Collision Cost Study

Final Report

Prepared For:

CRISP
CAPITAL REGION INTERSECTION SAFETY PARTNERSHIP

Prepared By:
Paul de Leur, PhD, P.Eng.
Road Safety Engineer
de Leur Consulting Ltd.

With Contributions From:
Laura Thue, PhD
Senior Research Coordinator
Office of Traffic Safety, Edmonton
And
Brian Ladd, MNRM, M.Sc.
Population Health Consultant
Alberta Health Services

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EXECUTIVE SUMMARY

ES-1 Project Objective / Overview

The objective of this assignment was to review the different collision cost models that exist, as well as the data inputs required for the models, to determine which costing model would be the most appropriate for the Capital Region of Alberta and the members of the Capital Region Intersection Safety Partnership (CRISP) committee. A collision cost model would be developed and used to calculate the collision costs in the Capital Region.

In general, the elements of a collision cost model are categorized into 3 types of costs including: 1) Direct Costs, 2) Human Capital (HC) Costs and 3) Willingness-to-Pay (WTP) Costs, which are defined below.

1) Direct Costs:

   These are the largely tangible and clearly understood costs that can be directly linked to the collision, including property damage costs, emergency services, medical expenses, legal costs, travel delay costs and the costs associated with lost time from the workplace. Often, the data required to accurately determine the direct costs of collisions are readily available.

2) Human Capital Costs:

   These are costs that are associated with the future net production that is lost to a society as a result of a collision. A value for future net production is determined by subtracting a collision victim's future net consumption from their future net production. This collision cost value represents a measure of the 'value' of that person to the society.

3) Willingness-To-Pay Costs:

   These are costs that a society is willing to pay to prevent or reduce the risks associated with the occurrence of collisions, particularly collisions that involve injury and death. This method involves surveying a representative sample in order to understand the tradeoff between collision risk and economic resources available to the population.

It was understood that the members of the CRISP committee would be most interested in the direct collision costs, but would also like to have some indication of the Human Capital (HC) costs and Willingness to Pay (WTP) costs. As such, most of the attention was given to establishing the various elements associated

with direct collision costs, while less effort was dedicated to the determination of HC and WTP collision costs.

ES-2 Literature Review / Critical Review

A literature review was completed at the outset of this assignment. The results from the literature review provided a description of several different methods that are used to produce collision cost estimates. A detailed summary of several key information sources is provided in Appendix 1, however, it is noted that many other studies were reviewed for the assignment and these references are cited within the body of the report.

The components of the collision cost estimates range from quite definitive direct costs (e.g., property damage costs, emergency response costs, etc.) to very abstract, non-tangible, indirect costs such as pain, suffering and grief, which are typically associated with human capital or WTP collision cost models.

Direct collision costs are typically calculated from existing databases associated with the various components of cost. For example, emergency response agencies such as the police services often maintain records of the time and costs associated with attending motor vehicle collisions. Since the collision costs associated with the direct / internal costs are often readily available and generated from existing databases, the literature concerning how these values were obtained is limited. More emphasis is generally placed on external costs, as it is often quite difficult to assign dollar values to intangible services that are borne by individuals and societies as a whole. As such, the various elements of external costs are the main focus of the literature review chapter, which includes the following main concepts:

- Loss of Productivity
- Pain, Suffering and Grief
- Loss of Quality of Life
- Value of Statistical Life

Due to the wide variety of the collision costing methods, there is a wide range in the values that have been generated for collision costs, which can vary from a low of approximately $1M to a high of nearly $20M for a fatal collision. This range is partly due to the differences in the collision cost models used, but it is believed that the differences are also due to data accuracy, data availability and the interests of the agency examining collision costs.

ES-3 Classification of Collision Severity

The third chapter of the report discussed the different ways in which collisions can be classified based on the level of severity. This is particularly important in how the collision cost model would be developed and how the final results would be presented.

For this assignment, the collision severity categories are based on a 'per collision' and on a 'per victim' basis. An example of the difference between the categorization is that one injury collision can results in more than one injury victim (i.e., there can be several persons injured in an incident recorded as a injury collision). As such the following collision severity classification was used, based on the classification system used in Alberta.

1) By Collision
    a. Fatal Collision
    b. Injury Collision
    c. Property Damage Only (PDO)
2) By Victim:
    a. Fatality
    b. Major Injury
    c. Minor Injury
    d. Property Damage Only (PDO)

ES-4 Baseline Collision Data

Chapter 4 of this report presented the baseline collision data that would form the basis for the collision cost model that was developed. The raw collision data from the province of Alberta and Edmonton's Office of Traffic Safety was obtained to represent specific communities within the Capital Region.
Collision data for 2007 from the following communities were included in the raw data set for the collision cost model.

- Devon
- Edmonton (Edmonton Police Service (EPS)
- Fort Saskatchewan
- Leduc
- Sherwood Park
- Spruce Grove
- St. Albert
- Stony Plain

The raw collision data from 2007 for each community is provided in Table ES-1, based on the two collision severity classifications described previously.

Table ES-1: Raw Collision Data (2007) for the Capital Region

Community	Collision Frequency (Collision)			Collision Frequency (Victim)			
	Fatal	Injury	PDO	Fatalities	Major Injuries	Minor Injuries	PDO
Devon	1	6	118	1	4	9	118
Edmonton	32	5,955	33,943	33	536	7,503	33,943
Ft. Saskatchewan	3	74	448	3	9	103	448
Leduc	1	111	917	1	17	128	917
Sherwood Park	2	375	1,534	2	33	473	1,534
Spruce Grove	1	70	667	1	14	84	667
St Albert	2	262	1,261	2	26	309	1,261
Stony Plain	0	29	396	0	7	30	396
TOTAL	42	6,882	39,284	43	646	8,639	36,880

Several adjustments must be made to the raw data to account for the under-reporting and misreporting of collisions. Making such corrections is a very common practice when collision-costing models are developed, and allows for a better representation of the true collision experience. The adjustment process for the raw collision data was fully documented in chapter 4, noting that the adjustment factors were obtained from literature sources. The results of the adjustments and the final collision data set used in the model are provided in Table ES-2. If local information becomes available to correct for the necessary adjustments, it can easily be input into the Capital Region collision cost model.

Table ES-2: Adjusted Collision Data for the Capital Region

Collision Type	Collision Frequency (Collision and Victim Data)			
	Fatal	Injury	PDO	TOTAL
Collisions	43	8,517	51,822	60,382
Fatalities	44			44
Injuries	207	13,540		13,746
Major Injury	66	891		956
Minor Injury	141	12,649		12,790

ES-5 Collision Cost Results

The results for the collision cost model are divided into three categories, which correspond to the 3 types of costs (i.e., direct costs, human capital costs, and willingness-to-pay costs). The specific elements associated with each type of collision cost are discussed fully within the body of the report. The reader is directed to chapter 5 for the direct collision cost elements, chapter 6 for the human capital costs elements, and chapter 7 for the willingness-to-pay collision cost elements.

ES-5.1 Direct Collision Costs

There are six categories for the direct collision cost elements, which includes a total of 20 specific cost elements. The direct collision cost elements that were included in the cost model are listed below and the final results for the various collision cost elements are provided in Table ES-3.

