1988-1995 (29)

Year	Number of Injuries	Number/100,000 Person-years	Number/100 million VMT*	% Change
1988	3,416,000	1,397	169	na
1989	3,284,000	1,331	157	-6.5
1990	3,231,000	1,295	151	-3.8
1991	3,097,000	1,228	143	-5.3
1992	3,070,000	1,204	137	-4.2
1993	3,125,000	1,212	136	-0.7
1994	3,215,000	1,235	136	0.0
1995	3,386,000	1,289	141	+3.6

* Vehicle miles traveled

Table 2.12: Total Reported and Unreported Injuries by Year, 1988-1995 (25)

Year	Total Injuries*	Number/100,000 Person-years*	% Change
1988	5,500,000	2,263	na
1989	5,300,000	2,156	-4.7
1990	5,200,000	2,098	-2.7
1991	5,000,000	1,989	-5.2
1992	5,000,000	1,950	-2.0
1993	5,100,000	1,964	+0.7
1994	5,200,000	2,001	+1.9
1995	5.500,000	2,088	+4.3

* Blincoe's 1994 estimate was used to calculate a conversion factor for the years shown in table 5.2.4.2, as the original estimate was made using constants, such as the proportion of unreported crashes (32, 33, 34) and undercounting by the police (25), which are not subject to year-to-year variation.

Table 2.13: Reported frequency of body parts injured in motor vehicle accidents in which the accident victim was evaluated at a hospital emergency room (23)

Body Region*	Number of Injuries**	% of Total Injured Population with Specific Injury***
Neck	319,114	20.5
Face	162,698	10.4
Chest	90,010	5.8
Brain	51,886	3.3
Abdomen	36,652	2.4
Pelvis	22,755	1.5
Skull	13,048	0.8

* Injuries of the skin, upper and lower extremities, and shoulders/back were not included in this analysis because they can be counted more than one time on a single individual, making comparisons with the other injured areas difficult to interpret. For example, although there are only 1,557,000 injured individuals included in the NASS/CDS analysis of injured body parts, there are a total of 2,722,078 skin injuries listed.

** This column only includes AIS 1-5 injuries, since AIS 6 is 99% unsurvivable.

*** Out of 1,557,000 injured individuals. This column does not total 100% because some injuries were not included in the analysis (see * above).

Table 2.14: Reported frequency of body parts injured in motor vehicle accidents, measured retrospectively by survey of the general population (33)

Body Region Injured/nature of Injury	% of Total Injured Population with Specific Injury*
Neck sprain/strain	53.0
Back sprain/strain	44.8
Minor cuts/bruises	43.3
Other sprain/strain	21.1
Psychological/emotional	17.9
Serious cuts/bruises	17.5
Concussion	12.4
Other fracture	10.8
Fractured leg, knee, foot, back, neck	8.1

* The difference between the figures in Table 1.13 and 14 is due to delayed onset of symptoms (symptoms not readily apparent and not immediately reported in the hospital emergency room) and the tendency for E.R. personnel to focus on life-threatening injuries rather than sprains.

THE ANNUAL NUMBER OF WHIPLASH INJURIES, ESTIMATED FOR 1995

Using data from the IRC, shown in Table 2.14, neck sprains or whiplash injuries were identified as occurring in 53.0% of the total population of MVA-injured individuals. Applying this 53.0% to the data in Table 2.12 (the total reported and unreported injuries

by year) yields an estimate of the annual incidence of whiplash injuries for the years 1988-1995 (see Table 2.15).

Table 2.15: Estimated annual incidence of whiplash injuries, for 1988-1995

Year	Total MVA-related Injuries	Estimated Number of Whiplash Injuries	Number/100,000 Person-years
1988	5,500,000	2,900,000	1199
1989	5,300,000	2,800,000	1143
1990	5,200,000	2,800,000	1112
1991	5,000,000	2,700,000	1054
1992	5,000,000	2,700,000	1034
1993	5,100,000	2,700,000	1041
1994	5,200,000	2,800,000	1061
1995	5,500,000	2,900,000	1107

The incidence rates in Table 2.15 are higher than most of the rates estimated by earlier authors, but are less prone to bias because they include unreported injuries, and are based on the symptoms of the individuals, rather than a construct such as insurance claims, which may be based on time-loss rather than injury (4, 42, 43). Table 2.16 contains estimates of whiplash incidence by other authors.

Table 2.16: Estimates of the annual incidence of whiplash, by author and year

Author	Year of Study	Whiplash Injuries per 100,000 Person-years
Schutt and Dohan (41)*	1968	1450
States et al. (5)**	1970	380
Mills and Horne (42)	1986	10
Dvorak et al. (43)	1989	44
Olsnes et al. (44)	1989	200
Spitzer et al. (4)	1995	70

* Reported on a population of female factory workers who drove daily, and thus were at higher risk for a motor vehicle accident

** The incidence rate was calculated by Barnsley et al. from States et al.'s data

THE EPIDEMIOLOGY OF LATE WHIPLASH

Data Sources

All abstracts of articles that included "whiplash," "neck sprain," and "cervical spine injury" which were included in Medline from 1969 to 1996 were examined for relevance to the cumulative incidence of late whiplash. In addition, whiplash texts, literature reviews, and other sources of references were examined for relevant literature. An article was considered relevant to late whiplash if it:

1. pertained to patients who initially were diagnosed with an acute whiplash injury following a motor vehicle accident;

2. estimated the proportion of patients who remained symptomatic with neck pain for at least six months; and,

3. included more than 20 subjects.

Study design in the whiplash literature

RETROSPECTIVE CASE SERIES

Twelve of the studies found in the relevant literature consisted of a retrospective case series design, in which a population of whiplash-injured individuals were retrospectively examined or surveyed regarding persistent neck pain six or more months post-accident, with no comparison group. Eliminated from this group were studies which enrolled subjects based upon their having symptoms for greater than six months, since by definition all of these individuals would have late whiplash.

Subjects were assembled for the studies either based on their having initially presented to a hospital emergency room following the accident, or from having been treated or evaluated in a clinician's private practice. The hospital-based studies were less prone to selection bias than were the clinically based studies because they typically reported on consecutive patients presenting to the emergency room following a MVA, whereas the clinical studies usually reported on patients who had been referred to a specialty practice.

The follow-up rate was given for those studies which reported on serial evaluations, like a panel study, but in which the initial evaluation of neck pain status was more than six months post-injury. The mean proportion of patients who developed late whiplash in these studies was 49%, with a 90% confidence interval of 13-82%, and a mean length of follow-up of 63 months. Post-accident follow-up time ranged from six to 150 months, with a median of 25 months.

Table 2.17: Retrospective case series studies of late whiplash

Author	Year	Selection Criteria	n	Follow-up Rate (%)	Mean Length of Follow-up (months)	% with Significant Chronic Neck Symptoms
Gotten (36)	1956	clinical	100	-	12	46
Hohl (45)	1974	ni*	146	-	5	43
Balla (46)	1980	clinical	300	-	24	64
Deans et al. (47)	1986	hospital	85	-	12	42
Maimaris et al. (48)	1988	hospital	102	85	26	34
Hodgson and Grundy (49)	1989	clinical	26	-	150	62
Pearce (50)	1989	selected medlegal	100	-	12	15
Gargan et al. (51)	1990	f/u of Norris et al. 1983 cohort	43	-	128	74
Kischka et al. (39)	1991	clinical	52	-	24	44
Watkinson et al. (19)	1991	f/u of Norris et al. 1983 cohort	35	57	128	26
Parmar and Raymakers (52)	1993	MVA litigants sent for defense eval	100	-	96	55
Robinson et al. (53)	1993	pts contacted after file review	21	-	138	86

* no information given

PROSPECTIVE CASE SERIES

The prospective case series studies differed from the retrospective case series in that the symptoms of the subjects were recorded close to the time of the accident, and then at predetermined intervals for at least six months post-injury. This study design was found in 17 studies. Both the prospective and the retrospective studies are useful for determining the cumulative incidence of late whiplash disease, because the entire cohort has been initially exposed to the putative etiologic agent; an acute whiplash injury. The prospective design is more accurate for this purpose, however, in that it samples the study population more than one time.

The prospective studies generally were of higher quality than the retrospective studies, in that, on average, they followed a less selected (hospital-based versus clinically-based) population of whiplash patients, gave more details regarding methodology, and did not rely on the recall of the subject for symptoms at the time of injury.

The figures listed in Table 2.18 for "% with significant chronic neck symptoms" represent the proportion of subjects with chronic neck pain at final evaluation in comparison with the total number of subjects who presented at the baseline evaluation with neck pain. The mean proportion of patients who developed late whiplash in these studies was 44%, with a 90% confidence interval of 15-73%, and a mean time at follow-up of 20 months. Post-accident follow-up time ranged from six to 60 months, with a median of 20 months.

Table 2.18: Prospective case series studies of late whiplash

Author	Year	Selection Criteria	n	Follow-up Rate (%)	Mean Length of Follow-up (months)	% with Significant Chronic Neck Symptoms
Macnab (54)	1964	clinical	299	45	36	45
Bingham (55)	1968	clinical	66	100	12	34
Schutt and Dohan (41)	1968	female employees at an RCA plant	76	100	6 to 26*	75
Ellertsson et al. (18)	1978	hospital	100	ni	18	12
Norris and Watt (56)	1983	hospital	61	100	22	44
Miles et al. (57)	1988	hospital	73	100	24	29
McKinney (58)	1989	hospital	167	100	24	38
Hildingsson et al. (40)	1990	hospital	93	ni	25	58
Olsson et al. (59)	1990	MVA injured reported by Swedish registry	33	ni	12	36
Radanov et al. (60)	1991	randomized referral from PCP to neurol	78	100	6	24
Ettlin et al. (61)	1992	hospital	21	ni	12	41
Radanov et al. (62)	1993	random sample of whiplash patients with neck pain who had presented to a PCP	30	100	6	83
Radanov et al. (63)	1993	random sample of whiplash pts with neck pain who had presented to a PCP	88	100	6	34
Gargan and Bannister (64)	1994	consecutive pts presenting to ER with neck pain following MVA	50	100	24	60

Table 2.18 (continued)

Jonsson et al. (65)	1994	consecutive pts presenting to ER with neck pain following MVA, who remained symptomatic >6 weeks	24	100	60	46
Ryan et al. (66)	1994	volunteer participants drawn from whiplash-injured pts in PCP and PT practices	29	91	6	66
Radanov et al. (67)	1995	random sample of pts presenting to PCP post-MVA injury	108	100	24	19

* It was not possible to calculate a mean follow-up from this study, and it was eliminated from the calculation of the mean of all of the studies.

COHORT STUDIES

Controlled studies were found in two instances. Nygren et al. reported on a cohort of 250 whiplash-injured individuals who were followed prospectively for 72 months post-accident (68). The subjects in the whiplash-exposed cohort were frequency-matched with at least five controls who had a negative history of neck injury following an MVA. At 72 months, both cohorts were surveyed for neck pain. Nygren et al. reported a chronic neck pain prevalence difference of 23%, with 38% of the exposed symptomatic and 15% of the controls symptomatic.

The second controlled study was Schrader et al.'s retrospective cohort study of neck pain and MVAs in Lithuania (20). The authors of this study used the history of a

MVA as the criteria for enrollment in the "exposed" cohort. They frequency matched a cohort of 202 individuals with a history of a MVA with an equal number of individuals who did not have a history of a MVA. The two cohorts were surveyed for neck pain an average of 22 months post-accident (relative to the time of exposure for the exposed cohort). Schrader et al. reported that there was no difference between the two groups with regards to chronic neck pain.

This study later was criticized for selection bias, because using exposure to a MVA as an enrollment criteria did not guarantee exposure to acute whiplash, the primary causal factor in developing late whiplash (21). Applying the estimate of late whiplash risk for all individuals exposed to an MVA from Table 2.22 to Schrader et al.'s cohort of 202 yields an expected 5 cases of late whiplash, making their results subject to a high degree of random error. Only 31 individuals in the "exposed" were injured in an MVA, and a 90% confidence interval calculated for the relative risk for these individuals ranged from 0.04 to 4.72. For these reasons, the Schrader et al. study was not included in this analysis.

Meta-analysis of late whiplash literature

In order to summarize the literature, it is useful to have a point estimate and confidence interval of the proportion of late whiplash cases that develop from comparable patient populations, along with an estimated mean of time post-accident. This estimate allows for an approximation of the cumulative incidence of late whiplash in the whiplash injured population. The greatest difficulty in estimating this measure is the non-comparability of study populations, which is a result of widely divergent methods of

randomization, ranging from consecutive patients presenting to a hospital emergency room to patients referred to a specialists practice for an insurance evaluation. For this reason, the majority (57%) of the studies from Tables 2.17 and 2.18 were rejected for this analysis. The remaining 13 studies which were accepted for the meta-analysis fit the following criteria:

1. they followed relatively unselected populations of acute whiplash patients; either patients presenting to a hospital emergency room, if the study was a prospective design, or a randomly assembled group of patients who were purposely recruited for the study, in a retrospective design;

2. the number of patients who had neck symptoms at the baseline evaluation was given, allowing for a comparison with those with neck symptoms at final follow-up;

3. the study gave enough detail regarding study design that it was clear how the authors arrived at their conclusions; and,

4. the study did not duplicate the results of an already included study with the same cohort.

Table 2.19 lists the studies that were excluded for the meta-analysis and the reasons for their exclusion.

Table 2.19: Studies that did not meet the inclusion criteria for the meta-analysis

Author	Year	Reason for Exclusion
Gotten (36)	1956	no details given regarding the selection of the cases
Macnab (54)	1964	non-consecutive patients presenting to a specialist
Bingham (55)	1968	non-consecutive patients presenting to a specialist
Schutt and Dohan (41)	1968	no point estimate was given for the duration of follow-up
Hohl (45)	1974	no information given regarding the selection of subjects
Ellertsson et al. (18)	1978	did not specify how many of symptomatic patients had neck pain at final follow-up
Balla (46)	1980	consecutive patients presenting to a specialist
Hodgson and Grundy (49)	1989	consecutive patients referred for medico-legal evaluation
Pearce (50)	1989	non-consecutive patients presenting to a specialist
Gargan et al. (51)	1990	duplicated results of earlier study with same cohort
Kischka et al. (39)	1991	non-consecutive patients referred to specialist
Ettlin et al. (61)	1992	non-consecutive patients referred to specialty practice
Parmar and Raymakers (52)	1993	non-consecutive patients referred for medico-legal evaluation
Radanov et al. (63)	1993	duplicated results of earlier study with same cohort
Robinson et al. (53)	1993	selected file review of medico-legal evaluations
Jonsson et al. (65)	1994	proportion of cohort with acute neck pain at baseline evaluation not given
Ryan et al. (66)	1994	subjects were volunteers presenting to private practices

Table 2.20 lists the studies that fit the meta-analysis inclusion criteria and that were used to calculate an estimate of the cumulative incidence of late whiplash. The equally weighted mean proportion of patients who developed late whiplash in these studies was 36%, with a 90% confidence interval of 14-58%, followed up at a mean of 31 months. Time post-accident of final follow-up ranged from six to 128 months. A subject number weighted meta-analysis of the studies in Table 1.20 yielded a mean cumulative incidence of 33% (with a 90% confidence interval of 11-55%) of subjects with chronic neck pain at 33

months post-injury. Post-accident follow-up time ranged from six to 128 months, with a median of 24 months.

Based on this estimation, it is estimated that 960,000 individuals, or 33% of the 2,900,000 individuals who sustained a whiplash injury in 1995 will continue to have neck pain 33 months post-accident. Table 2.21 shows the summary statistics for the various study types that were reviewed.

Table 2.20: Late whiplash studies fitting the criteria for meta-analysis

Author	Year	Cohort Type	n	Study Type	Follow-up Rate (%)	Mean Length of Follow-up (months)	% with Significant Chronic Neck Symptoms
Norris and Watt (56)	1983	hospital	61	prosp	100	22	44
Deans et al. (47)	1986	hospital	85	retro	--	12	42
Maimaris et al. (48)	1988	hospital	102	retro	85	26	34
Miles et al. (57)	1988	hospital	73	prosp	100	24	29
McKinney (58)	1989	hospital	167	prosp	100	24	38
Hildingsson et al. (40)	1990	hospital	93	prosp	ni	25	58
Olsson et al. (59)	1990	MVA injured reported by Swedish registry	33	prosp	ni	12	36
Radanov et al. (60)	1991	randomized referral from PCP to neurol	78	prosp	100	6	24
Watkinson et al. (19)	1991	f/u of Norris et al. 1983 cohort	35	retro	57	128	26

Table 2.20 (continued)

Radanov et al. (63)	1993	random sample of whiplash pts with neck pain who had presented to a PCP	88	prosp	100	6	34
Gargan and Bannister (64)	1994	consecutive pts presenting to ER with neck pain following MVA	50	prosp	100	24	60
Radanov et al. (67)	1995	random sample of pts presenting to PCP post-MVA injury	108	prosp	100	24	19
Nygren et al. (68)	1996	insurance register of injured, with 5 to 1 control/case ratio	250	co-hort	100	72	23

Table 2.21: Summary statistics for the retrospective, prospective, and selected studies

Study type	Mean % Chronic	90% Confidence Interval for % Chronic	Mean Months to Final Follow-up	Range of Time to Final Follow-up, in Months
retrospective case series	49	13-82	63	6-150
prospective case series	44	15-73	20	6-60
equally weighted selected studies	36	14-58	31	6-128
n-weighted meta-analysis of selected studies	33	11-55	33	6-128

The Estimated Incidence Of Late Whiplash For Various At-Risk Populations

Based on the estimate that 960,000 (33%) of the 2,900,000 individuals who sustained acute whiplash injuries in 1995 will develop late whiplash, the risk of developing late whiplash for various populations using 1995 data is estimated and given in Table 2.22.

Table 2.22: The estimated risk of late whiplash for 1995, by population

Population	Total number	% of At-risk Population That will Develop Late Whiplash
All occupants of all vehicles which have been crashed	39,300,000* (25)	2.4
All drivers (vehicles) which have been in reported crashes	17,600,000 (27)	5.5
All occupants of motor vehicles which have been crashed and at least one injury has resulted, including unreported accidents	9,400,000** (25)	10.2
All occupants who have sustained a non-fatal injury	5,500,000***	17.5
All occupants who have sustained a whiplash injury	2,900,000****	33

* Extrapolated from Blincoe's 1994 estimate

** Extrapolated from Blincoe's 1994 estimate

*** From Table 2.12

**** From Table 2.15

THE ECONOMIC AND PUBLIC HEALTH IMPACT OF MOTOR VEHICLE ACCIDENTS IN THE UNITED STATES

Overview

The cost of U.S. motor vehicle accidents totaled $150.5 billion in 1994. It is estimated that 9% of the economic expense of motor vehicle accidents is borne by the public; 6% by the federal government and 3% by the states (25). The remaining 82% is paid by insurers and employers. Table 2.21 shows the distribution of this expense.