- Property Damage Costs
  - Vehicle Damage Costs
  - Auto-Insurance Administration Costs
  - Out-of-Pocket Costs
  - Towing Costs
- Emergency Response Costs
  - Police Costs
  - Fire / Rescue and Ambulance Costs
  - Coroner / Medical Examiner Costs
- Health Services Costs
  - Emergency Department Costs
  - Intensive Care Unit Costs
  - Acute Care hospital Costs
  - Rehabilitation Costs
  - Long Term Care Costs
- Legal Costs
  - Cost of Correctional Services
  - Court Costs
  - Legal Aid and Prosecution Costs
  - Funeral Costs
- Travel Delay / Environmental Costs
  - Traffic Delay Costs and Extra Fuel Consumption Costs
  - Extra Pollution Costs
- Productivity
  - Lost Productivity Due to Injury Collisions
  - Lost productivity Due to Fatalities
  - Lost Productivity Due to PDO Incidents

Table ES-3: Summary of Direct Collision Costs for Capital Region

DIRECT Collision Costs		Collision Costs (by Victim)				Collision Costs (by Collision)		
		Fatality	Major Injury	Minor Injury	Property Damage	Fatal	Injury	PDO
1	**Property Damage (Vehicle Related)**							
	Vehicle Repairs	$25,841	$18,308	$15,509	$6,681	$26,456	$16,092	$6,272
	Auto-Insurance Administration	$3,235	$1,537	$920	$127	$3,312	$1,180	$120
	Out-of Pocket Expenses	$1,292	$975	$871	$429	$1,323	$898	$403
	Towing Services	$588	$512	$504	$333	$602	$586	$311
2	**Emergency Response Costs**							
	Police Costs	$5,884	$2,322	$441	$169	$5,884	$541	$169
	Fire / Rescue Costs	$628	$3,281	$81	$0	$628	$278	$0
	Ambulance Costs	$548	$3,775	$27	$0	$548	$222	$0
	Coroners Costs (Fatal Only)	$1,812	$0	$0	$0	$1,770	$0	$0
3	**Health Services Costs**							
	Emergency Room Costs	$1,039	$318	$254	$0	$1,064	$348	$0
	ICU Care Costs	$45,878	$26,517	$0	$0	$46,970	$2,489	$0
	Acute Care Costs	$9,156	$8,258	$0	$0	$9,374	$775	$0
	Rehabilitation Costs	$6418	$4735	$523	$0	$6571	$1101	$0
	Long Term Care Costs	$18,656	$15,035	$887	$0	$19,100	$2,525	$0
4	**Legal Costs**							
	Correctional Services	$1,061	$419	$8	$0	$1,061	$29	$0
	Court Costs	$434	$171	$3	$0	$434	$12	$0
	Legal Aid and Prosecution	$386	$152	$3	$0	$386	$11	$0
	Funeral Costs (Fatal Only)	$8,887	$0	$0	$0	$8,741	$0	$0
5	**Travel Delay Costs**							
	Delay Costs Caused by Collision	$16,903	$8,874	$4,648	$1,927	$16,903	$4,926	$1,927
	Extra Fuel Consumption	$2,069	$1,086	$569	$236	$2,069	$603	$236
	Environmental / Pollution Costs	$12,843	$6,742	$3,532	$1,464	$12,843	$3,743	$1,464
6	**Productivity / Disruption Costs**							
	Short-Term Work-Place (Injury)	$14,944	$10,606	$1,802	$0	$15,300	$3,165	$0
	Short-Term Work-Place (Fatal)	$3,882	$0	$0	$0	$3,975	$0	$0
	Short-Term Work-Place (PDO)	$0	$0	$0	$48	$0	$0	$48
	TOTAL for DIRECT Costs:	**$178,499**	**$113,624**	**$30,581**	**$11,367**	**$181,335**	**$39,524**	**$10,902**

A summary of the results from Table ES-3 is provided below for the direct collision cost elements of the collision cost model (rounded).

Direct Collision Costs:

Fatal Collision:	$181,300	Fatality:	$178,500
Injury Collision:	$39,500	Major Injury:	$113,600
PDO:	$10,900	Minor Injury:	$30,600
		PDO:	$11,400

ES-5.2 Indirect Collision Costs: Human Capital Costs

The human capital collision cost elements was discussed in detail in chapter 6 of the report. The human capital cost elements that were included in the cost model are listed below and the final results for the various collision cost elements

are provided in Table ES-4. Also included in Table ES-4 are the combined total collision costs for the human capital costs and the direct collision costs.

Human Capital Costs
- Discounted Future Earnings
  - Long-Term Income Loss for Fatal Collision Victims
  - Long-Term Income Loss for Permanently Disabled Victims
  - Long-Term Household Productivity Loss
- Pain, Suffering and Grief

Table ES-4: Summary of Human Capital Collision Costs for the Capital Region

Human Capital Costs of Collisions		Collision Costs (by Victim)					Collision Costs (by Collision)		
		Fatality	Major Injury	Minor Injury	Property Damage		Fatality	Injury	PDO
1	**Discount Future Earnings**								
	Long-Term Income Loss (Fatal Collision Victim)	$1,392,531	$0	$0	$0		$1,414,927	$0	$0
	Long-Term Income Loss (Disabled Injury Victim)	$105,990	$79,785	$7,827	$0		$108,513	$17,314	$0
	House-Hold Productivity and Disruption Costs	$74,957	$54,700	$6,388	$0		$76,741	$13,154	$0
2	**Pain, Suffering and Grief**								
	Pain, Suffering and Grief	$67,830	$113,624	$2,446	$0		$68,907	$11,067	$0
	TOTAL for HUMAN CAPITAL Costs:	**$1,641,308**	**$248,109**	**$16,661**	**$0**		**$1,669,088**	**$41,535**	**$0**
	TOTAL for HUMAN CAPITAL + DIRECT Costs:	**$1,819,807**	**$361,733**	**$47,242**	**$11,369**		**$1,850,423**	**$81,059**	**$10,902**

A summary of the results from Table ES-4 is provided below for the human capital cost elements of the model (rounded) and the combined results.

Human Capital Costs (Only):

1) By collision

Fatal Collision:	$1,669,100
Injury Collision:	$41,500
PDO:	$0

2) By victim

Fatality:	$1,641,300
Major Injury:	$248,100
Minor Injury:	$16,700
PDO:	$0

Human Capital Costs + Direct Collision Costs:

1) By collision

Fatal Collision:	$1,850,400
Injury Collision:	$81,100
PDO:	$10,900

2) By victim

Fatality:	$1,819,800
Major Injury:	$361,700
Minor Injury:	$47,200
PDO:	$11,400

ES-5.3 Indirect Collision Costs: Willingness-to-Pay Costs

The willingness-to-pay elements of the cost model were discussed in detail in chapter 7 of this report, including how the various elements were calculated for the collision cost model. The WTP cost elements that were included in the cost model are listed below and the final results for the various collision cost elements are provided in Table ES-5 below. Also included in Table ES-5 are the combined total collision costs for both the willingness-to-pay collision costs and the direct collision costs.

Willingness-to-Pay Costs:

Value of Statistical Life (VoSL)

Valuation of Injuries

Table ES-5: Summary of Willingness-to-Pay Collision Costs

Willingness to Pay Costs		Collision Cost (by Victim)				Collision Costs (by Collision)		
		Fatality	Major Injury	Minor Injury	Property Damage	Fatality	Injury	PDO
1	**Value of Statistical Life**							
	Valuation of Statistical Life (VoSL) (FATAL Only)	$5,237,750	$0	$0	$0	$5,362,458	$0	$0
2	**Valuation of Major Injuries**							
	Valuation of Injures (MAJOR Injuries Only)	$0	$1,272,025	$0	$0	$0	$95,032	$0
	TOTAL for WILLINGNESS TO PAY Costs:	**$5,237,750**	**$1,272,025**	**$0**	**$0**	**$5,362,458**	**$95,032**	**$0**
	TOTAL: WILLINGNESS TO PAY + DIRECT Cost:	**$5,416,249**	**$1,385,649**	**$30,581**	**$11,367**	**$5,543,793**	**$134,556**	**$10,902**

A summary of the results from Table ES-5 is provided below for the willingness-to-pay cost elements of the model (rounded) and the combined results.