Table 2.23: MVA-related economic costs for 1994, by expense type (25)

Expense type	Cost (billions of 1994 dollars)
Property damage	52.1
Lost market productivity	42.4
Medical expenses	17.0
Lost household productivity	12.3
Other costs	26.6

Comprehensive costs for 1995 MVA-related injuries, excluding fatalities, were estimated at $137,000 for each incapacitating injury, $37,000 for each nonincapacitating evident injury, and $20,000 for each possible injury (27). Comprehensive costs include economic costs and lost quality of life. The value of lost quality of life was calculated

using empirical studies of what people are willing to pay to prevent MVA-related injuries, through purchase of airbags, and other safety related items (69).

The Cost of Whiplash Injuries

It is difficult to state with any precision what the economic and public health consequences of whiplash injuries are due to factors such as unreported injuries, delayed onset of symptoms, and, perhaps most importantly, the inherently variable nature of the injury itself. No references have been found which quantify the average amount of disability or lost productivity caused specifically by whiplash injuries.

Some authors have estimated the economic cost of whiplash injuries; $19.1 billion was given in one report as the amount paid to claimants annually for whiplash claims (70). This same report estimated that $9,900 was the average sum paid for each whiplash injury by State Farm Insurance Company. Multiplying this figure by the estimated 2,900,000 whiplash injuries that occurred in6 1995 (Table 2.15) yields almost $28 billion estimated expenditure for whiplash injuries in 1995.

The estimates of cost for whiplash injuries do not take into account the future expenses incurred for the one out of three whiplash-injured individuals who continue to have symptoms in the form of late whiplash, nor do these estimates include lost productivity and quality of life, or other factors which negatively impact society. While a thorough literature search revealed no estimates of these costs, it is reasonable to assume that they are substantial.

REFERENCES

(1) Crowe, H.E.: Injuries to the cervical spine. Paper presented at the meeting of the Western Orthopedic Association, San Francisco, 1928

(2) MacNab I. Acceleration injuries of the cervical spine. J Bone Joint Surg Am 1964;46-A:1797-9.

(3) States JD, Korn MW, Masengill JB. The enigma of whiplash injury. NY State J Med 1970;70:2971-8.

(4) Spitzer WO, Skovron ML, Salmi LR, Cassidy JD, Duranceau J, Suissa S, Zeiss E. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. Spine 1995;20(8S):1S-73S.

(5) States JD, Balcerak JC, Williams JS, et al. Injury frequency and head restraint effectiveness in rear impact accidents. Proceedings of 16th STAPP car crash conference, Detroit, Michigan

(6) Foreman, SM, Croft AC. Whiplash injuries: the cervical acceleration/deceleration syndrome. Williams and Wilkins, Baltimore, MD 1988.

(7) Bogduk N. Post whiplash syndrome. Austral Fam Phys 1994;23(12):2303-7.

(8) Croft AC. Whiplash: The Master's Program. Module 1. Spine Research Institute of San Diego, San Diego, CA 1996.

(9) Severy DM, Mathewson JH, Bechtol CO. Controlled automobile rear-end collisions, an investigation of related engineering and mechanical phenomenon. Canservices Med J 1955;11:727-58.

(10) Severy DM, Mathewson JH. Automobile barrier and rear-end collision performance. Paper presented at the Society of Automotive Engineers summer meeting. Atlantic City, NJ. 1958, June 8-13.

(11) Severy DM, Mathewson JH, Bechtol CO. Controlled automobile rear-end collisions, an investigation of related engineering and mechanical phenomenon. N: Medical Aspects of Traffic Accidents, Proceedings of the Montreal Conference. 1955:152-84.

(12) Thomson RW, Romilly DP, Navin FPD, Macnab MJ. Energy attenuation within the vehicle during low speed collisions. Report to Transport Canada, University of British Columbia. August, 1989.

(13) West DH, Gough JP, Harper TK. Low speed collision testing using human subjects. Accid Reconstr J 1993;5(3):22-6.

(14) Foret-Bruno JY, Dauvilliers F, Tarriere C. Influence of the seat and head rest stiffness on the risk of cervical injuries. 13th International Technical Conference on Experimental Safety Vehicles. 1991;S-8-W-19:968-974.

(15) Olsson I, Bunketorp O, Carlsson G, et al. An in-depth study of neck injuries in rear end collisions. 1990 International IRCOBI Conference, Bron, Lyon, France. Sept 12-14,1990:1-15.

(16) Balla JI. The late whiplash syndrome. Aust NZ J Surg 1980;50:610-4.

(17) Barnsley L, Lord S, Bogduk N. Clinical review: whiplash injury. Pain 1994;58:283-307.

(18) Ellertsson AB, Sigurjousson K, Thorsteinsson T. Clinical and radiographic study of 100 cases of whiplash injury. Acth Neurol Scand (Suppl) 1978;67:269.

(19) Watkinson A, Gargan MG, Bannister GC. Prognostic factors in soft tissue injuries of the cervical spine. Injury 1991;22(4):307-9.

(20) Schrader H, Obelieniene D, Bovim G, et al. Natural evolution of late whiplash syndrome outside the medicolegal context. Lancet 1996;347:1201-11.

(21) Freeman MD, Croft AC. Late Whiplash Syndrome. Lancet 1996;348(9020):125.

(22) National Highway Transportation and Safety Administration organizational chart. Washington, DC: US Department of Transportation, NHTSA 1996

(23) The National Accident Sampling System/Crashworthiness Data System Report 1991-1993. Washington, DC: US Department of Transportation. DOT HS 808 298 August 1995.

(24) The General Estimates System Report 1989 Washington, DC: US Department of Transportation. DOT HS 807 665 December 1990.

(25) Blincoe LJ. The Economic Cost of Motor Vehicle Crashes, 1994. Washington, DC: US Department of Transportation, NHTSA 1996.

(26) The Fatal Accident Reporting System 1989: A Decade of Progress. Washington, DC: US Department of Transportation. DOT HS 807 693 March 1991

(27) National Safety Council. Accident Facts:1996 edition. Itasca, IL 1996.

(28) National Safety Council. Accident Facts:1994 edition. Itasca, IL 1994:2.

(29) Traffic Safety Facts 1995. National Center for Statistics and Analysis. Washington, DC: US Department of Transportation, NHTSA. September 1996.

(30) Rice DP, MacKenzie EJ. Cost of Injury in the United States. A Report to Congress 1989. San Francisco, CA: Institute for Health and Aging, University of California and Injury Prevention Centers, The John Hopkins University, 1989.

(31) Greenblatt J, Merrin MB, Morganstein D, Schwartz S. National Accident Sampling System Nonreported Accident Survey. Washington, DC: US Department of Transportation, NHTSA DOT HS-90218, November 1981.

(32) Miller TR, Viner JG, Rosman SB, Pindus NM, Gellert GW, Douglass JB, Dillingham AE, Plomquist GC. The Costs of Highway Crashes. Washington, DC: The Urban Institute, 1991

(33) Insurance Research Council. Paying for auto injuries: A consumer panel survey of auto accident victims. May, 1994 Insurance Research Council, Oak Brook, Illinois.

(34) Freeman MD, Croft AC. The controversy over late whiplash: are chronic symptoms following whiplash real? Whiplash '96 Abstracts, Brussels, Belgium. 1996:51-2

(35) Blincoe LJ, Faigin BM. The Economic Cost of Motor Vehicle Crashes, 1990. Washington, DC: US Department of Transportation, NHTSA DOT 807 876;1992.

(36) Gotten N. Survey of one hundred cases of whiplash after settlement of litigation. JAMA 1956;162(9):865-867.

(37) Deans GT, McGalliard JN, Kerr M, Rutherford WH. Neck sprain - a major cause of disability following car accidents. Injury 1987;18:10-12.

(38) Larder DR, Twiss MK, Mackay GM. Neck injury to car occupants using seat belts. 29th Ann Proc Am Assoc Auto Med 1985:153-165.

(39) Kischka U, Ettlin T, Heim S, Schmid G. Cerebral symptoms following whiplash. Eur Neurol 1991;31(3):136-140.

(40) Hildingsson C, Toolanen G. Outcome after soft-tissue injury of the cervical spine. A prospective study of 93 car-accident victims. Acta Orthopod Scand 1990;61:357-9.

(41) Schutt CH, Dohan FC. Neck injuries to women in accidents. A metropolitan plague. JAMA 1968;296:2689-92.

(42) Mills H, Horne G. Whiplash—manmade disease? NZ Med J 1986;99:373-4.

(43) Dvorak J, Valach L, Schmid S. Cervical spine injuries in Switzerland. Orthopade 1987;16:2-12.

(44) Olsnes BT. Neurobehavioral findings in whiplash patients with long-lasting symptoms. Acta Neurol scand 1989;80:584-8.

(45) Hohl M. Soft tissue injuries to the neck. Clin Orthop Rel Res 1975;109:42.

(46) Balla JI. The late whiplash syndrome: a study of an illness in Australia and Singapore. Culture, Medicine and Psychiatry 1982;6:191-210.

(47) Deans GT, McGalliard JN, Rutherford WH. Incidence and duration of neck pain among patients injured in car accidents. Br Med J 1986;292:94-5

(48) Maimaris C, Barnes MR, Allen MJ. "Whiplash injuries" of the neck: a retrospective study. Injury 1988;19(5):393-6.

(49) Hodgson SP, Grundy M. Whiplash injuries: their long-term prognosis and its relationship to compensation. Neuro Orthop 1989;7:88-99.

(50) Pearce JMS. Whiplash injury: a reappraisal. J Neurol Neurosurg Psychiatr 1989;52:1329-31.

(51) Gargan MF, Bannister GC. Long-term prognosis of soft tissue injuries of the neck. J Bone Joint Surg Br 1990;72:901-3.

(52) Parmar HV, Raymakers R. Neck injuries from rear impact road traffic accidents: prognosis in persons seeking compensation. Injury 1993;24(2):75-8.

(53) Robinson DD, Cassar-Pullicino VN. Acute neck sprain after road traffic accident: a long-term clinical and radiological review. Injury 1993;24(2):79-82.

(54) Macnab I. Acceleration injuries of the cervical spine. J Bone Joint Surg 1964;46A(8):1797-9.

(55) Bingham R. Whiplash injuries. Med Trial Tech Quart 1968;14:69-80.

(56) Norris SH, Watt I. The prognosis of neck injuries resulting from rear-end vehicle collisions. J Bone Joint Surg 1983;65B(5):608-11.

(57) Miles KA, Maimaris C, Finlay D, Barnes MR. The incidence and prognostic significance of radiological abnormalities in soft tissue injuries to the cervical spine. Skeletal Radiol 1988;17:493-6.

(58) McKinney LA, Dornan JO, Ryan M. the role of physiotherapy in the management of acute neck sprains following road-traffic accidents. Arch Emerg Med 1989;6:27-33.

(59) Olsson I, Bunketorp O, Carlsson G, et al. An in-depth study of neck injuries in rear end collisions. 1990 International IRCOBI Conference, Bron, Lyon France September 12-14:1-15.

(60) Radanov BP, Di Stefano GD, Schnidrig A, Ballinari P. Role of psychological stress in recovery from common whiplash. Lancet 1991;338:712-5.

(61) Ettlin T, Kischka U, Reichmann S, et al. Cerebral symptoms after whiplash injury of the neck: a prospective clinical and neuropsychological study of whiplash injury. J Neurol Neurosurg Psycheatr 1992;55(10):943-8.

(62) Radanov BP, Distefano GD, Schnidrig A, et al. Cognitive functioning after common whiplash: a controlled follow-up study. Arch Neurol 1993;50:87-91.

(63) Radanov BP, Di Stefano G, Schnidrig A, Sturzenegger M. Psychosocial stress, cognitive performance and disability after common whiplash. J Psychosom Res 1993;37(1):1-10.

(64) Gargan MF, Bannister GC. The rate of recovery following whiplash injury. Eur Spine J 1994;3:162-4.

(65) Jonsson H, Cesarini K, Sahlstedt, Rauschning W. Findings and outcome in whiplash-type neck distortions. Spine1994.

(66) Ryan GA, Taylor GW, Moore VM, Dolinis J. Neck strain in car occupants: injury status after 6 months and crash-related factors. Injury 1994;25(8):533-6.

(67) Radanov BP, Sturzenegger M, Di Stefano G. Long-term outcome after whiplash injury: a 2-year follow-up considering features of injury mechanisms and somatic, radiologic, and psychosocial findings. Medicine 1995;74(5):281-97.

(68) Nygren A, Berglund A. Long term follow up of whiplash associated disorders (WAD). *Swedish experience on insurance material.* Whiplash '96 Abstracts, Brussels, Belgium. 1996:34-5.

(69) National Safety Council. Accident Facts:1996 edition. Itasca, IL 1996:83.

(70) Whiplash, other strains, sprains give auto insurers big headaches; claim inflation remedies sought. Public Affairs Report 1995;26(7):1-3.

3. "WHIPLASH ASSOCIATED DISORDERS (WAD) - REDEFINING WHIPLASH AND ITS MANAGEMENT" BY THE QUEBEC TASK FORCE: A CRITICAL EVALUATION

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PREFACE

In the previous chapter (Chapter Two) , an overview of the literature relating to whiplash injuries and their chronic sequelae was presented. The results of the meta-analysis of late whiplash studies from Chapter Two suggested that chronic symptoms following acute whiplash injuries are common, with 33% of acutely whiplash-injured individuals still symptomatic 33 months post-injury.

The publications of the Quebec Task Force on Whiplash-Associated Disorders (QTF on WAD), the subject of the current chapter, give a considerably different portrayal of late whiplash, concluding that acute whiplash injuries "rarely result in permanent harm," and that 97% of acutely whiplash-injured individuals recover within 12 months post-injury.

The purpose of this chapter is to analyze the publications of the QTF on WAD for methodologic error that may account for the differences between the conclusions of the Quebec Task Force and the literature reviewed in Chapter Two.

INTRODUCTION

In January 1995, the Societe de l'assurance Automobile du Quebec (SAAQ) published a text entitled, *Whiplash Associated Disorders (WAD)--Redefining Whiplash and its Management* (referred to, henceforth, as the "text"). The text was authored by the Quebec Task Force on Whiplash-Associated Disorders, which was chaired by Walter O. Spitzer, M.D., M.P.H., F.R.C.P.C., and consisted of an eminent panel of experts in medicine, epidemiology and biostatistics, chiropractic, and other disciplines. The reported

mandate of the Task Force was to address a variety of issues concerning whiplash injuries, including:

1. the prevention of whiplash injuries;
2. an examination of the natural history of the condition;
3. the formulation of practical clinical guidelines for diagnosis and management of the condition;
4. the development of a strategy for the education of health care providers regarding whiplash injuries; and,
5. the development of recommendations for occupational and personal rehabilitation for whiplash-injured individuals.

The Task Force set out to comprehensively review the literature on the subject in order to respond to the issues of the mandate. In addition, a retrospective cohort study was performed on SAAQ data of whiplash-diagnosed individuals in Quebec who collected compensation for their injuries in 1987.

The strategy of the Task Force was to use the "preeminence of evidence" for developing the guidelines, and that, no matter how eminent the panel members were in their respective fields of specialty, their opinions were "always subordinate to evidence" (section 1, page 3).

The Task Force first set about this task by instructing its members on the anatomy, pathophysiology, and biomechanics of whiplash injuries. Then, they examined the existing literature on the subject, using a technique called "the best synthesis of evidence," to determine which literature was scientifically suitable for inclusion in the study. The Task Force then studied its cohort and analyzed the resulting data. Lastly, based upon the results of the literature search and the cohort study, conclusions and recommendations

were made regarding the research questions that had been asked. In addition to the text, which was several hundred pages long and available from the SAAQ (it is self-referred to as the "Official Report"), the Task Force published a 73-page pull-out supplement in the April 15, 1995 issue of the journal *Spine* (1) (referred to, henceforth, as the "supplement"). When the text and supplement were published, synopsized versions of the conclusions and recommendations were published widely in the popular press, under headlines such as *Whiplash Treatments Found to be Ineffective*, and *Much Whiplash Aid is Rated Worthless* (2, 3, 4).

It is our contention that some of the most critical conclusions and recommendations, as well as the methodology used by the Task Force in reaching those conclusions, are flawed to the point that the validity of the document must be questioned. The purpose of this paper is to describe our findings of the examination of the text and supplement and to present an analysis of potential sources of bias and other weaknesses.

Materials and Methods

Initially, we reviewed both the primary text and the supplement published by the Quebec Task Force. After examining both publications it was determined that only the primary text would be critiqued because it contained a more complete discussion of the study, and because the supplement contained no unique information.

Initially, only the Task Force's methodology was examined, particularly for sources of bias which might have threatened either the internal or external validity of the study. Internal validity is defined as the lack of bias in the study, and is threatened by comparison and information biases. External validity refers to the generalizability of the

results of the study; in the case of this study, how the results and conclusion from the cohort study apply to the general population.

After a review of the methodology, it became evident that there were other problems with the document that posed an equally large threat to the accuracy of the study's conclusions as did the study's lack of validity. These problems consisted of the confusing use of terminology, and conclusions and recommendations that were neither supported by the literature review nor by the results of the cohort study. They were, in some cases, contrary to findings reported in the literature cited by the Task Force.

Results and Discussion

We found five separate categories of methodologic flaws within the text. These categories were:

1. selection bias (a threat to internal validity);
2. information bias in the cohort study (a threat to internal validity);
3. confusing and unconventional use of terminology;
4. unsupported conclusions and recommendations; and,
5. inappropriate generalizations from the cohort study (a threat to external validity).

SELECTION BIAS

Selection Bias in Article Selection

The first area in which bias was noted was the manner of selection of articles considered eligible for inclusion in the study. In section 1 of the text, page 6, the statement

was made that an *a priori* "criteria of quality when accepting or rejecting studies" could not be used because it would have resulted in the rejection of "virtually all articles considered" for inclusion in the formal literature review. In spite of this declaration, nearly all of the articles considered were rejected. Specifically, of the 10,382 articles reviewed, 62 were deemed acceptable (section 1, page 4), yielding an acceptance rate of 0.6%, and a rejection rate of 99.4%. Wholesale rejection of existing literature is not a source of bias per se if it does not result in an unrepresentative selection of the literature. However, the variability of all of the literature is difficult to assess and, with such a small sample of the literature, the degree to which the accepted literature is representative of the whole pool of relevant literature cannot be determined.

The literature that was considered for review included searches of the computerized databases beginning in 1980 and continuing to April of 1994. Sources included computerized databases such as MEDLINE, TRIS, and NTIS. Also searched were reports by government agencies, and the Task Force members were asked to supply studies of which they were aware (chapter 5.1, page 3). Literature from before 1980 was included if it was considered either "seminal" or "important" by members of the Task Force. The criteria for gauging these characteristics was not provided. The seemingly arbitrary and nebulous nature of article selection for the period prior to 1980 contrasts greatly with the pan-inclusive search of the subsequent literature. There is no explanation for the discrepancy in search methodology for the periods before and after 1980. However, the use of noncomparable criteria for article selection may have seriously undermined the accuracy of the literature review.

Selection Bias in the Cohort Study

With the SAAQ whiplash-associated disorder cohort, the Task Force study set out to estimate the incidence of "**compensated** [emphasis added] whiplash injury" in Quebec and describe its variation by age, gender, and geographical region (section 6, page 2). The study subjects were identified from the SAAQ's database of individuals with ICD-9 diagnostic code 847.0 (cervical sprains and strains, including whiplash injury) and included only individuals who had received compensation for their injuries in 1987 in Quebec. Information for each individual receiving compensation was gathered from the computer database of the SAAQ. The following variables were considered:

1. demographic data (gender, age, area of residence, marital status, employment status, net income, and number of dependents);
2. collision-related data (vehicle type, occupant position, presence of multiple injuries, etc.);
3. the duration of compensation for time lost from work;
4. any recurrence of time loss compensation; and
5. the total cost to SAAQ.

No information was gathered about treatment rendered, symptoms, or the extent of functional impairment of the individuals receiving compensation. Several types of compensation were available from the SAAQ (section 6, page 17):

1. an allowance to replace regular income, with a one week waiting period before time loss payments could be collected;
2. reimbursement for expenses associated with the accident, such as damaged clothing;

3. a lump sum payment for bodily injury;

4. an allowance for rehabilitation, the example of which was given as re-fitting a vehicle or home with special equipment; and

5. payments made in case of death.

Not included as compensation was most of the cost of treatment for whiplash injuries because Quebec has universal health care insurance and private plans that provide for treatment of whiplash injuries. The text mentions that the SAAQ would reimburse for treatment when it was not provided by any other insurance, but the amount of reimbursement for treatment not otherwise covered was reported to be $0.00 for 1987 (section 6, page 4), whereas in the supplement, Table 6 enumerated numerous categories of expenditure not mentioned in the "Official Report." The reason for this disparity is unclear. Notwithstanding this inconsistency, it is apparent from the text that only individuals who sought compensation, regardless of treatment history, were included in the cohort.

Also not included in the cohort were individuals who suffered whiplash injuries during the course of their employment because, in Quebec, industrial injuries are the responsibility of another insurer. The selection criteria for subject eligibility for the cohort eliminated an unknown number of the following whiplash-injured individuals:

1. Whiplash-injured individuals who sought no professional treatment and were not disabled;

2. whiplash-injured individuals who sought treatment for their injuries, but no compensation;

3. whiplash-injured individuals who were injured in the course of their employment;

4. whiplash-injured individuals who may have sought and received compensation, but were not diagnosed with the ICD-9 code 847.0;

5. whiplash-injured individuals with less than one week of time loss (the SAAQ will not pay time loss until more than one week has elapsed); and

6. whiplash-injured individuals who were disabled for more than one week, but chose not to seek compensation.

Had the Task Force used the data generated by their study to estimate the incidence of "compensated whiplash injury" in Quebec and describe its variation by age, gender, and geographical region, as they had originally set forth, selection bias would have been a much less significant issue. However, in the results section (section 6, pages 5-12) the authors did not confine themselves to inferences regarding 847.0-diagnosed individuals receiving compensation. The data were extrapolated to all whiplash-injured individuals in Quebec in 1987, not just those receiving compensation.

Another substantial source of selection bias resulted from the elimination of large portions of the cohort. For example, of the original 4766 subjects, 1743 (36.6%) were excluded because their computer file contained no police report. In accidents where property damage exceeds CAN$500, or accidents in which occupants are injured and require immediate medical attention, or accidents involving animals larger than 50 kg, police may be summoned to the scene (5). This usually results in the generation of a police report of the accident. Thus, police reports are not randomly associated with accidents.

Eliminating all individuals from the cohort study who had no police report associated with their compensation history would exclude whiplash-injured individuals who had a delay in onset of symptoms requiring medical care and/or who had less than CAN$500 property damage to their vehicle. Determination of whether this exclusion

might be a source of selection bias requires examination of the literature regarding delayed symptom onset and the rate of whiplash injury at sub-vehicular damage velocities.

Several authors have reported delay of onset symptoms in whiplash-injured individuals (6, 7, 8, 9). For example, Hildingsson and Toolanen, in one of the 11 studies the Task Force accepted for their prognosis section, reported the following onset of symptoms in their cohort of 93 whiplash-injured patients (10): 65 patients were symptomatic within one hour; 77 patients were symptomatic within 5 hours; and 85 patients were symptomatic within 15 hours. Thus, 30% of these patients would not have been symptomatic immediately after the accident, and would not have met one of the response criteria of the Quebec Police Department. This figure is comparable to the 36.6% of the cohort that did not have police reports in their compensation claim file.

Several studies have examined damage thresholds for various vehicles. For example, Szabo et al. found that 1981-83 Ford Escorts could withstand multiple impacts at 10 mph without sustaining damage (11). Bailey et al. reported the damage thresholds for a 1980 Toyota Tercel, a 1977 Honda Civic, a 1980 Chevrolet Citation, and a 1981 Ford Escort as 8.1 mph, 8.2 mph, 8.4 mph, and 10.2 mph, respectively (12).

Wooley et al. tested a 1979 Pontiac Grand Prix, a 1979 Ford E-150 van, a 1978 Honda Accord, a 1979 Ford F-250 pick-up, a 1983 Ford Thunderbird, and a 1989 Chevrolet Citation and reported damage thresholds at 9.9 mph, 9.9 mph, 11.0 mph, 11.7 mph, 12.1 mph, and 12.7 mph, respectively (13).

Concerning the rate of occupant injury, Foret-Bruno et al. (14) reported that, at velocity changes below 9.3 mph, the injury rate was 36%, while at velocity changes greater than 9.3 mph, the injury rate was only 20%, pointing to an inverse relationship

between vehicle damage and occupant injury. Olsson et al. (15) found that 18% of these injuries occurred at crashes of less than 6.2 mph, and that 60% of injuries occurred between 6.2 and 12.4 mph. These findings nullify another of the Quebec police department response criteria because the majority of whiplash injuries occur at speeds that are unlikely to result in significant vehicle damage.

It is reasonable to conclude that a substantial subpopulation of whiplash-injured individuals were eliminated from the Task Force's cohort study by the police report selection criteria. These persons may have had a different history of compensation and recurrence than the group that was studied, resulting in study results that are difficult to interpret and that lack external validity. Moreover, the subpopulation of the cohort that was studied for recurrences did not include an additional 1,348 (28.3%) subjects who were given other diagnoses in addition to the ICD-9 diagnostic code 847.0. Accordingly, some of the most seriously injured individuals probably were excluded from the study by this selection criteria, further undermining the interpretability and external validity of the study findings.

INFORMATION BIAS IN THE COHORT STUDY

Information bias threatens the validity of the cohort study as a result of the use of ICD-9 diagnostic code 847.0 as the criteria for whiplash injury. In section 7, page 2, the Task Force remarked that diagnosis in whiplash was "confusing and non-standard," thereby suggesting that misdiagnosis may be common. We agree with this assessment.

Therefore, it is probable that some whiplash cases were overlooked due to misclassification or the use of codes other than 847.0.

CONFUSING AND UNCONVENTIONAL USE OF TERMINOLOGY

The **Results and Discussion** section of the cohort study (section 6, pages 5-15) contains numerous references to the portion of the study population that had "recovered" at the time of cessation of compensation. However, without any data gathered concerning the symptoms, level of treatment, or functional impairment at the time of cessation of compensation, it would not be possible to infer anything beyond the fact that the individual no longer was receiving compensation.

Although it is not unreasonable to assume that an unknown percentage of the cohort stopped receiving compensation because they had indeed "recovered" in the conventional sense of the word, alternative explanations for time loss cessation are also likely:

1. the individual partially recovered to the point that he/she could return to work;
2. the individual did not recover function but was able to find employment in another, less taxing line of work; and
3. the individual did not recover but returned to work at a decreased level of function due to economic pressure (it is unknown how influential this factor may have been because there is no information given in the text concerning the rate of reimbursement from SAAQ; presumably, earlier return to work would be a larger factor with lower reimbursement rates).

In the section following the description of the cohort study (section 6, page 2), recovery is defined as the "end of disability compensation." However, there is no

reference cited for this unusual use of the word; the use of "recovery" in this manner is inconsistent with its usual meaning and is, at best, confusing and, at worst, misleading.

Other words or phrases used to describe findings from the cohort study, which cannot be inferred from the data that were collected, are:

1. "return to activity," because the actual level of activity was not measured and cannot be accurately inferred from duration of compensation;
2. "time of absence" from work, because duration of compensation does not necessarily measure time away from work;
3. "whiplash injury," because only the admittedly inaccurate diagnosis of ICD-9 code 847.0 was used to determine the existence of whiplash injury; and
4. "relapse or recurrence of symptoms," because no information was collected about the level of symptomatology, and "relapse" may have been inferred incorrectly from the reinstitution of time loss compensation.

Table 3.1 enumerates the locations in the text where the above listed and similar phrases were found.

Table 3.1: Questionable use of Terminology in the Text

Location of Citation in Text		
Section #	**Page #**	**Quote from Text**
6	9	"Among the study cohort members, more than one fifth (22.1%) **recovered** within one week of the collision."
6	9	"Among those who sustained only a **whiplash injury**..."
6	10	"The **return to activity** curve ... reveals that approximately 50% of the 2,810 whiplash subjects **recovered** within one month of the collisions, while 64% **recovered** within 60 days ... at six months and one year after the collision date, the proportion of subjects who had **recovered** was 87% and 97%, respectively."
6	14	"The data showed that longer time to **return to activity** after whiplash were found in subjects ..."
6	15	"Being in a severe collision ... [was] associated with a **longer time of absence**."
6	15	"Rear-end collisions ... were found to be associated with a higher rate of **relapse or recurrence of symptoms** of whiplash subjects."

UNSUPPORTED CONCLUSIONS AND RECOMMENDATIONS

The Self-limited and Short-lived Nature of Whiplash Injuries

In several places in the text, the Task Force reports that whiplash injuries are relatively benign. In section 7, page 2, they note: "Whiplash-associated disorders are usually self-limited." In section 7, page 3, they note: "Patients should be reassured that Whiplash-associated disorders are almost always self-limited." Again in section 7, page 10, they note: "The clinical management of WAD patients should recognize that most WAD...is self-limited." In chapter 8.1, page 3, they note: "Patients should be reassured that most WAD are benign and self-limiting."

There were no references cited in the section on prognosis of whiplash injuries to support these statements. Indeed, Table 5.3.4.4, "Prevalence of symptoms at follow-up," lists the four studies on prognosis which were accepted for review along with the findings of those authors. Norris and Watt found that 66% of their cohort had neck pain at an average of two years post injury (16); Radanov et al. found that 27% of their cohort were symptomatic six months post-accident (17), and in a study published two years later, reported that 27% of their cohort continued to have headaches six months post-accident (18). Hildingsson and Toolanen found that 44% of their cohort were symptomatic an average of two years post-accident (10).

Even based upon the only literature accepted by the Task Force in this study which addressed long-term symptomatology, it appears that whiplash-associated disorders are frequently not self-limited and that a substantial number of injured individuals have long-term, chronic symptoms as a result of their injuries.

Additionally, there were no data collected on the physical status of the compensated whiplash injured subjects in the Quebec whiplash-associated disorder cohort study that would have allowed for an inference regarding recovery rates.

Favorable Prognosis

In section 7, page 2, the authors note: "All interventions...should be accompanied by reassurance about the favorable prognosis..."

A "favorable prognosis" is usually forecast in conditions that are known to spontaneously resolve without any residual symptoms or disability. Relying only on the literature cited by the Quebec Task Force, whiplash is a disorder that leaves 27% to 66% of the injured population symptomatic at six months to two years post-injury. They cited no studies in their text that would lend support to this statement about favorable prognosis.

Pain is not Harmful

In section 7, page 3, the Task Force recommended: "The key message to the WAD patient is that the pain is not harmful, [and] is usually short-lived... ." The Task Force did not study the nature or severity of pain experienced by the subjects of their cohort study, and none of the prognosis studies accepted for inclusion support the statement that WAD pain is not harmful or that it is short-lived. To the contrary, the pain apparently is long-lived in a substantial proportion of cases. The degree of harm caused by

pain from whiplash injuries is a complex subject that was not investigated by the Task Force.

Whiplash Results in Temporary Discomfort

In section 7, page 3, the Task Force reports: "...most incidents of WAD are self-limited, involving temporary discomfort, and rarely resulting in permanent harm.

The studies cited in Table 5.3.4.4 of the text do not support the statement that the "discomfort" is temporary for a substantial percentage of injured individuals. Additionally, using the term "discomfort" in lieu of "pain" may be misleading, because it may suggest to some that the pain experienced by whiplash-injured individuals is minimal or trivial. The degree of pain experienced by the average whiplash-injured individual was not studied by the QTF, in either its cohort study or its review of the literature.

A literature search was conducted to determine if there were other studies that contradicted the Task Force's conclusions that whiplash injuries short-lived, self limited, and temporary in nature. In addition to the four studies cited by the Task Force, 27 additional studies were found which reported on follow-up of acutely whiplash-injured individuals more than six months post-injury. A minimum quality criteria was established for these studies, which was as follows:

1. they followed a minimum of 30 relatively unselected acute whiplash patients; either patients presenting to a hospital emergency room, if the study was a prospective design, or a randomly assembled group of patients who were purposely recruited for the study, in a retrospective design;

2. the number of patients who had neck symptoms at the baseline evaluation was given, allowing for a comparison with those with neck symptoms at final follow-up;

3. the study gave enough detail regarding study design that it was clear how the authors arrived at their conclusions; and,

4. the study did not duplicate the results of a previously reviewed study which followed the same cohort.

Table 3.2 lists the 11 studies that fit the preceding criteria by author, year of study, cohort size, length of follow-up, and proportion of cohort with neck pain at final follow-up, with respect to those who initially presented with neck pain. The results of this literature search clearly contradict the Task Force's conclusions regarding the permanency of whiplash injuries.

Table 3.2: Prognosis studies that fit the minimum quality criteria for inclusion

Author	Year	Cohort Size	Mean Follow-up (months)	% Chronic
Deans et al. (19)	1986	85	12	42
Maimaris et al. (20)	1988	102	26	34
Miles et al. (21)	1988	73	24	29
McKinney et al. (22)	1989	167	24	38
Olsson et al. (23)	1990	33	12	36
Radanov et al. (24)	1991	78	6	24
Watkinson et al. (25)	1991	35	128	26
Radanov et al. (26)	1993	88	6	34
Gargan and Bannister (27)	1994	50	24	60
Radanov et al. (28)	1995	108	24	19
Nygren et al. (29)	1996	250	72	23

INAPPROPRIATE GENERALIZATIONS FROM THE COHORT STUDY

In section 6, page 15, the annual incidence rate of compensated insurance claims for whiplash injury in Quebec in 1987 was reported as 70/100,000, based upon the results of the cohort study. This rate is compared with that "of other countries," and Saskatchewan, where the rate was stated to be as "high as 700 per 100,000." However, due to the aforementioned substantial problems with subject selection criteria, the composition of the cohort, with regard to actual whiplash injury, is not clear. Moreover, there is no mention in the text of whether the selection criteria for these other cohorts were comparable. Thus, direct comparison of whiplash injury rates may not be comparable between these groups.

CONCLUSION

The validity of the conclusions and recommendations of the Quebec Task Force regarding the natural course of whiplash injuries is questionable. This stems from the presence of bias and unconventional terminology used in both the literature search and the cohort study. Although the Quebec Task Force set out to "redefine whiplash and its management," striving for the desirable goal of clarification of the numerous contentious issues surrounding the injury, its publications have instead further confused the subject. Fundamental issues concerning the disorder continue to be debated in the literature, as evidenced by a recent publication by Schrader et al. who hypothesized that chronic symptoms as a result of whiplash were not real and were primarily the result of avarice

(30). This study was later criticized for, among other faults, having "severe and fatal" selection bias (31, 32, 33).

We are in agreement with the Quebec Task Force concerning the need for high quality research concerning the true epidemiologic characteristics of whiplash injuries. Although the whiplash literature is extensive, no definitive studies have established widely accepted standards for either acute or chronic whiplash regarding effective treatment, prognosis, and risk factors for progression from the acute to the chronic stage.

Perhaps the unintended result of the publication of the Task Force findings will be to stimulate discussion in the literature and improve the quality of research on whiplash injuries.

REFERENCES

(1) Spitzer WO, Skovron ML, Salmi LR, Cassidy JD, Duranceau J, Suissa S, Zeiss E. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. Spine 1995;20(8S):1S-73S.

(2) Altman LK. Whiplash treatments found to be ineffective. New York Times May 2, 1995:C1,6.

(3) Altman LK. Much whiplash aid is rated worthless. San Diego Union Tribune May 2, 1995:A8.

(4) Altman LK. Whiplash can heal on own in days. Lakeland Ledger May 7, 1995:Science and Technology section.

(5) Gagne S. Conversation with Officer Sylvain Gagne of the Quebec Police Department, 7-15-96.

(6) Gotten N. Survey of one hundred cases of whiplash after settlement of litigation. JAMA 1956;162(9):865-867.

(7) Deans GT, Magalliard JN, Kerr M, Rutherford WH. Neck sprain - a major cause of disability following car accidents. Injury 1987;18:10-12.