Willingness-to-Pay Costs (Only):

Fatal Collision:	$5,362,500	Fatality:	$5,237,800
Injury Collision:	$95,000	Major Injury	$1,272,000
PDO:	$0	Minor Injury:	$0
		PDO:	$0

Willingness-to-Pay Costs + Direct Collision Costs:

Fatal Collision:	$5,543,800	Fatality:	$5,416,200
Injury Collision:	$134,600	Major Injury	$1,385,600
PDO:	$10,900	Minor Injury:	$30,600
		PDO:	$11,400

1.0 INTRODUCTION

It is clear that the total costs associated with the occurrence of motor vehicle collisions are considerable. However, there are many ways in which the cost of collisions can be evaluated, which can lead to significant variations in the estimates for the total cost of collisions. This becomes very evident upon the review of literature related to collision cost estimates, which shows that cost estimates can be significantly different, depending on the needs and interests of the agency that is interested in collision costs.

In general, the costs of collisions are categorized into three types of collision costs including: 1) Direct Costs, 2) Human Capital Costs, and 3) Willingness-to-Pay (WTP) Costs. The definitions for each collision cost category are as follows:

1) Direct Costs:

   These are the largely tangible and clearly understood costs that can be directly linked to the collision, including property damage costs, emergency services, medical expenses, legal costs, travel delay costs and the costs associated with lost time from the workplace. Often, the data required to accurately determine the direct costs of collisions are readily available.

2) Human Capital Costs:

   These are costs that are associated with the future net production that is lost to a society as a result of a collision. A value for future net production is determined by subtracting a collision victim's future net consumption from their future net production. This value represents a measure of the 'value' of that person to the society.

3) Willingness-To-Pay Costs:

   These are costs that a society is willing to pay to prevent or reduce the risks associated with the occurrence of collisions, particularly collisions that involve injury and death. This method involves surveying a representative sample in order to understand the tradeoff between collision risk and economic resources available to the population.

From the definitions listed above, it is clear that the level of certainty associated with the elements of the collision costs decreases from the largely tangible directs costs to the somewhat abstract willingness-to-pay costs.

1.1 Project Objective / Scope

The Capital Region Intersection Safety Partnership (CRISP) commissioned this study to identify, analyze, and interpret the costs associated with motor vehicle collisions within the Capital Region (i.e., the Edmonton Census Metropolitan Area) in the province of Alberta. It is duly noted that contributions made by staff from agencies represented within CRISP were very valuable in guiding this project and obtaining the data necessary to complete the study, including Mr. Brian Ladd from Alberta Health Services and Ms. Laura Thue from the Office of Traffic Safety. The organizational membership of the CRISP committee includes:

Alberta Motor Association;
Alberta Health Services;
City of Edmonton;
Edmonton Police Service;
City of St. Albert;
St. Albert RCMP;
Strathcona County;
Strathcona County RCMP; and,
The Office of Traffic Safety – City of Edmonton

The objective of this assignment was to critically review the various collision costing models to determine the most suitable model for the Capital Region, given the availability and accuracy of the local data that would be required to support the collision cost model.

It was understood that the members of the CRISP committee would be most interested in the direct collision costs, but would also like to have some indication of the Human Capital (HC) costs and Willingness to Pay (WTP) costs. As such, most of the attention was given to establishing the various elements associated with direct collision costs, while less effort was dedicated to the determination of the HC and WTP collision costs.

1.2 Project Overview / Tasks

There were several tasks that were associated with the assignment, as listed and described below.

1) Literature Review:

   Conduct a literature review to assess how other jurisdictions derive their collision cost values and, if the information is available, assess how the collision cost values are applied by the agency.

2) Critical Review:

   Conduct a critical review of the various collision costing models and model inputs to determine which collision costing model is most appropriate for the Capital Region.

3) Examine Model Inputs:

   The most suitable collision cost model determined from the critical review will require various inputs to calculate collision cost values. The success of applying the costing model will be dependent on the availability of the input data. This task will examine if the input data is available, the degree of difficulty in obtaining the data, and the reliability of the data for use in the collision costing model.

4) Formulate Collision Costing Methodology:

   Based on the collision cost model selected and the input data that can be obtained, the specific methodology will be determined.

5) Determine Collision Cost Values:

   Based on the needs of the various members of CRISP, there may be a need for several collision cost values broken down by location type (e.g., intersection type), by collision type (e.g., head-on, rear-end), or by gender, age, or other factors. These values will be determined as required.

1.3 Report Structure

This first chapter of the report has provided a brief introduction to the topic of collision costs and collision cost models. It has also included the objectives, scope and overview for the assignment.

Chapter 2 presents the results from the literature review and the critical review of the information that is available on the topic of collision costs and the various collision cost models in use today.

Chapter 3 is a very brief chapter that presents some definitions of the different collision severity categories and how collisions are classified. This information is necessary for the presentation of the collision cost model results.

Chapter 4 focuses on the direct collision costs that can be considered by the CRISP membership for the Capital Region. This includes the methodology associated with how the collision cost values were determined as well as the actual costs to be used.

Chapter 5 will focus on the human capital collision cost values. This includes an examination of a collision victim's consumption and production, as well as values for lost quality of life.

Chapter 6 presents the results for the willingness to pay collision cost model. Although the scope of the study did not allow for the detailed examination of this approach for the Capital Region (i.e., willingness to pay surveys were not conducted), an estimate for this collision cost model is provided.

Chapter 7 provides the results for the collision cost study. This includes a summary of the overall collision costs that can be used by the Capital Region, a sample of some detailed collision costs estimates and some potential limitations / caveats associated with the collision cost values. A concluding section is also provided at the end of Chapter 6.

2.0 LITERATURE REVIEW / CRITICAL REVIEW

A search of key works related to motor vehicle collisions was conducted in both the peer-reviewed research literature and grey literature[1]. Topic areas included: collision costs, cost models, societal collision costs and willingness to pay. Published reports were also obtained from the key transportation agencies in Canada, United States, and other comparable international jurisdictions. A large number of studies were reviewed for the assignment and are cited throughout the report. Significant findings from literature review were reviewed in depth (see Appendix 1) and are listed below:

1) The Alberta GPI Accounts: Auto Crashes and Injuries,
   - By Anielski, 2001
2) Crashes vs. Congestion - What's the Cost to Society?
   - By Meyer, 2008
3) Costs of Alcohol-Related Crashes: New Zealand
   - By Miller and Blewden, 2001
4) Long-Term Medical Costs of Crash Casualties in Alberta
   - By Jacobs et al, 2004
5) Crash Costs in the United States by Crash Geometry
   - By Zaloshnja, 2006
6) The Economic Costs of Road Traffic Crashes: Australia
   - By Connelly et al, 2006
7) Analysis and Estimation of the Social Cost of Collisions in Ontario
   - By Vodden et al, 2007
8) Calculating External Costs of Transportation in Norway
   - By Eriksen, 2000
9) International Comparison of Fatal Road Crash Costs
   - By Trawen et al, 2002
10) Cost of Road Crashes: Comparison of Methods / Australian Estimates
   - By Giles, 2003
11) Collision Cost Prediction Model: System Dynamics Approach
   - By Partheeban et al, 2008
12) External Costs of Crashes: Definition, Estimation, and Internalization
   - By Rune Elvik, 1994

[1]Databases searched included: Transportation Research Information Service (TRIS), Transportation Research Board, Compendex, the Internet.

2.1 Collision Cost Evaluation Methods

The costs associated with collisions are often grouped into three categories, including direct costs, human capital costs and willingness-to-pay costs. The direct costs are those costs that are borne by the individuals involved in the collision and are typically costs that are more clearly understood (e.g., property damage, medical costs, etc.). The human capital costs refer to the lost productivity to a society due to the collision and are costs that are less well understood (e.g., quantifying lost income). Finally the willingness-to-pay cost, which is a highly intangible cost, is the value that a society is willing to pay to prevent or reduce the risks associated with a collision that involves injury and / or death.

Collision costs can also be categorized into two groups, namely internal costs and external costs. The internal costs are similar to the direct costs in that these costs represent the losses to individuals who are involved in the collision. The external costs (similar to indirect costs) represent the damages and losses that are NOT necessarily borne by the individual who is involved in the incident, but are costs that are taken on by persons close to the individual (e.g., family members) and by society as a whole.

Direct collision costs are typically calculated from existing databases associated with the various services that respond to collision. For example, emergency response agencies such as the police, fire and rescue, and ambulance normally maintain records of the time and costs associated with attending motor vehicle collisions. Similarly, the healthcare service organizations have databases that track emergency department and hospital utilization and costs associated with injuries sustained in motor vehicle collisions.

Although the collision costs associated with the direct costs are typically generated from existing databases, the methods and assumptions related to gathering this data is limited. Similar to other reports, this costing study provides explanation on deriving indirect costs, as it is often quite difficult to assign dollar values to intangible services that are borne by individuals and societies as a whole.

The methods used to quantify indirect costs can be categorized into four categories as listed below.

- Loss of Productivity
- Lost Quality of Life
- Loss of utility and value of road injuries
- Pain and Suffering

Within each category, there are several techniques used to evaluate these costs. A brief overview of these techniques is provided in this section of the report. It must again be noted, however, that the main focus of this assignment was on the direct / internal costs, and the techniques listed in the following section were beyond the scope of the assignment.

TYPES OF INDIRECT/EXTERNAL COSTS

2.1.1 Loss of Productivity

Two methods are commonly used when trying to measure the loss of productivity associated with a collision, including, 1) the Human Capital Approach (HCA) and 2) the Friction Cost Method (FCM).

1) Human Capital Approach (HCA)

This approach involves estimating the value of earnings that the individual would have made had he/she not been involved in a collision. Authors Connelly and Supangan (2006) explained this by saying that from the point of view of the economy, an individual's lost productivity is irrecoverable after he/she has been in a collision. This method uses objective measures such as the number of lives that are saved and the disabilities that can be reduced (Marshall, 1930; Pigou, 1932). The main component is the calculation of the "discounted present value of the victim's future output forgone due to his/her death" (Dawson et al, 2007).

2) Friction Cost Method (FCM)

Some believe that the human capital approach overestimates the productivity losses to the economy (Connelly and Supangan 2006). It is argued that the loss of productivity to society should only be computed until another worker is found to replace the disabled/injured employee. The assumption is that the labor supply within an economy is perfectly

elastic, in the sense that any loss of labor due to collisions approaches zero if FCM is employed.

2.1.2 Pain, Suffering and Grief

Another component of the external costs that are associated with collisions is the pain, suffering and grief that are linked to either a severe injury collision or to a fatal collision. These costs can include the value of the pain, suffering and grief that is imposed on the individual who is involved in the collision or the family and friends of the victim.

The information contained in the collision costing literature on the pain, suffering and grief component of human capital costs is highly varied, which produces a wide range of results. Furthermore, the approach used to formulate the estimate for pain, suffering and grief appears to be largely abstract and highly subjective or arbitrary. There appears to be no definitive or scientific way to accurately determine how much pain, suffering and grief is worth.

In settling claims for pain, suffering and grief, attorneys and insurance companies will often consult legal publications that report the results of other cases that have gone to trial and produced values for pain, suffering and grief. This, in combination with many other factors related to a specific claim (e.g., the effectiveness of medication at controlling pain, persons affected, time frame in which the pain, suffering and grief must be endured), helps to determine the value of pain and suffering.

A study prepared by the Transportation Research Laboratory (TRL) in the United Kingdom (Jacobs, G.D., 1995) proposed that pain, suffering and grief could be calculated based on a proportion of the direct / internal costs associated with collisions. The TRL study, which was cited in a report by the International Road Assessment Program (Dawson, et al, 2007), recommends that the value for the pain, suffering and grief should be 8% of the total direct collision costs for minor collisions and up to 100% of the total direct collision costs for serious, long-term permanent injuries.

Obviously, this represents a guideline or a range of values that can be used for the average economic value for pain, suffering and grief. However, it appears

that a significant range exists when attempting to quantify the societal value for pain, suffering and grief.

2.1.3 Loss of Quality of Life

Lost quality of life as a result of an injury or disability is an important component of the external cost of collisions. This component is the main focus of the healthcare sector, specifically when making decisions about allocation of resources based on economic evaluations (Goebbels et al, 2008). Three methods are often used to determine lost quality of life, which are briefly described below.

(1) Quality Adjusted Life-Year (QALY)

This method combines life expectancy and the quality of life in a single outcome measure (Goebbels et al, 2008). For this approach, one year of perfect health / life expectancy is worth a unit value (i.e., 1.0), whereas one year of less than perfect health / life expectancy is equal to a value of less than 1.0. In order to apply this approach, it is necessary to have information regarding the type of disability/injury that results from an individual's suffering (associated with a collision) and the value of a "less than perfect life expectancy" associated with that disability/injury. These values will provide an indication of benefits gained in terms of quality of life and survival.

(2) Disability-Adjusted Life-Year (DALY)

This method includes calculating the burden that can be associated with an injury (in the case of motor vehicle collisions). There are 4 main concepts that constitute the DALY approach (Murray, 1994):

- Any health outcome which represents a net loss of "welfare" should be included in an indicator of a health status,
- The characteristics of individuals affected by a health outcome should be considered in calculating the burden of an injury, but it should be restricted to age and gender,
- All health outcomes should be treated alike, and
- The time (years) is the unit of measure of the burden of an injury.

In order to accurately evaluate the DALY, it is necessary to have information and data for various health outcomes, including the type of injuries caused as a result of the motor vehicle collision and the number of years that an individual needs to fully recuperate.

(3)Health Years Equivalent (HYE)

Health Years Equivalent represents the hypothetical number of years spent in good health, which is the equivalent to a health status. Gold (Gold et al, 1996) explained HYE as "the number of years of perfect health that has the same utility as the lifetime path of the state of health under consideration" (i.e., a "less than perfect" health status). The value of HYE is obtained by assigning values for each health outcome. Then, a weight for the expected value for each outcome is obtained by determining the probability of a specific path and the total across all paths. The assumptions required for the HYE method include determining a value for a healthy outcome and the health status attribute (Ried, 1998).

2.1.4 Value of Statistical Life (VoSL)

The overall value that a society associates with an unexpected death due to collisions is the main focus of most of the literature related to the indirect cost of collisions. Many economists believe that assigning monetary values to fatal collisions should reflect individual preferences (De Blaeij and Van Vuuren, 2003). This is often referred to in the literature as the value of statistical life (VoSL).

There are several methods that can be used to assess the VoSL, but the methods are generally based on two principle fundamental questions as listed below (Giles, 2003; Bellavance, 2007):

Willingness-to-Pay (WTP)

This is a measure of how much a society (or an individual) is willing to pay to avoid death due to a collision or to reduce the risk of death (Jones-Lee, 1974; Mishan, 1971; Schelling, 1968). This method involves a tradeoff between the level of risk and the economic resources available.

Willingness-to-Accept (WTA)

This is a measure of how much a society (or an individual) is willing to accept as compensation for a death as a result of a collision or the amount of financial compensation that an individual would need to receive before they are willing to accept the reduction in their life expectancy.

In general, two techniques are used to represent the value that an individual places on their own health (Connelly and Supangan, 2006), including 1) revealed preference and 2) stated preference, which are described below.