(8) Larder DR, Twiss MK, Mackay GM. Neck injury to car occupants using seat belts. 29th Ann Proc Am Assoc Auto Med 1985:153-165.

(9) Kischka U, Ettlin T, Heim S, Schmid G. Cerebral symptoms following whiplash. Eur Neurol 1991;31(3):136-140.

(10) Hildingsson C, Toolanen G. Outcome after soft-tissue injury of the cervical spine. A prospective study of 93 car-accident victims. Acta Orthopod Scand 1990;61:357-9.

(11) Szabo TJ, Welcher J. Dynamics of low speed crash tests with energy absorbing bumpers. SAE Tech Paper Series 1992;921573:1-9.

(12) Bailey MN, Wong BC, Lawrence JM. Data and methods for estimating the severity of minor impacts. SAE Tech Paper Series 1995;950352:1339-174.

(13) Wooley RL, Strother CE, James MB. Rear stiffness coefficients derived from barrier test data. SAE Inernational Congress, Detroit, MI 1991:910120.

(14) Foret-Bruno Jy, Dauvilliers F, Tarriere C. Influence of the seat and head rest stiffness on the risk of cervical injuries. 13th International Technical Conference on Experimental Safety Vehicles. 1991;S-8-W-19:968-974.

(15) Olsson I, Bunketorp O, Carlsson G, et al. An in-depth study of neck injuries in rear end collisions. 1990 International IRCOBI Conference, Bron, Lyon, France. Sept 12-14,1990:1-15.

(16) Norris SH, Watt I. The prognosis of neck injuries resulting from rear-end vehicle collisions. J Bone Joint Surg [Br] 1983;65:608-11.

(17) Radanov BP, Di Stefano G, Schnidrig A, Sturzenegger M, Augistiny KF. Cognitive functioning after common whiplash. A controlled follow-up study. Arch Neurol 1993;50:87-91.

(18) Radanov BP, Sturzenegger M, Di Stefano G, Schnidrig A, Aljinovic M. Factors influencing recovery from headache after common whiplash. Br Med J 1993;307:652-5.

(19) Deans GT, McGalliard JN, Rutherford WH. Incidence and duration of neck pain among patients injured in car accidents. Br Med J 1986;292:94-5.

(20) Maimaris C, Barnes MR, Allen MJ. "Whiplash injuries" of the neck: aretrospective study. Injury 1988;19(5):393-6.

(21) Miles KA, Maimaris C, Finlay D, Barnes MR. The incidence and prognostic significance of radiological abnormalities in soft tissue injuries to the cervical spine. Skeletal Radiol 1988;17:493-6.

(22) McKinney LA, Dornan JO, Ryan M. the role of physiotherapy in the management of acute neck sprains following road-traffic accidents. Arch Emerg Med 1989;6:27-33.

(23) Olsson I, Bunketorp O, Carlsson G, et al. An in-depth study of neck injuries in rear end collisions. 1990 International IRCOBI Conference, Bron, Lyon France September 12-14:1-15.

(24) Radanov BP, Di Stefano GD, Schnidrig A, Ballinari P. Role of psychological stress in recovery from common whiplash. Lancet 1991;338:712-5.

(25) Watkinson A, Gargan MG, Bannister GC. Prognostic factors in soft tissue injuries of the cervical spine. Injury 1991;22(4):307-9.

(26) Radanov BP, Di Stefano G, Schnidrig A, Sturzenegger M. Psychosocial stress, cognitive performance and disability after common whiplash. J Psychosom Res 1993;37(1):1-10.

(27) Gargan MF, Bannister GC. The rate of recovery following whiplash injury. Eur Spine J 1994;3:162-4.

(28) Radanov BP, Sturzenegger M, Di Stefano G. Long-term outcome after whiplash injury: a 2-year follow-up considering features of injury mechanisms and somatic, radiologic, and psychosocial findings. Medicine 1995;74(5):281-97.

(29) Nygren A, Berglund A. Long term follow up of whiplash associated disorders (WAD). Swedish experience on insurance material. Whiplash '96 Abstracts, Brussels, Belgium. 1996:34-5.

(30) Schrader H, Obelieniene D, Bovim G, et al. Natural evolution of late whiplash syndrome outside the medicolegal context. Lancet 1996;347:1201-11.

(31) Freeman MD, Croft AC. Late Whiplash Syndrome. Lancet 1996;348(9020):125.

(32) Bjorgen IA: Late Whiplash Syndrome. Lancet 1996;348(9020):124.

(33) de Mol BA, Heijer T: Late Whiplash Syndrome. Lancet 1996;348(9020):124-125.

4. CHRONIC NECK PAIN AND WHIPLASH: A CASE/CONTROL STUDY OF THE RELATIONSHIP BETWEEN ACUTE WHIPLASH INJURIES AND CHRONIC NECK PAIN

PREFACE

The preceding two chapters of this thesis examined existing literature on the subject of whiplash injuries. While the majority of the studies reviewed indicate a strong relationship between whiplash injuries and chronic neck pain, the authors of the *Quebec Task Force on Whiplash-Associated Disorders* (reviewed in Chapter Three) concluded that chronic neck pain and acute whiplash injuries are not strongly related, if related at all. In the current chapter, original research is presented that is intended to evaluate whether a link exists between chronic neck pain and acute whiplash injuries. This original research differs from previous studies in that it was designed to approach late whiplash from the chronic pain **sequelae** perspective (that is, how the problem affects the general population), rather than the acute whiplash **cause** perspective (the natural history of the condition). All of the studies reviewed in Chapter Two followed a group of whiplash-injured individuals for a specified amount of time and then surveyed the group for chronic pain. The weakness of this study design is that it is difficult, without a comparison group, to determine what proportion of the chronic pain is residual from the whiplash injury, as opposed to the proportion of pain that would have been present regardless of injury.

The present study is designed to overcome this methodologic weakness. In this study, a group of individuals with chronic neck pain are compared to a group of individuals with chronic low back pain with regard to the etiology of their pain.

Attribution and causation were assumed to be the same in this study; therefore, alternative causes of chronic pain were recorded and compared for the two groups of individuals, rather than, as with previous studies, remaining unreported (the assumption being that all symptoms were related to the original whiplash injury) and potentially confounding the results.

INTRODUCTION

The rate of recovery following acute whiplash injuries has been the subject of multiple studies. The majority of these studies have been designed as either prospective or retrospective case series, in which there is no control group. Generally, the prospective studies are of higher quality as they use an inception cohort, and are more likely include on consecutive patients presenting to a hospital emergency room (1, 2, 3, 4, 5, 6, 7, 8, 9). In comparison, the retrospective studies are more likely to describe cohorts that have been assembled from a specialist's practice, and are more susceptible to recall bias because the subjects are enrolled months, and sometimes years, after the original injury (10, 11, 12, 13, 14, 15, 16, 17, 18).

A comprehensive literature search revealed only two studies that used a controlled study design. Schrader et al. retrospectively studied 202 individuals in Lithuania who had been involved in a motor vehicle accident (MVA) (19). The authors assembled an age and gender matched control group that had no history of a MVA. The two groups were surveyed for neck pain an average of 22 months post-accident (relative to the time of the motor vehicle accident for the exposed cohort) and were found to have the same

prevalence of neck pain. The authors concluded that whiplash injuries do not cause chronic symptoms. This study later was criticized as suffering from "severe and fatal" selection bias, among other flaws (20).

The second controlled study was conducted by Nygren et al. who reported on a cohort of 250 whiplash-injured individuals that was followed prospectively for 72 months post-accident (21). The subjects in the whiplash-exposed cohort were age and gender matched with at least five controls who had a negative history of neck injury following an MVA. At 72 months, both cohorts were queried concerning for neck pain. Nygren et al. reported a chronic neck pain prevalence difference of 23%, with 38% of the exposed symptomatic and 15% of the controls symptomatic. These results contradicted the conclusions drawn by Schrader et al., and strongly suggested chronic symptoms following whiplash, or late whiplash, after Balla, (22) as a valid clinical entity.

Notwithstanding the above study, there are many unanswered questions regarding the nature of late whiplash, *e.g.*:

- what is the contribution of late whiplash to the total pool of individuals with chronic neck pain in the general population;
- which risk factors make an acutely whiplash-injured individual more likely to become chronic; and,
- how individuals with chronic neck pain compare with individuals with other chronic spinal pain with regard to a history of a MVA as the origin of their pain.

The purpose of this study is to explore the nature of the relationship between chronic neck pain and whiplash injuries by using a case/control study design. Chronic neck pain patients will be compared with chronic back pain patients with regard to history of onset of the pain, nature of the pain, treatment history, work history at the time of the

initial injury and currently, and characteristics such as age, gender, weight and height. Additionally, if the patient was ever injured in a MVA, the nature of the MVA is described with regard to known risk factors for acute injury, i.e. impact direction, seat belt use, position in the vehicle at the time of impact, and vehicle damage.

For this study, consecutive patients presenting to the practices of 100 randomly selected U.S. chiropractic physicians in nine states were surveyed. Chiropractic practices were selected because:

- most chiropractic patients present with complaints of spine pain (23);
- typically, a substantial proportion of a chiropractor's practice consists of patients with chronic neck and back pain (24); and,
- chiropractors are the initial treating physician for one out of three individuals who seek treatment for spine pain (25), and provide 40% of all treatment for low back pain (26); thus, chiropractors treat a broad cross-section of the population with spinal pain (allowing for inferences that are applicable to the general population with chronic spine pain).

MATERIALS AND METHODS

An initial sample size estimate, that was calculated with an odds-ratio of two, an alpha of 0.05 and a beta of 0.10, indicated that approximately 150 cases and 150 controls (300 subjects total) would be sufficient for the study. It was decided, however, that because a sub-group analysis was anticipated, to double the sample size estimate (600 subjects total) to ensure adequate statistical power for the subset analysis as well as for the estimation of overall effects.

One hundred chiropractic physicians were randomly recruited from a list of 8,000 practitioners with an interest in whiplash injuries in nine states (California, Louisiana, New York, Oklahoma, Oregon, Texas, Washington, Wisconsin and Utah, the states with the largest proportions of practitioners on the list), initially by phone, and then by letter. The chiropractors were sent a packet of instructions, 50 pre-surveys (described below), 10 surveys (that had been previously validated using a sample population of chronic spine pain patients), a copy of a statement of informed consent, and a tally sheet. The chiropractors were asked to administer a brief pre-survey to all consecutive patients to determine if the patient met the eligibility criteria of the study. These criteria were:

- the patient was 18 years of age or older; and,
- the patient had experienced at least one intrusive episode of back or neck pain, per week, for the preceding consecutive 26 weeks (six months) or longer.

When a patient was determined to be eligible for the study, he or she was given a questionnaire to complete, along with an explanation of informed consent. The chiropractor was given a tally sheet to keep track of the number of surveys completed for chronic neck pain patients (cases), and chronic back pain patients (controls). The questionnaires were color coded for the two groups. When five surveys were completed for each category, the completed surveys along with the tally sheets were returned to the authors. The chiropractors were asked to record the number of patients, if any, who refused to complete the questionnaire.

Initially, 163 chiropractors were contacted by phone and asked if they would participate in the study. Of the 100 who agreed, six returned the information packet and

survey forms, stating that they would not have time to administer the questionnaires. Of the remaining 94 chiropractors, 33 returned ten completed surveys, five cases and five controls. Thirty-four chiropractors returned ten surveys that were collected from consecutive patients, without regard to case or control status. Fifteen returned surveys were unusable because they were incomplete. Sixty-seven chiropractors participated in the study, for a response rate of 41% (67 of the original 163 contacted). There were a total of 665 completed surveys returned; 419 cases and 246 controls. Every eligible patient in the participating offices agreed to fill out the survey.

The data from the surveys were tabulated and stratified by age and gender. An exposure-odds ratio (EOR) was calculated for the different strata with regard to a history of MVA-induced chronic pain. The chi square heterogeneity test was used to test for effect modification between age groups and gender, and the Mantel-Haenszel pooled estimator was used to calculate a point estimate and 95% confidence interval for those strata that were found to have homogenous effects. Epi Info 6 was the statistical program used for these calculations.

In addition, individuals who had sustained an acute MVA-caused injury that later resolved (they attributed their chronic spine pain to a cause other than an MVA) were compared with those whose chronic symptoms were attributed to a MVA. Comparisons were made between the two groups for direction of impact, seat belt use, position in vehicle during impact, vehicle damage, gender, age at time of impact, and ideal body mass. The chi square test was used to determine if there were statistically significant differences between categorical variables, and t-tests were used to determine if there were statistically

significant differences for continuous variables. SPSS for Windows was the program used for the inferential statistics.

Finally, cases were compared with controls for the primary type of treatment used for the first six months following the onset of their chronic pain, as well as their satisfaction levels with that treatment.

RESULTS

Of the 665 respondents, 419 (63%) had chronic neck, or chronic neck and back pain (cases), and 246 (37%) had chronic low back pain (controls). The cases consisted of 120 (40%) males, and 299 (60%) females, and the controls were comprised of 117 (48%) males, and 129 (52%) females. The mean age of the male and female cases was 45.1 years (range 21-79, SD 14.25) and 42.4 years (range 18-83, SD 12.84), respectively, and the mean age of the male and female controls was 44.5 years (range 19-83, SD 12.47) and 42.1 years (range 18-79, SD 14.95), respectively.

Cause of Pain

The most frequently named cause of chronic pain among the cases was an acute motor vehicle accident injury, reported by 44% of all male cases and 45% of all female cases. The highest proportion (67%) was observed in male cases, 21-30 years of age. Among the controls, the most frequently reported cause of chronic pain for the males was a work injury (27%), and for the females, insidious or unknown onset (38%). The next

most prevalent cause of chronic pain in the female control group was MVA injuries, (29%), whereas for the male controls, insidious onset (22%), lifting (21%), and other causes (21%) all ranked ahead of MVA injuries (17%). The group with the highest proportion of work-related chronic pain was female cases, with 38% of respondents attributing their neck or neck and back pain to an on-the-job injury (see Tables 4.1-4.4). Work-related injuries were treated as a separate category from the other causes, and were not exclusive of other types of injuries (a work-related injury could also be a lifting injury, or a MVA injury). For this reason, work-related are presented in a table separate from the other causes of chronic spine pain (see Table 4.5).

Table 4.1: Attribution of cause of pain, for male respondents with chronic neck, or chronic neck and back pain (cases), stratified by age.

	CAUSE OF PAIN (Male Cases) Number of Cases (Percent)						
Age (years)	**Motor Vehicle Accident**	**Insidious Onset**	**Lifting**	**Fall**	**Sports**	**Other**	**Total for Each Age**
21-30	12(67)	2(11)	1(5)	0(0)	2(11)	1(5)	**18(100)**
31-40	18(58)	6(19)	0(0)	1(3)	1(3)	5(17)	**31(100)**
41-50	11(34)	7(22)	3(10)	2(6)	2(6)	7(22)	**32(100)**
51-60	4(20)	7(35)	1(5)	2(10)	1(5)	5(25)	**20(100)**
61-79	8(42)	7(37)	2(11)	1(5)	0(0)	1(5)	**19(100)**
Total Male Cases	**53(44)**	**29(24)**	**7(6)**	**6(5)**	**6(5)**	**19(16)**	**120(100)**

Table 4.2: Attribution of cause of pain, for female respondents with chronic neck, or chronic neck and back pain (cases), stratified by age.

	CAUSE OF PAIN (Female Cases) Number of Cases (Percent)						
Age (years)	**Motor Vehicle Accident**	**Insidious onset**	**Lifting**	**Fall**	**Sports**	**Other**	**Total for Each Age**
18-30	37(56)	14(21)	0(0)	2(3)	3(5)	10(15)	**66(100)**
31-40	29(51)	13(22)	2(4)	2(4)	1(2)	10(17)	**57(100)**
41-50	39(45)	23(26)	0(0)	6(7)	5(6)	14(16)	**87(100)**
51-60	17(35)	16(33)	1(2)	2(4)	4(8)	9(18)	**49(100)**
61-83	12(30)	16(40)	2(5)	5(13)	2(5)	3(7)	**40(100)**
Total Female Cases	**134(45)**	**82(27)**	**5(2)**	**17(6)**	**15(5)**	**46(15)**	**299(100)**

Table 4.3: Attribution of cause of pain, for male respondents with chronic back pain (controls), stratified by age.

	CAUSE OF PAIN (Male Controls) Number of Cases (Percent)						
Age (years)	**Motor Vehicle Accident**	**Insidious Onset**	**Lifting**	**Fall**	**Sports**	**Other**	**Total for Each Age**
19-30	6(37)	3(19)	4(25)	0(0)	2(13)	1(6)	**16(100)**
31-40	6(19)	4(12)	6(18)	2(6)	5(15)	10(30)	**33(100)**
41-50	3(10)	9(28)	6(19)	4(12)	4(12)	6(19)	**32(100)**
51-60	3(11)	6(24)	5(19)	2(8)	3(11)	7(27)	**26(100)**
61-83	2(20)	3(30)	3(30)	0(0)	1(10)	1(10)	**10(100)**
Total Male Controls	**20(17)**	**25(21)**	**24(21)**	**8(7)**	**15(13)**	**25(21)**	**117(100)**

Table 4.4: Attribution of cause of pain, for female respondents with chronic back pain (controls), stratified by age.

	CAUSE OF PAIN (Female Controls) Number of Cases (Percent)						
Age (years)	**Motor Vehicle Accident**	**Insidious Onset**	**Lifting**	**Fall**	**Sports**	**Other**	**Total for Each Age**
18-30	15(44)	8(23)	1(3)	3(9)	2(6)	5(15)	**34(100)**
31-40	8(23)	16(47)	2(6)	2(6)	1(3)	5(15)	**34(100)**
41-50	8(28)	9(31)	1(3)	0(0)	3(10)	8(28)	**29(100)**
51-60	2(12)	8(47)	3(17)	0(0)	2(12)	2(12)	**17(100)**
61-79	5(33)	8(53)	1(7)	0(0)	0(0)	1(7)	**15(100)**
Total Female Controls (%)	**38(29)**	**49(38)**	**8(6)**	**5(3)**	**8(6)**	**21(18)**	**129(100)**

Table 4.4 (continued):

	Motor Vehicle Accident	Insidious Onset	Lifting	Fall	Sports	Other	Total of all Strata
Total of Each Injury Category for all Strata	245(37)	185(28)	44(7)	36(5)	44(7)	111(17)	665(100)

Table 4.5: Number of respondents with chronic neck, or chronic neck and back pain (cases), and chronic back pain (controls), who ascribe their pain to an on-the-job injury, stratified by age and gender.

	WORK-RELATED INJURIES Number of Cases (Percent)					
	CASES			CONTROLS		
Age (years)	Male	Femal	Total:	Male	Female	Total:
18-30	2(20)	8(80)	**10(100)**	6(60)	4(40)	**10(100)**
31-40	8(40)	12(60)	**20(100)**	15(71)	6(29)	**21(100)**
41-50	12(34)	23(66)	**35(100)**	13(72)	5(28)	**18(100)**
51-60	10(48)	11(52)	**21(100)**	9(69)	4(31)	**13(100)**
61-83	3(30)	7(70)	**10(100)**	1(25)	3(75)	**4(100)**
Total:	**35(36)**	**61(64)**	**96(100)**	**44(67)**	**22(33)**	**66(100)**

Comparison Of Cases With Controls

Exposure-odds ratios (EORs) were calculated for each age and gender strata for respondents with chronic neck, or neck and back pain (cases) compared with respondents with chronic back pain (controls), with regard to a history of a motor vehicle accident (MVA) as the cause of their chronic pain. A chi square for heterogeneity was calculated

for all of the age strata for males and females, which showed that there was not a statistically significant difference between the EORs of the different age strata ($p = 0.80$ for males, $p = 0.43$ for females).

The Mantel-Haenszel odds ratio was 4.01 (95% CI 2.14, 7.52) for males, and 2.08 (95% CI 1.33, 3.27) for females. These findings indicate that respondents with chronic neck, or neck and back pain were significantly more likely to have a history of a MVA as the cause of their pain than were the respondents with chronic back pain.

Table 4.6: Exposure-Odds ratios for males with neck, or neck and back pain (cases) vs. males with back pain (controls), for a history of chronic pain initiated by a MVA, stratified by age

	MALES AGES 19-30 YEARS		
	MVA	NO MVA	Total
cases	12	6	18
controls	6	10	16
EOR = 4.33	18	16	34

	MALES AGES 31-40		
	MVA	NO MVA	Total
cases	18	13	31
controls	6	27	33
EOR = 6.23	24	40	64

Table 4.6 (continued):

	MALES AGES 41-50 YEARS		
	MVA	NO MVA	Total
cases	11	21	32
controls	3	29	32
EOR = 5.06	14	50	64

	MALES AGES 51-60 YEARS		
	MVA	NO MVA	Total
cases	4	16	20
controls	3	23	26
EOR = 1.92	7	39	46

	MALES AGES 61-83 YEARS		
	MVA	NO MVA	Total
cases	8	11	19
controls	2	8	10
EOR = 2.91	10	19	29

$\chi^2_{\text{heterogeneity}}$ of age-specific EORs = p = 0.80

Mantel-Haenszel pooled estimate = 4.01, 95% CI 2.14, 7.52

Mantel-Haenszel summary chi square = p (2) = 0.00002

Table 4.7: Exposure-odds ratios for females with neck, or neck and back pain (cases) vs. males with back pain (controls), for a history of chronic pain initiated by a MVA, stratified by age.

	FEMALES AGES 18-30 YEARS		
	MVA	NO MVA	Total
cases	37	29	66
controls	15	19	34
EOR = 1.62	52	48	100

	FEMALES AGES 31-40 YEARS		
	MVA	NO MVA	Total
cases	29	28	57
controls	8	26	34
EOR = 4.37	37	54	91

	FEMALES AGES 41-50 YEARS		
	MVA	NO MVA	Total
cases	39	48	87
controls	8	21	29
EOR = 2.13	47	69	116

Table 4.7 (continued):

	FEMALES AGES 51-60		
	MVA	NO MVA	Total
cases	17	32	49
controls	2	15	17
EOR = 4.98	19	47	66

	FEMALES AGES 61-83 YEARS		
	MVA	NO MVA	Total
cases	12	28	40
controls	5	10	15
EOR = 0.86	17	38	55

$\chi^2_{\text{heterogeneity}}$ of age-specific EORs = p = 0.43

Mantel-Haenszel pooled estimate = 2.08, 95% CI 1.33, 3.27

Mantel-Haenszel summary chi square = p (2) = 0.002

Comparison of Responses of Subjects With MVA-Related Chronic Pain (Chronics) With Responses of Subjects With a History of an Acute MVA-Related Injury But Chronic Pain Due to an Other Cause (Non-Chronics)

The responses of cases and controls who attributed their pain to a MVA injury were compared to the responses of cases and controls who previously had been acutely injured in an MVA, but whose current chronic pain was not caused by the MVA injury. These respondents were a subset of the entire group of respondents; excluded were subjects who did not attribute their chronic pain to an MVA *and* who never had been acutely injured in an MVA. This stratification allowed for identification of all respondents who had been acutely injured in an MVA, and then division of these individuals into the group that developed chronic pain as a result of their MVA-related injuries, and the group that recovered, but went on to develop chronic pain from other causes. Additionally, this stratification allowed for inferences regarding a variety risk factors for chronic pain following an acute MVA injury.

There were a total of 187 cases and 58 controls who attributed their chronic pain to a MVA. There were 71 cases and 45 controls who attributed their chronic pain to a cause other than an MVA, but who had been acutely injured in a MVA in the past.

COLLISION TYPE

The type of collision (rear impact, front impact, side impact, collision with a fixed object, and rollovers) was found to be unrelated to the chronicity of pain following an MVA injury for those with neck, or neck and back pain (cases); however, a significant

difference was noted among those with back pain (controls) for side impacts. Thirty-three percent of the controls with chronic MVA-caused pain were initially injured in a side-impact collision, whereas 13% of the non-chronics were acutely injured. Rear impacts comprised the largest proportion of injury-producing accidents among all groups (53% of the chronic and non-chronic cases, and 53% of the chronic controls, and 51% of the non-chronic controls).

Table 4.8: Number and proportion of case responses regarding collision type

CHRONIC NECK, OR NECK AND BACK PAIN (CASES)			
Collision Type	**Chronic Pain, MVA Caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
Rear	100 (53)	38 (53)	0.99
Front	51 (27)	17 (24)	0.59
Side	59 (32)	18 (25)	0.94
Collision with a fixed object	19 (10)	8 (11)	0.80
Rollover	10 (5)	5 (7)	0.60
Total:	***187**	***71**	

* The total is less than the sum of the collision types because some respondents listed more than one type of collision.

Table 4.9: Number and proportion of control responses regarding collision type

CHRONIC BACK PAIN (CONTROLS)			
Collision Type	**Chronic Pain, MVA Caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
Rear	31 (53)	23 (51)	0.81
Front	17 (29)	13 (29)	0.96
Side	19 (33)	6 (13)	0.02
Collision with a fixed object	8 (14)	12 (27)	0.10
Rollover	2 (3)	5 (11)	0.13
Total:	*58	*45	

* The total is less than the sum of the collision types because some respondents listed more than one type of collision.

HEAD RESTRAINT USE

Head restraints were reportedly present in over two-thirds of the case MVAs, both chronic (69%) and non-chronic (68%), and in a similar proportion of chronic control MVAs (65%). Only the non-chronic controls varied from the trend, with head restraints present in 43% of the injury-causing MVAs. The difference was not statistically significant, with a chi-square of 2.37, and a p-value of 0.12.

Table 4.10: Number and proportion of case responses regarding presence or absence of a head restraint, for history of rear-impact collision

CHRONIC NECK, OR NECK AND BACK PAIN (CASES)			
Headrest Present	**Chronic Pain, MVA Caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
Yes	69 (69)	26 (68)	0.95
No	31 (31)	12 (32)	0.95
Total:	**100 (100)**	**38 (100)**	

Table 4.11: Number and proportion of control responses regarding presence or absence of a head restraint, for history of rear-impact collision

CHRONIC BACK PAIN (CONTROLS)			
Headrest Present	**Chronic Pain, MVA Caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
Yes	20 (65)	10 (43)	0.12
No	11 (35)	13 (57)	0.12
Total:	**31 (100)**	**23 (100)**	

SEAT BELT USE

The use of seat belts was found to be significantly larger among the chronic cases. Eighty percent (80%) were using a seat belt at the time of injury, compared with 62% of

the non-chronic cases ($\chi^2 = 9.18$, $p = 0.002$). The use of a lap belt and shoulder harness also was found to be significantly higher among the chronic cases; 65% used a lap and shoulder belt, compared with 51% of the non-chronic cases ($\chi^2 = 4.24$, $p = 0.04$). Seat belt use was not found to be significantly different between chronic and non-chronic controls.

Table 4.12: Number and proportion of case responses regarding seat belt use and type

CHRONIC NECK, OR NECK AND BACK PAIN (CASES)			
Seat Belt Use	**Chronic Pain, MVA Caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
Yes	150 (80)	44 (62)	0.002
lap only	24 (13)	7 (10)	0.51
lap and shoulder	121 (65)	36 (51)	0.04
no response	8 (4)	3 (4)	0.99
No	33 (10)	25 (35)	0.003
Total:	**187 (100)***	**71 (100)****	

* Four subjects in this category did not respond
**Two subjects in this category did not respond

Table 4.13: Number and proportion of control responses regarding seat belt use and type

CHRONIC BACK PAIN (CONTROLS)			
Seat Belt Use	**Chronic Pain, MVA Caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
Yes	41 (71)	32 (71)	0.96
lap only	5 (9)	7 (16)	0.28
lap and shoulder	35 (60)	22 (49)	0.25
no response	1 (1)	3 (7)	0.20
No	17 (29)	13 (29)	0.96
No response	(0)	2 (4)	*
Total:	**58 (100)**	**45 (100)****	

* Chi square cannot be calculated with a zero in any cell
** Four subjects in this category did not respond

POSITION IN VEHICLE

Where the respondent was situated in the vehicle during the impact, with regard to passenger or driver status, was not significantly different between chronic and non-chronic cases and controls. The majority of the cases (73% of chronics, and 69% of non-chronics) and the controls (64% of chronics, and 76% of non-chronics) were drivers of the vehicle at the time of the MVA.

Table 4.14: Number and proportion of case responses regarding position in vehicle at time of impact

CHRONIC NECK, OR NECK AND BACK PAIN (CASES)			
Position	**Chronic Pain, MVA Caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
Driver	137 (73)	49 (69)	0.50
Passenger	49 (26)	20 (28)	0.75
Total:	**187 (100)***	**71 (100)****	

* One subject in this category did not respond
** Two subjects in this category did not respond

Table 4.15: Number and proportion of control responses regarding position in vehicle at time of impact

CHRONIC BACK PAIN (CONTROLS)			
Position	**Chronic Pain, MVA Caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
Driver	37 (64)	35 (76)	0.18
Passenger	21 (36)	9 (20)	0.06
Total:	**58 (100)**	**46 (100)****	

* Chi square cannot be calculated with a zero in any cell
** One subject in this category did not respond

VEHICLE DAMAGE

The amount of vehicle damage sustained in the injury-producing MVA was not significantly different between chronics and non-chronics, in either the cases or the controls. Twenty-six percent of the chronic cases were injured in accidents with $1500 or less damage, compared with 27% of the non-chronic cases. A considerably smaller proportion of controls were injured at the same damage threshold; 15% of the chronics and 14% of the non-chronics were injured in vehicles that sustained $1500 or less in damage.

Table 4.16: Number and proportion of case responses regarding dollar amount of vehicle damage resulting from injury producing crash

CHRONIC NECK, OR NECK AND BACK PAIN (CASES)			
Vehicle Damage ($US)	**Chronic Pain, MVA Caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
None	8 (4)	4 (6)	0.64
<500	10 (5)	3 (4)	0.71
500 - 1500	31 (17)	12 (17)	0.95
1500 - 5000	47 (25)	16 (23)	0.66
5000 to total loss	72 (39)	24 (34)	0.49
Don't know/ can't recall	18 (10)	10 (14)	0.30
Total:	**187 (100)***	**71 (100)****	

* One subject in this category did not respond
** Two subjects in this category did not respond

Table 4.17: Number and proportion of control responses regarding dollar amount of vehicle damage resulting from injury producing crash

CHRONIC BACK PAIN (CONTROLS)			
Vehicle Damage ($US)	**Chronic pain, MVA caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
None	2 (3)	1 (2)	0.71
<500	3 (5)	3 (7)	0.75
500 - 1500	10 (17)	10 (22)	0.53
1500 - 5000	17 (29)	10 (22)	0.42
5000 to total loss	19 (27)	12 (27)	0.50
Don't know/ can't recall	7 (12)	7 (16)	0.46
Total:	**58 (100)**	**45 (100)***	

* Chi square cannot be calculated with a zero in any cell
** One subject in this category did not respond

GENDER OF RESPONDENTS

Seventy percent (70%) of the chronic cases were female, compared with 75% of the non-chronic cases ($\chi^2 = 0.23$, $p = 0.63$). The controls were more evenly balanced with regard to gender, with 66% of the chronics female, compared to 49% of female non-chronics ($\chi^2 = 2.88$, $p = 0.09$). Gender was found to be independent of chronicity in both the cases and controls.

Table 4.18: Gender of Case Respondents

CHRONIC NECK, OR NECK AND BACK PAIN (CASES)			
Gender	**Chronic Pain, MVA Caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
Male	53 (28)	18 (25)	0.63
Female	134 (72)	53 (75)	0.63
Total:	**187 (100)**	**71 (100)**	

Table 4.19: Gender of Control Respondents

CHRONIC BACK PAIN (CONTROLS)			
Gender	**Chronic Pain, MVA Caused (% of total)**	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**χ^2 (p-value)**
Male	20 (34)	23 (51)	0.09
Female	38 (66)	22 (49)	0.09
Total:	**58 (100)**	**45 (100)**	

HEIGHT AND WEIGHT OF RESPONDENTS

The height and weight of the respondents was used to calculate the ideal body mass (IBM) of each respondent (weight in kilograms/height in meters squared). Cases and controls were compared separately by gender. There were no differences noted between the mean IBM of chronic and non-chronic male cases (p (2) = 0.59), or between the IBM

of chronic and non-chronic male controls (p (2) = 0.10). There was a significant difference between the mean IBMs of the chronic and non-chronic female cases (p (2) = 0.03) and of the chronic and non-chronic female controls (p (2) = 0.05).

Table 4.20: Average ideal body mass of male cases, chronics vs. non-chronics (weight in kg/height in meters squared)

	MALES WITH CHRONIC NECK, OR NECK AND BACK PAIN (CASES)		
	Chronic Pain, MVA Caused (% of total)	Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)	t-test Probability (2 tailed)
IBM average (kg/m2)	27.2	28.0	0.59
IBM std dev (kg/m2)	4.41	6.15	

Table 4.21: Average ideal body mass of male controls, chronics vs. non-chronics (weight in kg/height in meters squared)

	MALES WITH CHRONIC BACK PAIN (CONTROLS)		
	Chronic pain, MVA caused (% of total)	Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)	t-test Probability (2 tailed)
IBM average (kg/m2)	28.1	28.2	0.10
IBM std dev (kg/m2)	5.10	5.14	

Table 4.22: Average ideal body mass of female cases, chronics vs. non-chronics (weight in kg/height in meters squared)

	FEMALES WITH CHRONIC NECK, OR NECK AND BACK PAIN (CASES)		
	Chronic Pain, MVA Caused (% of total)	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**t-test Probability (2 tailed)**
IBM average (kg/m2)	25.3	27.8	0.03
IBM std dev (kg/m2)	5.61	6.93	

Table 4.23: Average ideal body mass of female controls, chronics vs. non-chronics (weight in kg/height in meters squared)

	FEMALES WITH CHRONIC BACK PAIN (CONTROLS)		
	Chronic Pain, MVA Caused (% of total)	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**t-test Probability (2 tailed)**
IBM average (kg/m2)	25.3	28.9	0.05
IBM std dev (kg/m2)	5.10	7.24	

AGE AT TIME OF MVA

The age of each respondent at the time of the injury-producing MVA was calculated by subtracting the time elapsed since the date of the MVA from the stated age of the respondent. The mean age of the chronic cases at the time of the MVA was 34.9 years, with a standard deviation of 14.77, which was significantly greater than the mean age of the non-chronic cases, which was 31.2, with a standard deviation of 13.13 (p (2) =

0.04). There was no significant difference (p (2) = 0.99) between the mean age of 32.0 for the chronic controls (SD = 15.38), and of 33.0 for the non-chronic controls (SD = 13.01).

Table 4.24: Average age of cases at time of MVA, chronics vs. non-chronics

	CHRONIC NECK, OR NECK AND BACK PAIN (CASES)		
	Chronic pain, MVA Caused (% of total)	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**t-test Probability (2 tailed)**
Average age at time of MVA (years)	34.9	31.2	0.04
Std dev of age at time of MVA (years)	14.775	13.135	

Table 4.25: Average age of controls at time of MVA, chronics vs. non-chronics

	CHRONIC BACK PAIN CONTROLS)		
	Chronic Pain, MVA Caused (% of total)	**Acute MVA Injury, not Resulting in Chronic Symptoms (% of total)**	**t-test Probability (2 tailed)**
Average age at time of MVA (years)	32.0	33.0	0.99
Std dev of age at time of MVA (years)	15.383	13.013	

Primary Treatment Type Following Initial Injury

All respondents were queried with regard to the primary type of treatment they used for the first six months following the initial onset of their pain, as well as their

satisfaction with that treatment. These results are most likely to be biased due to the fact that the respondents were randomly selected from chiropractic practices, thus excluding a proportion of injured people who were dissatisfied with chiropractic treatment and, in all likelihood, including a larger proportion of those dissatisfied with other forms of treatment. However, the large differences observed between satisfaction levels for chiropractic and other types of treatment probably were too large to be accounted for solely by selection bias.

Fifty-four percent (54%) of the cases, and 53% of the controls primarily used chiropractic treatment for the first six months following injury. Nineteen percent (19%) of the cases and controls used medical treatment, the next largest proportion. Physical therapy was used by 14% of the cases, and 10% of the controls. Eleven percent (11%) of the cases self-treated or sought no treatment, as did 14% of the controls. One percent (1%) of cases used osteopathic treatment, and 3% of the controls did the same.