1) Revealed Preference

Revealed preference is a method that involves identifying various situations where people are asked to make a tradeoff between money and risk (Hiselius, 2003). It measures the "utility change in probability of a fatal collision by looking at the revealed behavior" (De Blaeij, D.J. van Vuuren, 2003). This method includes designing a survey aimed at determining tradeoffs. Road users are asked to make decisions between specific safety features and money; for example, one of the questions on the surveys could be: "how much are you willing to pay to have air-bags installed in your vehicle" (WTP) or "how much risk are you willing to accept to remove air-bags from your vehicle" (WTA). The revealed preference approach involves assessment of risk and willingness of individuals to choose resources in exchange for reducing risk to an acceptable level (Dawson et al, 2007).

2) Stated Preference

There are several methods that are used in order to determine the stated preference of road users but the WTP and WTA are still the fundamental basis of this approach. Stated preference is obtained by surveys that are designed to determine WTP and WTA values and this method is used when the revealed preference data is either unavailable or inconclusive. The estimates are obtained from hypothetical choices determined by questionnaires designed to address specific impacts. The approach facilitates the collection of detailed data on safety impacts that are of specific interest.

Respondents of stated preference questionnaires are expected to answer the questions based on the objective risk and not individual preference. In addition, it is assumed that the values obtained from the methods reflect those that occur in the real market. Respondents who complete the survey are assumed to be representative sample of the population.

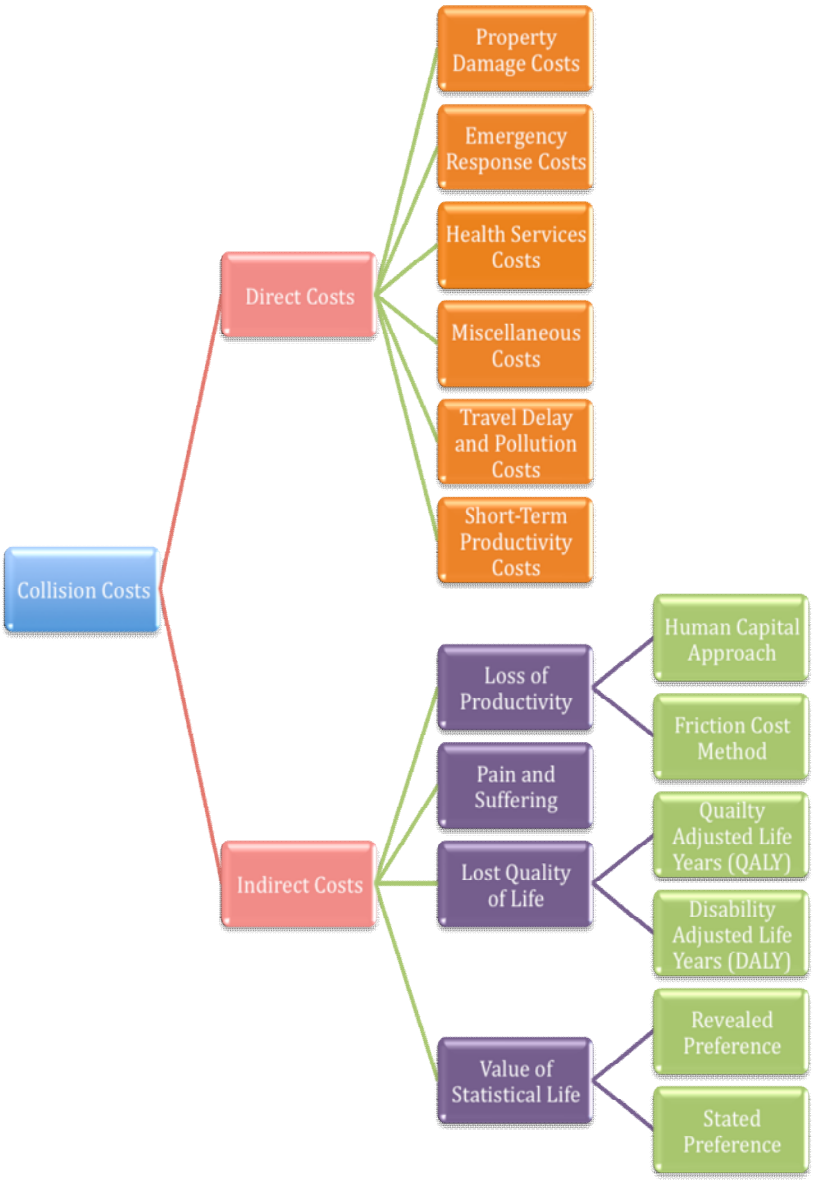
There are a number of survey methods that can be used to obtain stated preferences related to the risks associated with collisions. Some of these techniques include contingent valuation methods (i.e., respondents state their

WTP or WTA values), choice experiments, standard gamble, Firsch Method (Lhs et al, 2003), transfer price methods, and prospect theory. Greater detail on these techniques can be found in literature related to survey techniques.

2.1.5 Summary of Collision Cost Evaluation Methods

A graphical summary of the different collision cost elements for the internal (direct) costs and the external (human capital and willingness-to-pay) costs are provided below.

Figure 2.1: Summary of Collision Cost Evaluation Methods



2.2 Collision Cost Studies from Other Jurisdictions

The methods discussed in the preceding section are very sensitive to the location where the collision costs are calculated, including the understanding of the concept of risk. Equally importantly in the assessment of collision cost is the accuracy and availability of data used to evaluate costs. This section of the report presents some results from studies that list the values for the different components of the overall collision cost. It is noted that there is not an ideal costing approach used in any of the reported collision costing studies; however, there are approaches that are relevant and applicable within the Capital Region context.

The results in Table 2.1 show values for both the direct and indirect collision costs, based on a study from New Zealand (Miller and Blewden, 2001). The overall categorization of the cost elements and how the collision severity is disaggregated is very similar to the results that are produced from this study.

Table 2.1: Summary of Collision Costs in New Zealand

	Fatal	Serious injury	Minor injury	PDO crash
Per injury				
Medical	4800	10 700	600	0
Lost work/quality of life	2 151 800	172 500	8700	0
Legal and court	3300	400	200	30
Property damage	3600	2400	2600	1600
Total	2 163 500	186 000	12 100	1630
Accident Compensation	59 000	1900	1900	0
External costs (not paid by the drinking driver)	914 400	90 500	7500	1000
Per crash				
Medical	10 900	13 100	900	0
Lost work/quality of life	2 581 100	211 400	11 700	0
Legal and court	4200	600	300	30
Property damage	6700	4400	3500	1600
Total	2 602 900	229 500	16 400	1630

Conversion Factor: ($1.0 NZ = $0.69 CDN)

The Australian Bureau of Transport Economics (ABTE) estimate for the average human capital collision cost is listed below in Australian dollars ($1.0 AUS = $0.877 CDN) (Connelly and Supangan, 2006). Table 2.2 shows the distribution of costs by the different cost categories.

- Fatality: $1,832,310
- Serious injury: $397,000
- Minor injury: $14,183
- Property damage only crash: $7,329

Table 2.2: Collision Cost Distribution Measured by Australian Bureau of Economics

Cost category	Percentage of cost category	Percentage of total costs
Human costs		
Medical, ambulance and rehabilitation	4.31	2.41
Long-term care	23.73	13.28
Labour in the workplace	19.38	10.85
Labour in the household	17.81	9.97
Quality of life	21.10	11.81
Legal	9.70	5.43
Correctional services	0.20	0.11
Workplace disruption and staff replacement	3.73	2.09
Funeral	0.04	0.02
Coroner	0.01	0.01
Total human costs	100.00	55.97
Vehicle costs		
Vehicle repairs	94.53	25.93
Unavailability of vehicles	4.43	1.21
Towing	1.05	0.29
Total vehicle costs	100.00	27.44
General costs		
Travel delays	58.15	9.65
Insurance administration	37.26	6.18
Police	2.98	0.49
Non-vehicle property damage	1.21	0.20
Fire and emergency services	0.40	0.07
Total general costs	100.00	16.59

Source: Derived from BTE (2000, p. xi). *Note*: Percentages have been rounded to two decimal places.