Eighty-three percent (83%) of the cases were either somewhat satisfied (23%) or extremely satisfied (60%) with their chiropractic treatment, compared with 44% of the cases who were treated with physical therapy (27% somewhat and 17% extremely satisfied), 24% of the medically treated cases (18% somewhat and 9% extremely satisfied), and 12% of the self/no treatment cases (10% somewhat and 2% extremely satisfied). Of the six osteopathic cases, two (33%) were somewhat satisfied with their treatment.

Fifty seven-percent (57%) of the medically treated cases were either somewhat dissatisfied (26%) or extremely dissatisfied (31%) with their treatment, compared with

55% of the respondents who treated with physical therapy (25% somewhat and 30% extremely dissatisfied), and 38% of those who self/no treated (13% somewhat and 25% extremely dissatisfied). Eleven percent (11%) of the chiropractic treatment group were dissatisfied with their care (3% somewhat and 8% extremely dissatisfied). Three of the six osteopathic cases (50%) were dissatisfied with their treatment.

Eighty-two percent (82%) of the controls who received chiropractic treatment were somewhat satisfied (28%) or extremely satisfied (54%) with the care they received in the six months following injury. Physical therapy was next, with 47% satisfied (29% somewhat and18% extremely satisfied), then medical, with 26% (24% somewhat and 2% extremely satisfied), followed by self/no treatment, at 17% (14% somewhat and 3% extremely satisfied). As with the cases, there were only a small amount of responses (seven) regarding osteopathic treatment. One of these individuals (14%) was satisfied with treatment.

Sixty-one percent (61%) of the self/no treatment controls were dissatisfied with their care (35% somewhat and 26% extremely). Fifty percent (50%) of the medically treated controls were dissatisfied with their care (25% somewhat and 25% extremely dissatisfied). Forty three percent (43%) of the physical therapy controls were dissatisfied (25% somewhat and extremely dissatisfied), and 14% of the chiropractic control group were dissatisfied (6% somewhat and 8% extremely). Four of the seven (57%) osteopathic controls were dissatisfied with their treatment.

Table 4.26: Comparison of primary type of treatment used by cases within first six months following onset of chronic pain, and satisfaction level with that treatment.

CHRONIC NECK, OR NECK AND BACK PAIN (CASES)							
Treatment Type	**Extreme -ly Dis-satisfied (%)**	**Some-what Dissat-isfied (%)**	**Neither Satisfied Nor Dissatis-fied (%)**	**Some-what Satis-fied (%)**	**Extreme -ly Satisfied (%)**	**No Res-ponse (%)**	**Total of Each Type* (%)****
Medical	27 (31)	23 (26)	14 (16)	16 (18)	8 (9)	0 (0)	88 (19)
Chiropractic	20 (8)	8 (3)	11 (4)	56 (23)	147 (60)	3 (1)	245 (54)
Physical Therapy	19 (30)	16 (25)	8 (13)	17 (27)	11 (17)	0 (0)	64 (14)
Osteopathic	2 (33)	1 (17)	1 (17)	2 (33)	0 (0)	0 (0)	6 (1)
Self/No Treatment	12 (25)	6 (13)	17 (35)	5 (10)	1 (2)	7 (13)	48 (11)
Other	1 (50)	1 (50)	0 (0)	0 (0)	0 (0)	0 (0)	2 (<1)
No Response	0 (0)	0 (0)	0 (0)	0 (0)	1	3	4 (1)
					Total Responses:		**457 (100)**

* the sum of the **Total of Each Type** of treatment is greater than the number of cases because some respondents listed more than one primary type of treatment.

** the percentages in brackets in this column represent the proportion of the row total relative to the number of total responses.

Table 4.27: Comparison of primary type of treatment used by controls within first six months following onset of chronic pain, and satisfaction level with that treatment.

CHRONIC BACK PAIN (CONTROLS)							
Treatment Type	**Extreme -ly Dis-satisfied (%)**	**Some-what Dissat-isfied (%)**	**Neither Satisfied Nor Dissatis-fied (%)**	**Some-what Satis-fied (%)**	**Extreme -ly Satisfied (%)**	**No Res-ponse (%)**	**Total of each type* (%)****
Medical	13 (25)	13 (25)	10 (20)	12 (24)	3 (2)	0 (0)	51 (19)
Chiropractic	12 (8)	8 (6)	6 (4)	41 (28)	78 (54)	0 (0)	145 (53)
Physical Therapy	5 (18)	7 (25)	3 (11)	8 (29)	5 (18)	0 (0)	28 (10)
Osteopathic	1 (14)	3 (43)	2 (28)	0 (0)	1 (14)	0 (14)	7 (3)
Self/No Treatment	9 (26)	13 (35)	7 (19)	5 (14)	1 (3)	2 (5)	37 (14)
Other	0 (0)	2 (100)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)
No Response	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (100)	2 (1)
					Total Responses:		272 (100)

* the sum of the **Total of Each Type** of treatment is greater than the number of controls because some respondents listed more than one primary type of treatment

** the percentages in brackets in this column represent the proportion of the row total relative to the number of total responses.

DISCUSSION

Potential Bias In The Data

The disparity between the number of cases and controls in the study was a result of the enrollment techniques employed by the chiropractors who participated in the study.

While precautions were taken to prevent misinterpretation of the instructions, approximately one-half of the chiropractors collected the surveys from the first ten consecutive patients with chronic spinal pain, rather than five chronic neck, or neck and back patients, and five chronic back patients. Because the definition of a case was less restrictive than that of a control, *i.e.* neck pain, *and* neck and back pain, as opposed to back pain alone, the prevalence of cases in the general population, and in this study, was higher than the prevalence of controls. Thus, 63% of the respondents had neck, or neck and back pain, and 37% had only back pain. It is not likely that this difference biased the results of the study since it was due to external factors, i.e. the prevalence of the disease, rather than internal factors, such as a systematic error in the way the data was collected.

The other disparity observed among the subjects was in the distribution of gender among the cases. Sixty percent (60%) of the cases were female, and 40% were male. This difference is accounted for by fact that more women have chronic neck pain than do men (27). Bias resulting from the disparity was controlled for by stratification by gender in the data analysis.

Although the 41% response rate (67 of 163) among the chiropractors was low, it was not considered to be a substantial source of bias, because both the cases and the controls were surveyed at the same physician's office.

Recall bias was prevented by the design of the survey, particularly with regard to questions about chronic pain causation, and the use of chronic pain as a criteria for inclusion in the study. Because chronic pain can act as a psychological confounder and thus affect recall (28), both the cases and the controls were matched for chronicity.

Cause of Pain

RESPONDENTS WITH CHRONIC NECK, AND CHRONIC NECK AND BACK PAIN (CASES)

Motor vehicle accidents caused more chronic neck and chronic neck and back pain than any other etiologic agent. While men and women are acutely injured at different rates in MVAs (16), the etiologic fraction of MVA injuries of chronic neck, and neck and back pain in this study was very close between genders, 44% for males and 45% for females. For both genders, the younger ages generally had a higher etiologic fraction of MVA injuries in comparison with the older ages. This increase was probably due to a lack of competition from other causes of pain, particularly insidious onset of pain, which was observed to be directly related to age. The observed increase of insidious onset of pain with age most probably is due to the effect of degenerative disc and joint disease, which typically begins at age 40 years, and progresses thereafter, and can cause or contribute to chronic spine pain (29).

RESPONDENTS WITH CHRONIC BACK PAIN (CONTROLS)

Motor vehicle accidents were the second most frequently reported cause of chronic low back pain among females (29%), after insidious onset (38%). This finding was in sharp contrast with the most frequently named causes of chronic low back pain among the males, where lifting, insidious onset, and other causes each accounted for 21% of responses (MVAs caused only 17% of chronic pain among male controls).

Among the males, it was not surprising to observe that lifting and insidious onset were leading causes of chronic low back pain, since men typically work in occupations in which more lifting is involved. In addition, degenerative changes in the low back are more prevalent among men than women (30).

Among males and females together, MVA injuries accounted for 45% of all neck and neck and back pain, and 24% of all mid to low, and low back pain. MVA injuries were the cause of 37% of all chronic spine pain, 32% more than the next largest cause, insidious onset (28%), and more than all of the other causes combined.

Comparison Between Cases And Controls

Given the fact that the etiologic fraction of MVA injuries among cases is almost identical between the two genders (44% male, 45% female), the difference between exposure-odds ratios for males and females (4.01 and 2.08, respectively) is explained solely by the greater contribution of MVA injuries to chronic pain among the female controls, relative to the males.

It can be concluded, from the results of this study, that males with chronic neck, or chronic neck and back pain are four times more likely to have acquired that pain as a result of a motor vehicle accident, in comparison with males with chronic back pain. Females with chronic neck, or neck and back pain are twice as likely to have been chronically injured in a motor vehicle accident compared with their counterparts with chronic low back pain.

This finding is unusual in the medical literature, in that, to my knowledge, no other authors have studied the contribution of MVA injuries to the prevalence of chronic spine pain, and no studies have examined the difference of that contribution between neck and back pain. The findings of the current study is at odds with conclusions reached by earlier authors that acute MVA injuries are unlikely to or do not progress to chronic pain (19,31). The current results are not likely to be a result of bias in the selection or recall of the subjects, or due to confounding by gender or age.

Comparison of Chronics with Non-chronics

In this study, comparisons were made between the subgroup of respondents who developed chronic pain as a result of a MVA (chronics) and the subgroup who were acutely injured in a MVA but did not develop chronic symptoms as a result of their injury (non-chronics). The purpose of this comparison was to determine if there were significant extrinsic (accident-related) and/or intrinsic (individual characteristic) risk factors for chronicity. The results of this risk factor analysis should be read with some caution because of the small number of subjects, and hence lower precision, in some of the categories that were analyzed.

EXTRINSIC FACTORS

Collision Type (direction of impact)

The direction of impact had no significant relationship to whether or not a respondent with chronic neck, or neck and back pain developed these symptoms as a

result of the MVA. This finding was surprising, because numerous authors previously have reported that rear-impact collisions are more likely to cause chronic symptoms (32). What is apparent from the current study is that rear-impact collisions are more likely to cause acute injury than were other types of collisions. Rear-impact crashes comprise 19% of all crashes (33), but caused 53% of all injuries in both the chronic and non-chronic group.

Among the chronic back pain group, side impacts were a predictor of chronicity. Side impact collisions accounted for a two and a half times larger proportion of chronically injured respondents than non-chronically injured respondents (13% to 33%). The difference in acute low back injury occurrence (between side and other impacts) has been explained by previous authors as a result of seat design (34). Sideways excursion of the low back is not prevented by most seat designs in side-impact collisions, as is rearward excursion in rear impacts. Shoulder harnesses and steering wheels prevent forward travel in front impacts. This difference in protection against injury leads to more severe initial injury and evidently a higher rate of chronicity.

Head Restraint Use

Several previous studies have reported that the absence of a head restraint is a predictor of more severe initial whiplash injury and longer duration of symptoms (35). It has been postulated that the absence of a head restraint also predicts chronicity, however, this relationship was not found in this study. The proportion of chronic cases and non-chronic cases who did not have a head restraint during the impact was approximately the

same (31% and 32%, respectively). Based on the literature, head restraint use was not expected to interact with chronicity among the back pain respondents, and it did not.

Seat Belt Use

The use of seat belts, particularly shoulder harnesses, has been reported to increase whiplash injuries in several studies (36). Seat belts have also been implicated in the development of chronic neck pain following acute whiplash injuries (13). The current study supports this supposition. The proportion of respondents who did not have a seat belt during the collision was three and a half times greater among the non-chronic neck, and neck and back pain respondents as among their chronically injured counterparts (35% versus 10%). Seat belt use did not vary between chronics and non-chronics among the back pain group.

An explanation for this finding is that the shoulder harness abruptly restrains the torso during forward acceleration of the occupant in a collision. The difference in acceleration between the head, which continues forward, and the torso, which does not, produces greater cervical spine injury. Based upon the findings of this study, the greater initial injury may lead to chronic pain.

Position in Vehicle

The position of the occupant at the time of impact was not found to be significantly different for cases or controls, with regard to development of chronic symptoms. Previous authors have reported that passengers are more likely than drivers to

sustain injury, possibly because the driver can grasp the steering wheel for support during a collision (37). There were substantially more injured drivers than passengers among study subjects (approximately two-thirds to one third), however, this difference is readily explained by the fact that more accidents occur with single occupants than with multiple occupants (38).

Vehicle Damage

An unexpected finding of this study was that the severity of the accident (measured by dollar amount of damage to the vehicle the occupant was in during the collision) was unrelated to the status of chronicity of the respondent, for cases and controls. This finding was surprising because of the expectation that more damage to a vehicle would seem to be related to greater severity of initial injury to the occupant. Greater severity of the initial injury is related to greater likelihood of chronicity, as seen in this and other studies with shoulder restraint use for whiplash injuries, and side impacts, with regard to low back injuries. An alternative explanation is that there is a non-linear association between the damage to a vehicle and the severity of the resultant soft-tissue injury. This explanation is supported by the work of earlier authors, such as Thomson et al., who reported that lower velocity impacts with minimal vehicle damage are more likely to transfer the force of the impact to the occupants than do impacts with greater damage, where the collision force is absorbed by the plastic deformation of the vehicle (39).

An interesting finding of the current study is that more acute injuries of the neck, and neck and back occur at a lower level of vehicular damage in comparison with injuries

of the back only. This finding is supported by the work of earlier authors, who reported that the whipping action of the head in a collision made the neck more susceptible to injury at lower impact speeds (40, 41, 42, 43).

Airbag deployment was considered a possible extrinsic risk factor, and was included as a survey question. Because fewer than 5% of the subjects experienced airbag deployment during their crash, this variable was not included in the analysis.

INTRINSIC FACTORS

Gender of Respondents

The population sampled in this study contained approximately three times as many women with neck, and neck and back injuries as men. While the observation that women sustain whiplash injuries at a higher rate than men is concurrent with national demographics of whiplash injuries (38), in the present study, women with acute neck injuries were not found to become chronic at a higher rate than men with acute neck injuries. The same observation was made among male and female controls. This finding is at odds with the reports of several earlier authors, who theorized that women are more likely to develop chronic pain following a whiplash injury (18,35).

Height and Weight of Respondents

The ideal body mass (IBM) of the females in the study was a significant predictor of chronicity, among both cases and controls. Respondents with chronic neck, and neck and back pain were likely to have a lower IBM than were their non-chronic counterparts.

The same was true for female respondents with chronic back pain. The chronic cases had a mean IBM that was 10% less than the non-chronic cases, and the chronic controls had a mean IBM that was 14% less than the non-chronic controls. While prior authors have explained the difference in injury rate between the genders with body size and density (44), none have used intra-gender stature differences to explain the development of chronic symptoms. The probable explanation behind the difference observed in the current study is that the larger IBM predicts a stockier torso and neck that is more resistant to injury by indirect trauma.

The difficulty with this explanation is that among male cases and controls, there were no significant differences observed in the IBM of chronic and non-chronic respondents. An alternative explanation for this variation between genders is that on average, males are sufficiently muscled to resist injury at lower velocity impacts, and that increased musculature is not protective against injury at higher velocities. Lighter-structure females are not protected against lower velocity impacts, thus accounting for the large gender discrepancy in the injury rate.

Age at Time of MVA

Several authors have discussed the role of increased age, with regard to the greater risk of whiplash injury (35,45). It has been postulated that age-related degenerative changes in the spine make older individuals more susceptible to injury, in comparison with younger individuals. In the present study, it was found that older individuals are more likely to develop chronic symptoms following whiplash. Respondents with chronic neck,

and neck and back pain were an average of 3.7 years older than their non-chronic counterparts. Age was not related to chronicity for back pain, where more support from surrounding soft tissue, more substantial bony structure, and greater support from the seat back play a larger role. There was no significant interaction observed between cases and controls, with regard to age.

Primary Treatment Type Following Injury

While it is likely that some selection bias exists in the entire study group, with regard to treatment preferences, the respondents were queried about the primary type of treatment sought for the first six months following the onset of their chronic pain. These results must be interpreted carefully because the study cohort was weighted toward individuals who were satisfied with chiropractic treatment and did not include those individuals who were dissatisfied with chiropractic treatment to point that they would not return to a chiropractor. Additionally, individuals who were extremely satisfied with other treatment and did not feel a need to seek an alternative treatment were under-represented in this study. This bias is somewhat countered by the lack of those who would be satisfied with chiropractic treatment, but who have not tried it, for various reasons.

Slightly over half of the cases and controls used chiropractic treatment initially, which is more than the 40% described in other population-based studies (25, 26). Of the cases who were treated with chiropractic, 83% were satisfied with their care. A similar proportion of controls (82%) were satisfied with their chiropractic treatment. These

proportions are much larger than the next highest rated treatment, physical therapy, which had a satisfaction proportion of 44% (cases), and 47% (controls). Medical treatment had the next highest level of satisfaction, at 24% (cases) and 26% (controls). The differences seen are too large to be accounted for by bias alone, and, while greater than would be expected in the general population, are probably real.

Previous authors have reported similar, although somewhat smaller disparities in satisfaction levels between chiropractic treatment and other forms of treatment (24,26). Satisfaction with a treatment is of interest because it is considered a valid measurement of efficacy of that treatment (46). However, because of probable selection bias, generalization of the results in this section to the general population with chronic pain are not possible.

CONCLUSION

It is reasonable to conclude, based on the results of this study, that injuries resulting from motor vehicle accidents contribute significantly to the population of individuals with chronic spine pain in the United States. In addition, individuals with chronic pain in the neck, and neck and back, are more likely to have acquired their pain as a result of a motor vehicle accident, in comparison with individuals with chronic back pain. This study demonstrates that chronic symptoms following whiplash, or "late whiplash," is far more prevalent than previously reported in earlier studies (19,31).

The prevalence of chronic neck pain in the general population has been estimated by various authors to range from 13.8% (47) for both genders, to 32.9% for women and

27.5% for men (27). Extrapolating the 45% etiologic fraction of MVA injuries found in this study to the most conservative estimate of chronic neck pain prevalence (13.8%) yields 6.2% prevalence of late whiplash, or 15.5 millions Americans with the chronic pain disorder. This figure is close to an estimate published earlier by Croft (48).

It was found, in this study, that there are specific risk factors, both extrinsic and intrinsic to the injured individual, which make an acute spinal injury following a motor vehicle accident more likely to become chronic. The extrinsic risk factors are side impacts for back pain, and the use of shoulder harnesses for neck pain. Both of these risk factors can be controlled through better equipment design; better side bolsters for car seats will protect against acute and chronic back injury, and seat belts which provide more gradual deceleration during maximum restraint will decrease neck injuries, and subsequent chronicity.