In a study of societal costs of collisions and traffic congestion prepared for the American Automobile Association, (Meyer, 2008) estimated a comprehensive cost of $3.25M per fatality and $68K per injury ($1.0 US = $1.12 CDN), based on an approach by the US Federal Highway Administration (FHWA).

A very comprehensive study was prepared for the province of Ontario (Vodden et al, 2007), which generated a range of willingness-to-pay estimates. The values are considerably higher than other estimates, ranging from a low of $7.5M to a high of $19.7M per fatal collision (CDN currency). These results are shown in Table 2.3 together with the other WTP estimates.

Table 2.3: Core Willingness to Pay Parameters for Human Consequences ($2004 CDN)

	Value by type of effect by scenario:		
Type of effect	**Upper bound**	**Lower bound**	**Mean value**
Death	$19.7 million	$7.5 million	$13.6 million
Activity day used for short term disabling injury below:	$2,885	$577	$1,730
Per major injury	$215,510	$43,102	$129,231
Per minor injury	$43,275	$8,655	$25,950
Per minimal injury	$2,308	$462	$1,384
Partial disability	$1,201,977	$240,395	$721,186
Total disability	$2,403,954	$480,790	$1,442,372

The same study for the province of Ontario (Vodden et al, 2007) produced estimates for the human capital costs, including the assessment of discount future earning, as shown in Table 2.4.

Table 2.4: Discount Future Earning Estimate Component for Human Capital Costs ($2004 CDN)

Injury Severity	Average/case
Fatality	$1.1 million
Permanent Total Disability	$1.1 million
Permanent Partial Disability	$189,081
Major Injury*	$7,709
Minor Injury*	$1,136
Minimal Injury*	$36

* Excluding those resulting in permanent disability.

A study prepared by Anielski Management Inc. for the Alberta Motor Association (Anielski, 2004) states that the total societal costs (direct and indirect) is $3.0M per fatality and $100K per injury, which is based on previous work by the Urban Institute and Ted Miller for the British Columbia Ministry of Transportation.

The original work by the Urban Institute and Ted Miller for the British Columbia Ministry of Transportation produced a willingness-to-pay estimate of $3.8M per

fatal collision and $100K per injury collision. Subsequent to this estimate, the cost of a fatal collision was set lower by the BC MOT's Highway Safety Branch, which was set to $2.9M per fatality ($1994). It should be noted that these values have been updated several times over the years and the most recent estimate prepared by Apex Engineering for the BC MOT produced collision costs of $6.1M fatal, $135K injury and $7800 for PDO ($2007).

Parry (Parry, 2004) provided an estimate of the direct and indirect collision costs, and the portion of these costs that are borne by insurance. Table 2.5 summarizes his estimate of different types of costs for five different collision severity levels. The "Quality of Life Costs" in the table represents the value of non-monetary costs such as pain, grief and reduced enjoyment due to deaths and injuries.

Table 2.5: Collision Cost Estimates From Parry ($2004 - US)

	Fatal Injury	Disabling Injury	Evident Injury	Possible Injury	Property Damage Only
Medical	$22,095	$19,471	$5,175	$3,485	$140
Household Productivity	0	$6,944	$1,854	$1,244	$85
Lost Wages	0	$25,014	$6,239	$4,160	$155
Legal Costs	$102,138	$5,167	$1,101	$681	$15
Insurance Administration	$37,120	$5,999	$1,776	$1,181	$152
Property Damage	$10,273	$4,357	$3,824	$3,413	$1,642
Police & Fire Services	$833	$175	$112	$90	$31
Travel Delay	$5,247	$885	$797	$785	$696
Employer Costs	0	$1,679	$665	$461	$67
Total, Excluding Quality of Life Costs	*$186,480*	*$69,479*	*$21,543*	*$15,500*	*$2,983*
Quality of Life Costs	$3,000,000	$83,239	$19,560	$10,725	$464
Total, Including Quality of Life Costs	*$3,186,408*	*$152,718*	*$41,103*	*$26,225*	*$3,447*

Cited in: Transportation Cost and Benefit Analysis, Victoria Transport Policy Institute

The National Safety Council in the United States (NSC, 2005) published 2 estimates of motor vehicle collision costs, as summarized in Table 2.6. One estimate only includes the short-term productivity costs, lost wages, medical expenses, administrative expenses, motor vehicle damage and employers' uninsured costs. The other cost estimate is a comprehensive willingness-to-pay approach, which includes costs for pain and suffering.

Table 2.6: Collision Cost Estimates by the National Safety Council ($2004 - US)

	Economic Productivity Costs	Comprehensive Costs
Death	$1,130,000	$3,760,000
Non-fatal disabling injury	$49,700	$188,000
Nonincapacitating evident injury		$48,200
Possible injury		$22,900
Property damage crash (including nondisabling injuries)	$7,400	$2,100

Cited in: Transportation Cost and Benefit Analysis, Victoria Transport Policy Institute

IN the United States, the National Highway Traffic Safety Administration (NHTSA) conducted a study (Blincoe et al, 2002) using the human capital method to develop an estimate of indirect collision costs. Of these costs, approximately three-quarters are considered external to individual drivers involved in the collision. Table 2.7 lists the cost categories included in this analysis and their estimated average values for various collision severity ratings. The last row indicates the ratio of non-market costs Quality Adjusted Life Years (QALY) to market costs (i.e., direct costs).

Table 2.7: NHTSA Estimate of Collision Costs ($2000 - US)

	PDO	MAIS 0	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	FATAL
Injury Severity		None	Minor	Moderate	Serious	Severe	Critical	Fatal
Medical	$0	$1	$2,380	$15,625	$46,495	$131,306	$332,457	$22,095
Emergency Services	$31	$22	$97	$212	$368	$830	$852	$833
Market Productivity	$0	$0	$1,749	$25,017	$71,454	$106,439	$438,705	$595,358
HH Productivity	$47	$33	$572	$7,322	$21,075	$28,009	$149,308	$191,541
Insurance Administration	$116	$80	$741	$6,909	$18,893	$32,335	$68,197	$37,120
Workplace Costs	$51	$34	$252	$1,953	$4,266	$4,698	$8,191	$8,702
Legal Costs	$0	$0	$150	$4,981	$15,808	$33,685	$79,856	$102,138
Injury Subtotal	$245	$170	$5,941	$62,019	$178,359	$337,302	$1,077,566	$957,787
Travel Delay	$803	$773	$77	$846	$940	$999	$9,148	$9,148
Property Damage	$1,484	$1,019	$3,844	$3,954	$6,799	$9,833	$9,446	$10,273
Non-Injury Subtotal	$2,287	$1,792	$4,621	$4,800	$7,739	$10,832	$18,594	$19,421
Market Cost Summary	$2,532	$1,962	$10,562	$66,820	$186,097	$348,133	$1,096,161	$977,208
QALY (Nonmarket)	$0	$0	$4,455	$91,137	$128,107	$383,446	$1,306,836	$2,389,179
Total Comprehensive	$0	$0	$15,017	$157,958	$314,204	$731,580	$2,402,997	$3,366,388
Non-market/Market	*0.00*	*0.00*	*0.42*	*1.36*	*0.69*	*1.10*	*1.19*	*2.44*

Cited in: Transportation Cost and Benefit Analysis, Victoria Transport Policy Institute

Another American report by the Federal Highway Administration (FHWA, 1994) provided an estimate of collision costs based on the KABCO collision severity classification. See Table 2.8.

Table 2.8: FHWA Collision Cost by Collision Severity (KABCO) ($1994 - US)

KABC Scale			Abbreviated Injury Scale (AIS)		
Severity	Descriptor	Cost	Severity	Descriptor	Cost
K	Fatal	$2,600,000	AIS 6	Fatal	$2,600,000
A	Incapacitating	$180,000	AIS 5	Critical	$1,980,000
B	Evident	$36,000	AIS 4	Severe	$490,000
C	Possible	$19,000	AIS 3	Serious	$150,000
PDO	Property Damage Only	$2,000	AIS 2	Moderate	$40,000
			AIS 1	Minor	$5,000

Cited in: Transportation Cost and Benefit Analysis, Victoria Transport Policy Institute

A study of collision costs was completed in Michigan (Streff and Molnar, 1998), which included an estimate for some of the direct collision costs and an estimate for the quality of life lost due to the occurrence of a collision. The results are shown in Table 2.9.

Table 2.9: Collision Costs in Michigan ($1997 - US)

	Fatal	Serious Injury	Moderate Injury	Minor Injury	Property Damage Only
Medial Care	22,254	17,464	3,823	2,051	68
Future Earnings	1,053,152	23,563	7,786	3,876	319
Public Services	1,275	314	204	133	29
Property Losses	11,901	4,683	3,980	3,008	1,257
Subtotal (Monetary Losses)	*1,088,592*	*46,025*	*15,793*	*9,067*	*1,672*
Quality of Life	2,093,660	113,992	25,566	10,647	244
Total	*3,182,252*	*160,016*	*41,359*	*19,714*	*1,916*

Cited in: Transportation Cost and Benefit Analysis, Victoria Transport Policy Institute

A study for the European Union (ICF Consulting, 2003) evaluated both direct and indirect collision costs for fatal and injury collisions. Results are provided in Table 2.10.

Table 2.10: Collision Costs (European Study) ($2003 Euros)

	Lost Output	Human Costs	Medical Costs	Property Damage	Insurance Admin.	Police Costs	Delay Costs	Total Costs
Fatal Crash	598,408	1,150,000	8,056	11,172	314	1,999	15,000	1,789,754
Injury Crash	6,632	35,000	3,524	3,445	130	91	5,000	53,736
Individual Fatality	520,355	1,000,000	7,005	NA	NA	NA	NA	1,527,360
Individual Injury	4,877	26,000	2,591	NA	NA	NA	NA	33,468

Cited in: Transportation Cost and Benefit Analysis, Victoria Transport Policy Institute

Another study (Elvik, 2002) generated an estimate for both internal and external collision costs by the different injury severity levels. The results are shown in Table 2.11.

Table 2.11: Collision Costs by Elvik (2002)

Injury severity	Type of cost	Distribution of costs by interested party				Total costs
		Road users	Household members	Private third parties	Public sector	
Fatal	Lost quality of life	8,279,000	1,250,000			9,529,000
	Travel time delay			5,000		5,000
	Medical treatment				6,000	6,000
	Lost output	1,651,000	1,656,000		1,275,000	4,582,000
	Property damage	44,000	6,000	8,000		58,000
	Administrative costs	26,000	3,000	3,000	10,000	42,000
	Total costs	10,000,000	2,915,000	16,000	1,291,000	14,222,000
Very severe	Lost quality of life	2,500,000	312,000			2,812,000
	Travel time delay			4,000		4,000
	Medical treatment	40,000	40,000		108,000	188,000
	Lost output	336,000	337,000	144,000	1,357,000	2,174,000
	Property damage	33,000	4,000	7,000		44,000
	Administrative costs	20,000	3,000	3,000	36,000	62,000
	Total costs	2,929,000	696,000	158,000	1,501,000	5,284,000
Severe	Lost quality of life	800,000	100,000			900,000
	Travel time delay			3,000		3,000
	Medical treatment	13,000	12,000		81,000	106,000
	Lost output	55,000	55,000	94,000	455,000	659,000
	Property damage	23,000	3,000	4,000		30,000
	Administrative costs	14,000	2,000	3,000	13,000	32,000
	Total costs	905,000	172,000	104,000	549,000	1,730,000
Slight	Lost quality of life	100,000	12,000			112,000
	Travel time delay			1,000		1,000
	Medical treatment	2,000	2,000		9,000	13,000
	Lost output			5,000	5,000	10,000
	Property damage	16,000	2,000	3,000		21,000
	Administrative costs	11,000	1,000	2,000	3,000	17,000
	Total costs	129,000	17,000	11,000	17,000	174,000
Currency conversion: convert to US Dollars (December 1993) by multiplying each figure by 0.135						

Conversion Factor: ($1.0 Norwegian Kroner = $0.177 CDN)

2.3 Summary of Findings from the Literature

In summary, the international literature provides several different approaches or methods that are used to produce collision cost estimates. Components of the collision cost estimates range from quite definitive direct costs (e.g., property damage, emergency response costs, etc.) to very abstract and non-tangible indirect costs (e.g., surveys to attempt to quantify the tradeoff between safety risk and economic value, based on a willingness-to-pay approach).

Because of the wide range of the collision cost methodologies, there are equally wide ranges in the values that have been generated for collision costs. For example, estimates for the cost of a fatality range from a low of approximately $1M to a high of nearly $20M. The range of values is attributed to the differences in the methods, data accuracy, data availability and the interests of the agency examining collision costs.

3.0 CLASSIFICATION SYSTEMS FOR COLLISION SEVERITY

During the review of the information related to collision costing, it was found that there are several different ways in which collision severity can be classified. This variation is likely due to differences in how the collision data is collected and based on the various needs and interests of the agencies that are interested in collision costs.

The most common classification of collision severity level is limited to three groups: 1) fatal collisions, 2) injury collisions and 3) property damage only (PDO) collisions.

Fatal: A collision that results in at least one death as a result of the collision, with the death occurring either at the scene or within a certain time frame from the date of the collision (often 30 days is used for this timeframe).

Injury: A collision that results in at least one injury from all persons that were involved in the collision. Most often, the injury must be readily apparent to the attending emergency response personal to be coded as an injury collision or in some cases, the injury will be noted if the person involved in the collision indicates that they believe that they are injured.

PDO: A collision that only involves property damage to vehicles and/or property as a result of the collision, and no apparent (or stated) injuries or deaths has occurred.

The definitions associated with the collision severity levels of fatal and PDO collisions are quite definitive, whereas the definition associated with an injury collision is less definitive, likely due to the range of injuries that can be associated with a motor vehicle collision and how this information is assessed and recorded. Because of this, agencies have devised other collision severity classification schemes in order to denote different injury severity levels. A well-known example of this is the **Abbreviated Injury Scale** (AIS), which was conceived more than three decades ago by the Association for the Advancement of Automotive medicine to describe the severity of injuries. The AIS injury severity scale has six categories as depicted in Table 3.1.

Table 3.1: Abbreviated Injury Scale (AIS)[2]

AIS Code	Description of Injury
1	Minor injuries
2	Moderate injuries
3	Serious injuries
4	Severe injuries
5	Critical injuries
6	Un-survivable injuries

In most cases, obtaining the 6 classifications used in the AIS is not possible during the normal collection of collision data. This is due to the inability of the police officers attending a collision to accurately assess the full extend of injuries. These injuries could only be accurately assessed by medical experts who may or may not be available at the scene or later in hospital after the collision report has been completed by the attending police officials.

Some agencies have reduced the number of injury severity classifications from the 6 categories proposed in the AIS to better reflect the collision severity levels that could be reasonably assessed by attending police officials. The most common approach is to divide the injury collisions into two categories (major injury and minor injury) or into three categories (major injury, moderate injury and minor injury). The highest severity category would define the type of collision (i.e., a collision involving a fatality and PDO would be recorded as a fatal, not a PDO).