The intrinsic risk factors are: slight body composition, for females with both neck and back injuries; and increased age, for neck injuries. Neither of these factors can be isolated and controlled. Only by improving vehicle equipment, such as seats and seat belts, and decreasing the rate of collisions, through increased driver awareness, and improved roadway safety regulation, can the rate of MVA-caused spinal injury be decreased for at-risk individuals.

Whiplash injuries are very common in the United States. For many years, the whiplash-injured individual with persistent symptoms has been viewed, by some, as an opportunist, a malingerer, or both. Even the originator of the term "whiplash," later joked that a whiplash injury was "any strain of the cervical spine that doesn't resolve until all

litigation is concluded."(48) While the connection between whiplash injuries and litigation has been investigated and refuted in numerous studies (8,9,13-15), the motives of individuals seeking compensation for chronic pain resulting from a motor vehicle accident injury continue to be in question (19). This perception is at least partially due to the fact that there have been very few controlled studies of late whiplash.

While further study of late whiplash is needed, it is intended that this current study will help to clarify some of the misperceptions regarding the disorder, leading to better understanding of the condition, and how to prevent or mitigate it.

REFERENCES

(1) Olsson I, Bunketorp O, Carlsson G, et al. An in-depth study of neck injuries in rear end collisions. 1990 International IRCOBI Conference, Bron, Lyon France September 12-14:1-15.

(2) Radanov BP, Di Stefano GD, Schnidrig A, Ballinari P. Role of psychological stress in recovery from common whiplash. Lancet 1991;338:712-5.

(3) Ettlin T, Kischka U, Reichmann S, et al. Cerebral symptoms after whiplash injury of the neck: a prospective clinical and neuropsychological study of whiplash injury. J Neurol Neurosurg Psychiatr 1992;55(10):943-8.

(4) Radanov BP, Distefano GD, Schnidrig A, et al. Cognitive functioning after common whiplash: a controlled follow-up study. Arch Neurol 1993;50:87-91.

(5) Radanov BP, Di Stefano G, Schnidrig A, Sturzenegger M. Psychosocial stress, cognitive performance and disability after common whiplash. J Psychosom Res 1993;37(1):1-10.

(6) Gargan MF, Bannister GC. The rate of recovery following whiplash injury. Eur Spine J 1994;3:162-4.

(7) Jonsson H, Cesarini K, Sahlstedt, Rauschning W. Findings and outcome in whiplash-type neck distortions. Spine1994.

(8) Ryan GA, Taylor GW, Moore VM, Dolinis J. Neck strain in car occupants: injury status after 6 months and crash-related factors. Injury 1994;25(8):533-6.

(9) Radanov BP, Sturzenegger M, Di Stefano G. Long-term outcome after whiplash injury: a 2-year follow-up considering features of injury mechanisms and somatic, radiologic, and psychosocial findings. Medicine 1995;74(5):281-97.

(10) Robinson DD, Cassar-Pullicino VN. Acute neck sprain after road traffic accident: a long-term clinical and radiological review. Injury 1993;24(2):79-82.

(11) Balla JI. The late whiplash syndrome: a study of an illness in Australia and Singapore. Culture, Medicine and Psychiatry 1982;6:191-210.

(12) Hohl M. Soft tissue injuries to the neck. Clin Orthop Rel Res 1975;109:42.

(13) Deans GT, McGalliard JN, Rutherford WH. Incidence and duration of neck pain among patients injured in car accidents. Br Med J 1986;292:94-5.

(14) Maimaris C, Barnes MR, Allen MJ. "Whiplash injuries" of the neck: a retrospective study. Injury 1988;19(5):393-6.

(15) Hodgson SP, Grundy M. Whiplash injuries: their long-term prognosis and its relationship to compensation. Neuro Orthop 1989;7:88-99.

(16) Pearce JMS. Whiplash injury: a reappraisal. J Neurol Neurosurg Psychiatr 1989;52:1329-31.

(17) Gargan MF, Bannister GC. Long-term prognosis of soft tissue injuries of the neck. J Bone Joint Surg Br 1990;72:901-3.

(18) Parmar HV, Raymakers R. Neck injuries from rear impact road traffic accidents: prognosis in persons seeking compensation. Injury 1993;24(2):75-8.

(19) Schrader H, Obelieniene D, Bovim G, et al. Natural evolution of late whiplash syndrome outside the medicolegal context. Lancet 1996;347:1201-11.

(20) Freeman MD, Croft AC. Late Whiplash Syndrome. Lancet 1996;348(9020):125.

(21) Nygren A, Berglund A. Long term follow up of whiplash associated disorders (WAD). *Swedish experience on insurance material.* Whiplash '96 Abstracts, Brussels, Belgium. 1996:34-5.

(22) Balla JI. The late whiplash syndrome. Aust NZ J Surg 1980;50:610-4.

(23) Chiropractic: State of the art - 1994-1995. J Amer Chiro Assoc 1995.

(24) Carey TS, Evans A, Hadler N, Kalsbeek W, McGlaughlin C, Fryer T. Care-seeking among individuals with chronic low back pain. Spine 1995;20(3):312-7.

(25) Carey TS, Evans AT, Hadler NM, Lieberman G, Kalsbeek WD, Jackman AM, Fryer JG, McNutt RA. Acute severe low back pain. A population-based study of prevalence and care-seeking. Spine 1996;21(3):339-44.

(26) Shekelle PG, Markovich M, Louie R. Factors associated with choosing a chiropractor for episodes of back pain care. Medical Care 1995;33(8):842-50.

(27) Andersson HI. The epidemiology of chronic pain in a Swedish rural area. Qual Life Res 1994 Dec;Suppl 1:S19-26.

(28) Polatin PB, Kinney RK, Gatchel RJ, Lillo E, Mayer TG. Psychiatric illness and chronic low-back pain. The mind and the spine - which goes first? Spine 1993;18(1):66-71.

(29) Does the prevalence of back pain increase with age? The Back Letter 1997;12(2):21.

(30) Frymoyer JW, Andersson GBJ. Clinical Classification, in Pope MH, Andersson GBJ, Frymoyer JW, Chaffin DB (eds): Occupational Low Back Pain. St. Louis, MO, Mosby Year Book. 1991:50.

(31) Spitzer WO, Skovron ML, Salmi LR, Cassidy JD, Duranceau J, Suissa S, Zeiss E. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. Spine 1995;20(8S):1S-73S.

(32) Macnab I. Acceleration injuries of the cervical spine. J Bone Joint Surg 1964;46A(8):1797-9.

(33) The National Accident Sampling System/Crashworthiness Data System Report 1991-1993. Washington, DC: US Department of Transportation. DOT HS 808 298 August 1995.

(34) Foreman SM, Croft AC. Whiplash injuries: The cervical acceleration/deceleration syndrome. Baltimore, Williams & Wilkins Co., 1988:3.

(35) Nygren A. Injuries to car occupants - some aspects of interior safety of cars. Acta Oto-Laryngologica 1984;Suppl #394.

(36) Galasko CSB, Murray PM, Pitcher M, et al. Neck sprains after road traffic accidents: a modern epidemic. Injury 1993;24(3):155-7.

(37) Otte D, Rether JR. Risks and mechanisms of injuries to the cervical spine in traffic accidents. International IRCOBI/AAAM Conference on the Biomechanics of Impact. Goetberg, Sweden. 1985:17-31.

(38) National Safety Council. Accident Facts:1996 edition. Itasca, IL 1996.

(39) Thomson RW, Romilly DP, Navin FPD, Macnab MJ. Energy attenuation within the vehicle during low speed collisions. Report to Transport Canada, University of British Columbia. August, 1989.

(40) Severy DM, Mathewson JH, Bechtol CO. Controlled automobile rear-end collisions, an investigation of related engineering and mechanical phenomenon. Canservices Med J 1955;11:727-58.

(41) Severy DM, Mathewson JH. Automobile barrier and rear-end collision performance. Paper presented at the Society of Automotive Engineers summer meeting. Atlantic City, NJ. 1958, June 8-13.

(42) Severy DM, Mathewson JH, Bechtol CO. Controlled automobile rear-end collisions, an investigation of related engineering and mechanical phenomenon. N: Medical Aspects of Traffic Accidents, Proceedings of the Montreal Conference. 1955:152-84.

(43) West DH, Gough JP, Harper TK. Low speed collision testing using human subjects. Accid Reconstr J 1993;5(3):22-6.

(44) Ommaya A, Backaitis S, Fan W, Partyka S. Automobile neck injuries. Ninth Internatl Technical Conference on Experimental Safety Vehicles, US Dept of Transportation, NHTSA, Kyoto, Japan. Nov 1-4, 1982:274-8.

(45) Lovsund P, Nygren A, Salen B, Tingvall C. Neck injuries in rearend collisions among front and rear seat occupants. International IRCOBI Conference on the Biomechanics of Impacts, Bergisch-Gladbach, Germany. 1988:319-25.

(46) Cherkin DC, MacCormack FA. Patient evaluations of low back pain care from family physicians and chiropractors. West J Med 1989;150:351-5.

(47) Bovim G, Schrader H, Sand T. Neck pain in the general population. Spine 1994;19(12):1307-9.

(48) Croft AC. Whiplash: The Master's Program. Module 1. Spine Research Institute of San Diego, San Diego, CA 1996.

5. SUMMARY AND RECOMMENDATIONS

SUMMARY OF CHAPTER 2

In Chapter Two, the comprehensive literature review, it was reported that in 1995, there were 39,300,000 crash victims in the U.S.. Of these, 5,500,000 sustained some injury, and 2,900,000 sustained a whiplash injury. It was predicted, based on the meta-analysis of relevant literature, that 33% of the whiplash-injured population will continue to have chronic whiplash symptoms (late whiplash) at least 33 months post-accident. The cost in the U.S. of acute whiplash injuries was estimated at $28 billion for 1995. The cost of late whiplash was found to be unestimable (given the large amount of unknown variables to consider and the scope of this thesis).

SUMMARY OF CHAPTER 3

In Chapter Three, the review and critique of the Quebec Task Force on Whiplash-Associated Disorders, it was found that the QTF documents contained five major areas of methodologic weakness that compromised both the internal validity (the accuracy and precision) and the external validity (the generalizability) of the study and its conclusions. It was concluded that the QTF on WAD documents did not accomplish the QTF's goals of clarifying the nature of whiplash injuries, and seemed instead to confuse the subject of late whiplash because of apparently serious methodologic flaws and inferences in the document. The contradiction between the findings presented in Chapter Two of this thesis

and the findings and conclusions of the QTF on WAD can be explained by the methodologic failings of the QTF on WAD.

SUMMARY OF CHAPTER 4

In Chapter Four, the case-control study of chronic neck pain and whiplash injuries, it was found that whiplash injuries caused 45% of the neck pain of the study population and 37% of all spine pain, more than from any other single cause. These estimates suggest that a minimum of 6.2%, or 15.5 million Americans suffer from late whiplash. Additionally, it was found that the use of a shoulder harness is a risk factor for late whiplash, and a side impact is a risk factor for chronic low back pain following MVA. Slight body composition, for females for both neck and low back injuries, and increased age, for both genders, also were found to be risk factors for chronicity. The findings of this study further invalidate the conclusions of the Quebec Task Force with regard to the natural history of whiplash injuries and their chronic sequelae.

CONCLUSION

Based on the research findings presented in this thesis, it is reasonable to conclude that chronic neck pain and acute whiplash injuries appear to be strongly related. This statement is based on the quantity and quality of studies reviewed that supported the hypothesis as well as the absence of sound research invalidating it. Additional support for the hypothesis was found in the results of the case-control study presented in Chapter Four.

It is difficult to compare the 33% risk of late whiplash at 33 months post-accident (from the meta-analysis in Chapter Two) with the 6.2% prevalence of the condition in the general American population (from the conclusion of Chapter Four). Likewise, it is unknown precisely how the 960,000 new cases of late whiplash that occur each year in the U.S. compares with the 15.5 million Americans with the condition. The reason the figures are not exactly comparable is because it is unknown what happens to the late whiplash victim after he or she acquires the condition; how many recover or die within 10 years, for example, or how many sustain multiple injuries that contribute to the chronicity of the pain.

RECOMMENDATIONS FOR FUTURE STUDY

Further study is needed for more precise estimates of the prevalence and risk of late whiplash. Additionally, a population-based, prospective cohort study is necessary to confirm risk factors for late whiplash that were identified in Chapter Four, particularly because some of the estimates were based on a small number of subjects. It also is important to evaluate other potential risk factors, such as the position of the head restraint relative to the head of the occupant, that are more easily studied using a prospective study design. Once common, alterable, risk factors are identified, intervention trials should be undertaken to determine the most effective methods of risk reduction.

BIBLIOGRAPHY

Altman LK. Much whiplash aid is rated worthless. San Diego Union Tribune May 2, 1995:A8.

Altman LK. Whiplash can heal on own in days. Lakeland Ledger May 7, 1995:Science and Technology section.

Altman LK. Whiplash treatments found to be ineffective. New York Times May 2, 1995:C1,6.

Andersson HI. The epidemiology of chronic pain in a Swedish rural area. Qual Life Res 1994 Dec;Suppl 1:S19-26.

Bailey MN, Wong BC, Lawrence JM. Data and methods for estimating the severity of minor impacts. SAE Tech Paper Series 1995;950352:1339-174.

Balla JI. The late whiplash syndrome. Aust NZ J Surg 1980;50:610-4.

Balla JI. The late whiplash syndrome: a study of an illness in Australia and Singapore. Culture, Medicine and Psychiatry 1982;6:191-210.

Barnsley L, Lord S, Bogduk N. Clinical review: whiplash injury. Pain 1994;58:283-307.

Bingham R. Whiplash injuries. Med Trial Tech Quart 1968;14:69-80.

Bjorgen IA: Late Whiplash Syndrome. Lancet 1996;348(9020):124.

Blincoe LJ. The Economic Cost of Motor Vehicle Crashes, 1994. Washington, DC: US Department of Transportation, NHTSA 1996.

Blincoe LJ, Faigin BM. The Economic Cost of Motor Vehicle Crashes, 1990. Washington, DC: US Department of Transportation, NHTSA DOT 807 876;1992.

Bogduk N. Post whiplash syndrome. Austral Fam Phys 1994;23(12):2303-7.

Bovim G, Schrader H, Sand T. Neck pain in the general population. Spine 1994;19(12):1307-9.

Carey TS, Evans A, Hadler N, Kalsbeek W, McGlaughlin C, Fryer T. Care-seeking among individuals with chronic low back pain. Spine 1995;20(3):312-7.

Carey TS, Evans AT, Hadler NM, Lieberman G, Kalsbeek WD, Jackman AM, Fryer JG, McNutt RA. Acute severe low back pain. A population-based study of prevalence and care-seeking. Spine 1996;21(3):339-44.

Cherkin DC, MacCormack FA. Patient evaluations of low back pain care from family physicians and chiropractors. West J Med 1989;150:351-5.

Chiropractic: State of the art - 1994-1995. J Amer Chiro Assoc 1995

Croft AC. Whiplash: The Master's Program. Module 1. Spine Research Institute of San Diego, San Diego, CA 1996.

Crowe, H.E.: Injuries to the cervical spine. Paper presented at the meeting of the Western Orthopedic Association, San Francisco, 1928

de Mol BA, Heijer T: Late Whiplash Syndrome. Lancet 1996;348(9020):124-125. 15.

Deans GT, McGalliard JN, Rutherford WH. Incidence and duration of neck pain among patients injured in car accidents. Br Med J 1986;292:94-5.

Deans GT, Magalliard JN, Kerr M, Rutherford WH. Neck sprain - a major cause of disability following car accidents. Injury 1987;18:10-12.

Does the prevalence of back pain increase with age? The Back Letter 1997;12(2):21.

Dvorak J, Valach L, Schmid S. Cervical spine injuries in Switzerland. Orthopade 1987;16:2-12.

Ellertsson AB, Sigurjousson K, Thorsteinsson T. Clinical and radiographic study of 100 cases of whiplash injury. Acth Neurol Scand (Suppl) 1978;67:269.

Ettlin T, Kischka U, Reichmann S, et al. Cerebral symptoms after whiplash injury of the neck: a prospective clinical and neuropsychological study of whiplash injury. J Neurol Neurosurg Psychiatr 1992;55(10):943-8.

The Fatal Accident Reporting System 1989: A Decade of Progress. Washington, DC: US Department of Transportation. DOT HS 807 693 March 1991.

Foreman, SM, Croft AC. Whiplash injuries: the cervical acceleration/deceleration syndrome. Williams and Wilkins, Baltimore, MD 1988.

Foreman SM, Croft AC. Whiplash injuries: The cervical acceleration/deceleration syndrome. Baltimore, Williams & Wilkins Co., 1988:3.

Foret-Bruno JY, Dauvilliers F, Tarriere C. Influence of the seat and head rest stiffness on the risk of cervical injuries. 13th International Technical Conference on Experimental Safety Vehicles. 1991;S-8-W-19:968-974.

Freeman MD, Croft AC. Late Whiplash Syndrome. Lancet 1996;348(9020):125.

Freeman MD, Croft AC. The controversy over late whiplash: are chronic symptoms following whiplash real? Whiplash '96 Abstracts, Brussels, Belgium. 1996:51-2

Gagne S. Conversation with Officer Sylvain Gagne of the Quebec Police Department, 7-15-96.

Galasko CSB, Murray PM, Pitcher M, et al. Neck sprains after road traffic accidents: a modern epidemic. Injury 1993;24(3):155-7.

Gargan MF, Bannister GC. Long-term prognosis of soft tissue injuries of the neck. J Bone Joint Surg Br 1990;72:901-3.

Gargan MF, Bannister GC. The rate of recovery following whiplash injury. Eur Spine J 1994;3:162-4.

The General Estimates System Report 1989 Washington, DC: US Department of Transportation. DOT HS 807 665 December 1990.

Gotten N. Survey of one hundred cases of whiplash after settlement of litigation. JAMA 1956;162(9):865-867.

Greenblatt J, Merrin MB, Morganstein D, Schwartz S. National Accident Sampling System Nonreported Accident Survey. Washington, DC: US Department of Transportation, NHTSA DOT HS-90218, November 1981.

Hildingsson C, Toolanen G. Outcome after soft-tissue injury of the cervical spine. A prospective study of 93 car-accident victims. Acta Orthopod Scand 1990;61:357-9.

Hodgson SP, Grundy M. Whiplash injuries: their long-term prognosis and its relationship to compensation. Neuro Orthop 1989;7:88-99.

Hohl M. Soft tissue injuries to the neck. Clin Orthop Rel Res 1975;109:42.

Insurance Research Council. Paying for auto injuries: A consumer panel survey of auto accident victims. May, 1994 Insurance Research Council, Oak Brook, Illinois.

Jonsson H, Cesarini K, Sahlstedt, Rauschning W. Findings and outcome in whiplash-type neck distortions. Spine1994.

Kischka U, Ettlin T, Heim S, Schmid G. Cerebral symptoms following whiplash. Eur Neurol 1991;31(3):136-140.

Larder DR, Twiss MK, Mackay GM. Neck injury to car occupants using seat belts. 29th Ann Proc Am Assoc Auto Med 1985:153-165.

Lovsund P, Nygren A, Salen B, Tingvall C. Neck injuries in rearend collisions among front and rear seat occupants. International IRCOBI Conference on the Biomechanics of Impacts, Bergisch-Gladbach, Germany. 1988:319-25.

MacNab I. Acceleration injuries of the cervical spine. J Bone Joint Surg Am 1964;46-A:1797-9.

Maimaris C, Barnes MR, Allen MJ. "Whiplash injuries" of the neck: a retrospective study. Injury 1988;19(5):393-6.

McKinney LA, Dornan JO, Ryan M. the role of physiotherapy in the management of acute neck sprains following road-traffic accidents. Arch Emerg Med 1989;6:27-33.

Miles KA, Maimaris C, Finlay D, Barnes MR. The incidence and prognostic significance of radiological abnormalities in soft tissue injuries to the cervical spine. Skeletal Radiol 1988;17:493-6.

Miller TR, Viner JG, Rosman SB, Pindus NM, Gellert GW, Douglass JB, Dillingham AE, Plomquist GC. The Costs of Highway Crashes. Washington, DC: The Urban Institute, 1991

Mills H, Horne G. Whiplash—manmade disease? NZ Med J 1986;99:373-4.

The National Accident Sampling System/Crashworthiness Data System Report 1991-1993. Washington, DC: US Department of Transportation. DOT HS 808 298 August 1995.

The National Accident Sampling System/Crashworthiness Data System Report 1991-1993. Washington, DC: US Department of Transportation. DOT HS 808 298 August 1995.

National Highway Transportation and Safety Administration organizational chart. Washington, DC: US Department of Transportation, NHTSA 1996

National Safety Council. Accident Facts:1994 edition. Itasca, IL 1994:2.

National Safety Council. Accident Facts:1996 edition. Itasca, IL 1996:83.

National Safety Council. Accident Facts:1996 edition. Itasca, IL 1996.

Norris SH, Watt I. The prognosis of neck injuries resulting from rear-end vehicle collisions. J Bone Joint Surg [Br] 1983;65B:608-11.

Nygren A. Injuries to car occupants - some aspects of interior safety of cars. Acta Oto-Laryngologica 1984;Suppl #394.

Nygren A, Berglund A. Long term follow up of whiplash associated disorders (WAD). *Swedish experience on insurance material.* Whiplash '96 Abstracts, Brussels, Belgium. 1996:34-5.

Olsnes BT. Neurobehavioral findings in whiplash patients with long-lasting symptoms. Acta Neurol scand 1989;80:584-8.

Olsson I, Bunketorp O, Carlsson G, et al. An in-depth study of neck injuries in rear end collisions. 1990 International IRCOBI Conference, Bron, Lyon, France. Sept 12-14,1990:1-15.

Ommaya A, Backaitis S, Fan W, Partyka S. Automobile neck injuries. Ninth Internatl Technical Conference on Experimental Safety Vehicles, US Dept of Transportation, NHTSA, Kyoto, Japan. Nov 1-4, 1982:274-8.

Otte D, Rether JR. Risks and mechanisms of injuries to the cervical spine in traffic accidents. International IRCOBI/AAAM Conference on the Biomechanics of Impact. Goetberg, Sweden. 1985:17-31.

Parmar HV, Raymakers R. Neck injuries from rear impact road traffic accidents: prognosis in persons seeking compensation. Injury 1993;24(2):75-8.

Pearce JMS. Whiplash injury: a reappraisal. J Neurol Neurosurg Psychiatr 1989;52:1329-31.

Polatin PB, Kinney RK, Gatchel RJ, Lillo E, Mayer TG. Psychiatric illness and chronic low-back pain. The mind and the spine - which goes first? Spine 1993;18(1):66-71.

Radanov BP, Di Stefano G, Schnidrig A, Sturzenegger M, Augistiny KF. Cognitive functioning after common whiplash. A controlled follow-up study. Arch Neurol 1993;50:87-91.

Radanov BP, Di Stefano GD, Schnidrig A, Ballinari P. Role of psychological stress in recovery from common whiplash. Lancet 1991;338:712-5.

Radanov BP, Di Stefano G, Schnidrig A, Sturzenegger M. Psychosocial stress, cognitive performance and disability after common whiplash. J Psychosom Res 1993;37(1):1-10.

Radanov BP, Sturzenegger M, Di Stefano G. Long-term outcome after whiplash injury: a 2-year follow-up considering features of injury mechanisms and somatic, radiologic, and psychosocial findings. Medicine 1995;74(5):281-97.

Radanov BP, Sturzenegger M, Di Stefano G, Schnidrig A, Aljinovic M. Factors influencing recovery from headache after common whiplash. Br Med J 1993;307:652-5.

Rice DP, MacKenzie EJ. Cost of Injury in the United States. A Report to Congress 1989. San Francisco, CA: Institute for Health and Aging, University of California and Injury Prevention Centers, The John Hopkins University, 1989.

Robinson DD, Cassar-Pullicino VN. Acute neck sprain after road traffic accident: a long-term clinical and radiological review. Injury 1993;24(2):79-82.

Ryan GA, Taylor GW, Moore VM, Dolinis J. Neck strain in car occupants: injury status after 6 months and crash-related factors. Injury 1994;25(8):533-6.

Schrader H, Obelieniene D, Bovim G, et al. Natural evolution of late whiplash syndrome outside the medicolegal context. Lancet 1996;347:1201-11.

Schutt CH, Dohan FC. Neck injuries to women in accidents. A metropolitan plague. JAMA 1968;296:2689-92.

Severy DM, Mathewson JH. Automobile barrier and rear-end collision performance. Paper presented at the Society of Automotive Engineers summer meeting. Atlantic City, NJ. 1958, June 8-13.

Severy DM, Mathewson JH, Bechtol CO. Controlled automobile rear-end collisions, an investigation of related engineering and mechanical phenomenon. Canservices Med J 1955;11:727-58.

Severy DM, Mathewson JH, Bechtol CO. Controlled automobile rear-end collisions, an investigation of related engineering and mechanical phenomenon. N: Medical Aspects of Traffic Accidents, Proceedings of the Montreal Conference. 1955:152-84.

Shekelle PG, Markovich M, Louie R. Factors associated with choosing a chiropractor for episodes of back pain care. Medical Care 1995;33(8):842-50.

Spitzer WO, Skovron ML, Salmi LR, Cassidy JD, Duranceau J, Suissa S, Zeiss E. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. Spine 1995;20(8S):1S-73S.

States JD, Balcerak JC, Williams JS, et al. Injury frequency and head restraint effectiveness in rear impact accidents. Proceedings of 16th STAPP car crash conference, Detroit, Michigan

States JD, Korn MW, Masengill JB. The enigma of whiplash injury. NY State J Med 1970;70:2971-8.

Szabo TJ, Welcher J. Dynamics of low speed crash tests with energy absorbing bumpers. SAE Tech Paper Series 1992;921573:1-9.

Thomson RW, Romilly DP, Navin FPD, Macnab MJ. Energy attenuation within the vehicle during low speed collisions. Report to Transport Canada, University of British Columbia. August, 1989.

Traffic Safety Facts 1995. National Center for Statistics and Analysis. Washington, DC: US Department of Transportation, NHTSA. September 1996.

Watkinson A, Gargan MG, Bannister GC. Prognostic factors in soft tissue injuries of the cervical spine. Injury 1991;22(4):307-9.

West DH, Gough JP, Harper TK. Low speed collision testing using human subjects. Accid Reconstr J 1993;5(3):22-6.

Whiplash, other strains, sprains give auto insurers big headaches; claim inflation remedies sought. Public Affairs Report

Wooley RL, Strother CE, James MB. Rear stiffness coefficients derived from barrier test data. SAE Inernational Congress, Detroit, MI 1991:910120.

APPENDICES

APPENDIX A

PRE-SURVEY

Chronic Spine Pain Study Eligibility Questionnaire

1. Are you 18 years of age or older?

☐ **YES** ☐ **NO**

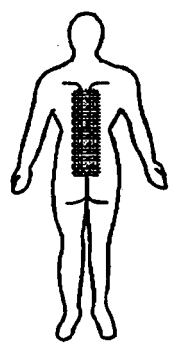
2. Do you have chronic back or neck pain (pain in the same area at least once a week for the past 6 or more months)?

☐ **YES** ☐ **NO**

If you answered **NO** to either question #1 or #2, please stop, and give this questionnaire back to the person who gave it to you.

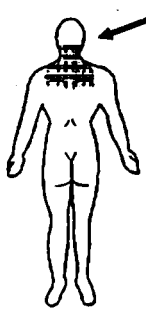
If you answered **YES** to both of the questions above, please read the following questions and check the one which best describes you. When you are finished, please give this questionnaire back to the person who gave it to you.

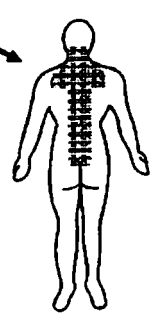
☐ **CHRONIC LOWER OR/AND MIDDLE BACK PAIN. You have pain only in a part of your back that is shaded in this drawing.**



☐ **CHRONIC NECK PAIN ALONE, OR IN COMBINATION WITH OTHER BACK PAIN**

you have pain in your neck or, neck <u>and</u> other spinal pain





APPENDIX B

Informed Consent Statement

Dear Patient,

Thank you for taking the time to complete this questionnaire. The purpose of this study is to better understand the reasons why people have chronic spine pain. **It is important that you only fill out the survey if you are 18 years of age or older and have had pain in your spine at least once a week for more than six months.** If not, return the questionnaire to the person who gave it to you. Please answer the questions to the best of your knowledge or memory. **Please answer all of the questions. All of your answers are completely confidential, and will only be used anonymously, for the purposes of this study.** If you don't understand one of the questions, ask the person who gave you the questionnaire for assistance. If you decide that you do not want to complete the questionnaire, stop, and return it to the person who gave it to you. Please let them know that you did not finish. If you decide to not complete the questionnaire, it will not affect your patient/physician relationship with your doctor. If you have any questions, comments, or concerns about this survey, please contact:

Michael D. Freeman, D.C., M.P.H.
Doctoral candidate, Oregon State University, Department of Public Health
503-393-3133

or,

Annette Rossignol, Sc.D.
Professor, Oregon State University, Department of Public Health
541-737-3840

We thank you for your time.

APPENDIX C

17. Was the vehicle you were in equipped with air bags? *(circle one number)*

    1 NO (please skip now to question 17)
    2 YES
    → 17a. Did the air bags discharge? *(circle one number)*

        1 NO
        2 YES

18. Did you have a headrest? *(circle one number)*

    1 YES
    2 NO

19. Was your vehicle damaged? *(circle one number)*

    1 NO (Please skip now to question # 20)
    2 YES
    → 19a. Approximately how much damage was done to your vehicle?

        1 less than $500
        2 between $500 and 1500
        3 between $1500 and $5000
        4 $5000 to total loss
        5 don't know/can't recall

20. Please give your height in feet and inches.

    _____/_____
    FEET INCHES

21. What is your current weight in pounds? (Your best estimate is fine)

    _____WEIGHT IN POUNDS

22. What is your current age?

    _____YEARS

23. And, are you:

    1 MALE
    2 FEMALE

Thank you for taking the time to complete this survey. Please return it to the person who gave it to you.

12. When your chronic spine pain first started, you may have used several types of treatment during the first six months after your pain started. What was the **main** type of treatment that you used during the first six months after the pain began. *(circle only one number)*

    1 MEDICAL (MEDICATION OR SURGERY)
    2 CHIROPRACTIC
    3 PHYSICAL THERAPY
    4 OSTEOPATHIC
    5 NONE OR SELF TREATMENT
    6 OTHER (Specify_____)

13. How would you rate your satisfaction with the treatment that you indicated in question #12? *(circle only one number)*

Satisfaction level:

EXTREMELY DISSATISFIED	SOMEWHAT DISSATISFIED	NEITHER SATISFIED NOR DISSATISFIED	SOMEWHAT SATISFIED	EXTREMELY SATISFIED
1	2	3	4	5

The next section should be completed if your chronic spine pain is a result of a motor vehicle accident, or if you have *ever* been injured in a motor vehicle accident. If you have *never* been injured in a motor vehicle accident, check this box ⟶ ☐ **and please skip to question 20.**

14. Please indicate which of the following describes the motor vehicle accident in which you were injured. *(check all that apply)*

	YES	NO	NOT SURE
a. Struck from behind (rear-end)	1	2	3
b. Struck in front	1	2	3
c. Struck from the side	1	2	3
d. Some other collision with another vehicle	1	2	3
e. Collision with a fixed object	1	2	3
f. Rollover	1	2	3
g. Any other (specify_____)	1	2	3

15. Were you wearing a seat belt? *(Circle one number)*

    1 NO (please skip now to question 16)
    2 YES
    ↳ 15a. Was this a shoulder and lap belt, or just a lap belt? *(circle one number)*

        1 SHOULDER AND LAP BELT
        2 LAP BELT ONLY

16. Were you the: *(circle one number)*

    1 DRIVER
    2 A PASSENGER

6. Are you employed outside the home now? *(circle one number)*

   1 NO (please skip to question 8)
   2 YES
   → 6a. Which of the following best describes the type of work you are doing now? *(circle one number)*

      1 SEDENTARY WORK (no lifting, low activity)
      2 LIGHT WORK (lifting less than 10 lbs, low to moderate activity)
      3 MEDIUM WORK (lifting more than 10 lbs but less than 50 lbs; moderate to high activity)
      4 HEAVY WORK (lifting more than 50 lbs., high activity)

7. Which one of the following best describes any effect your pain currently has on your ability to do your job? *(circle only one number)*

   1 NO CHANGE OF DUTIES
   2 I OCCASIONALLY CAN'T DO OR HAVE DIFFICULTY DOING MY REGULAR WORK
   3 I FREQUENTLY CAN'T DO OR HAVE DIFFICULTY DOING MY REGULAR WORK
   4 I AM UNABLE TO DO MY REGULAR WORK AT ALL

8. Your pain may affect other responsibilities you have at home, such as doing house work or yard work, taking care of small children, or running a home-based business. Which one of the following best describes how your pain effects these tasks. *(circle one number)*

   1 NO CHANGE OF ACTIVITY
   2 I OCCASIONALLY CAN'T DO OR HAVE DIFFICULTY DOING THESE TASKS
   3 I FREQUENTLY CAN'T DO OR HAVE DIFFICULTY DOING THESE TASKS
   4 I AM UNABLE TO DO THESE TASKS AT ALL

9. Overall, how do your symptoms interfere with other activities of daily living? *(circle one number)*

   1 SYMPTOMS DON'T AFFECT MY NORMAL DAILY ACTIVITIES
   2 SYMPTOMS INTERFERE SLIGHTLY WITH DAILY ACTIVITIES
   3 SYMPTOMS INTERFERE GREATLY WITH DAILY ACTIVITIES

10. On a scale of 0 to 10, where 0 is no pain and 10 is maximum pain, how would you rate your current symptoms? *(circle one number)*

NO PAIN										MAXIMUM PAIN
0	1	2	3	4	5	6	7	8	9	10

11. Below is a list of possible treatments for the type of pain you are experiencing. Please indicate how your current symptoms have responded to each. *(circle one number for each)*

	Symptoms are:					
	MUCH IMPROVED	SOMEWHAT IMPROVED	NO CHANGE	SOMEWHAT WORSE	MUCH WORSE	HAVEN'T TRIED
a. Rest	1	2	3	4	5	6
b. Medication	1	2	3	4	5	6
c. Chiropractic	1	2	3	4	5	6
d. Physical therapy	1	2	3	4	5	6
e. Exercise	1	2	3	4	5	6

CHRONIC SPINE PAIN QUESTIONNAIRE

1. In what part of your back or neck have you had pain or stiffness for longer than six months? *(circle one number)*

   1 IN MY NECK, OR IN MY NECK AND BACK
   2 IN MY MIDDLE AND/OR LOW BACK, BUT NOT IN MY NECK

2. When did this pain start? *(Give the approximate month and year)*

   _____/_____
   MONTH YEAR

3. Which one of the following best describes how this pain began. *(circle only one number)*

   1 AFTER A SPORTS INJURY
   2 AFTER A MOTOR VEHICLE ACCIDENT
   3 AFTER SOME OTHER INJURY (Specify_____)
   4 I DON'T KNOW, THE PAIN JUST STARTED ONE DAY

4. If you did <u>not</u> indicate a motor vehicle accident in question #3, have you ever hurt your neck or back in a motor vehicle accident? *(circle one number)* **(If you <u>did</u> indicate a motor vehicle accident for question #3, please check this box ⟶ ☐ and skip to question #5)**

   1 NO (please skip now to question #5)
   2 YES

   ↳ 4a. When did this accident occur? (Give the approximate month and year)

   _____/_____
   MONTH YEAR

5. Were you employed outside the home when your chronic spine pain began? *(circle one number)*

   1 NO (please skip now to question 6)
   2 YES

   ↳ 5a. Which of the following best describes the type of work you were doing at that time *(circle one number)*

   1 SEDENTARY WORK (no lifting, low activity)
   2 LIGHT WORK (lifting less than 10 lbs, low to moderate activity)
   3 MEDIUM WORK (lifting more than 10 lbs but less than 50 lbs; moderate to high activity)
   4 HEAVY WORK (lifting more than 50 lbs., high activity)

   5b. To the best of your knowledge, is the cause of your pain work related?

   1 YES
   2 NO
   3 DON'T KNOW

   5c. Are you still employed at this job?

   1 YES (skip now to question 7)
   2 NO