In Alberta, collisions are categorized by the traditional collision severity classifications of fatal, injury and PDO. However, Alberta also provides information related to the victims (i.e., the number of fatalities and injuries per incident), including the disaggregation of injury collisions into two categories: major injury and minor injury. It is important to note that in some instances, a very severe fatal collision could actually involve two fatalities, two major injuries, three minor injuries and PDO. This information must be captured in the collision cost model.

[2] Developed by the Association for the Advancement of Automotive Medicine (AAAM), with more information available on the website www.carcrash.org.

Two collision severity categorization schemes were used for this study. The first approach slots each collision into one of 3 collision severity levels: fatal, injury, or PDO. The second approach, which is based on the number of victims, has 4 collision severity levels: fatalities, major injuries, minor injuries, and PDO. These two classifications are used in the present study for consistency with the classifications used in Alberta.

The definitions for the different collision severity levels used in this study are provided below.

Collision Severity by Collision (Classification 1):

Fatal:	A collision that results in at least one death as a result of the collision, and which has occurred either at the scene or within 30 days from the date of the collision.
Injury:	A collision that results in at least one readily apparent injury, or vehicle damages that would support the claim of an injury from an involved individual.
PDO:	A collision that only involves property damage to vehicles and/or other property in excess of $1000, with no apparent injuries or deaths.

Collision Severity by Victim (Classification 2):

Fatalities:	A collision that results in one or more deaths, with the deaths occurring either at the scene or within 30 days from the date of the collision.
Major Injury:	A collision that results in an injury that requires the injured individual to be transported in an ambulance to a hospital by emergency response personnel.
Minor Injury:	A collision that involves a readily apparent injury or a claim of an injury but does not require that the injured individual be transported by an ambulance to a hospital.
PDO:	A collision that only involves property damage to vehicles or other property in excess of $1000 and no apparent injuries or deaths is associated with the collision.

4.0 BASELINE COLLISION DATA

Before the various elements of the overall collision cost model are described, it is necessary to establish the source of the collision data that will be used as the basis for the collision cost model. This data, which comes from the members of CRISP, is described below, including how the raw collision data is adjusted to account for problems with the reporting of collision data.

4.1 Raw Collision Data

The collision data that is used for the collision cost model was made available from the Office of Traffic Safety for the Province of Alberta. Collision data for 2007 from the following communities were included in the raw data set for the collision cost model. A data reference identifier was also provided for each community. The raw collision data from 2007 for each community is provided in Table 4.1 below, based on the two collision severity classifications described previously.

- Devon (K3656)
- Edmonton (Edmonton Police Service (EPS)
- Fort Saskatchewan (K1172, K1165)
- Leduc (K1886, K1872)
- Sherwood Park (K1912, K1905, K5297)
- Spruce Grove (K1453)
- St. Albert (K1673, K5206)
- Stony Plain (K1474, K1467)

Table 4.1: Raw Collision Data (2007) for the Capital Region

Community	Collision Severity Class 1			Collision Severity Class 2 (Victim)			
	Fatal	Injury	PDO	Fatalities	Major Injuries	Minor Injuries	PDO
Devon	1	6	118	1	4	9	118
Edmonton	32	5,955	33,943	33	536	7,503	33,943
Ft. Saskatchewan	3	74	448	3	9	103	448
Leduc	1	111	917	1	17	128	917
Sherwood Park	2	375	1,534	2	33	473	1,534
Spruce Grove	1	70	667	1	14	84	667
St Albert	2	262	1,261	2	26	309	1,261
Stoney Plan	0	29	396	0	7	30	396
TOTAL	**42**	**6,882**	**39,284**	**43**	**646**	**8,639**	**36,880**

4.2 Adjustments to Raw Collision Data

The literature concerning the development of collision-cost models suggest that the raw collision data needs to be adjusted for several reasons. Some of these reasons include:

1) To reflect potential differences in the number of fatal collisions, which can occur when the death happens later in hospital (i.e., not at the collision scene), but this information does not get updated on the collision report (i.e., it is still noted as an injury collision).

2) To resolve discrepancies between police reported injury collisions and hospital admission records. These types of adjustments include those for soft-tissue injuries (e.g., whiplash) that may not be readily apparent at the scene when a collision report is being completed, but show up later denoted as a collision-related injury in a healthcare record (e.g., emergency department, hospital, or clinic).

3) To reflect the differences between police reported collision data and the actual collision experience, recognizing that most police agencies do not attend all collisions or collect data for all collisions. This can be particularly problematic for lower severity incidents (e.g., minor injury and PDO collisions).

The following adjustments are made to the raw collision data for the Capital Region based on the approach reported in a very thorough Transport Canada study, Analysis and Estimation of the Social Cost of Motor Vehicle Collisions in Ontario, (Vodden et al, 2007).

4.2.1 Adjustment 1: Additional Deaths

To account for the potential for additional deaths, the authors of the above noted study used information from The Office of the Chief Coroner for Ontario to determine that a multiplier of 1.02 should be applied to the number of fatal collisions to account for this under-reporting of fatal collisions and fatalities. This factor was determined based on a large sample of fatal collisions (i.e., approximately 800 fatal collisions were used to determine this factor).

4.2.2 Adjustment 2: Additional Injuries Due to Misreporting

To account for the potential misreporting of injuries, the Ontario study by Vodden used two sources of information. First, codes specific to motor vehicle collisions from the Ministry of Health were compared to the reported number of collisions to determine the ratio between police reported injury incidents and the health data. The second source of information came from analysis conducted by Chipman[3] of the Ontario Health Survey, in which the survey results produced an estimate of the number of injuries resulting from motor vehicle collisions. The data for the correction due to injury misreporting from the Ontario study is shown below, with the raw data shown in Table 4.2 and the adjusted data shown in Table 4.3.

Table 4.2: Raw Collision Data from Ontario Study

Collision Type	Collision Severity Classification 1 (Collision)			
	Fatal	Injury	PDO	TOTAL
Collisions	718	49,948	180,882	231,548
Fatalities	799			799
Injuries	764	72,247		73,011
Major Injury	245	3,320		3,565
Minor Injury	330	29,589		29,919
Minimal Injury	189	39,338		39,527

Table 4.3: Adjusted Collision Data from Ontario Study

Collision Type	Collision Severity Classification 1 (Collision)			
	Fatal	Injury	PDO	TOTAL
Collisions	730	61,814	169,004	231,548
Fatalities	813			813
Injuries	2,859	121,968		124,827
Major Injury	317	4,961		5,278
Minor Injury	1,574	59,152		60,726
Minimal Injury	968	57,855		58,823

[3] Chipman, Mary L., Health Service Use Attributable to Injury in Traffic Crashes: Data from a Population Survey, 36th Annual Proceedings, Association for the Advancement of Automotive Medicine (AAAM), Portland Oregon, October 5-7, 1992.

The results from the Ontario study indicated that overall, a multiplier of 1.48 should be applied to injury collisions to account for the misreporting collisions (i.e., collisions that were coded as PDO but were in fact an injury collision). These additional collisions should be taken from the total PDO collisions.

It is noted that the multiplier varies among collision severity categories (including PDO). The factor of 1.48 was also applied to all collision severity categories due to the difference in reporting across jurisdictions in the Capital Region. It is worth noting that the Capital Region jurisdictions do not include a category for "minimal" injuries.

4.2.3 Adjustment 3: Additional Collisions Due to Under-Reporting

The final adjustment to the raw data addresses the potential for under-reporting of collisions, which are typically associated with minimal injury and PDO type collisions. The Ontario study suggests a multiplier of 1.49 that can be applied to minimal injury and PDO collisions to account for under-reporting. Since the Capital Region does not include a collision severity category for "minimal" injuries, this multiplier is applied to the PDO collisions.

This under-reporting multiplier value of 1.49 was checked using collision data from British Columbia, from the police reported collision data and the auto-insurance claims-based collision records. The police reported collision data was obtained and compared to the auto-insurance records for selected highways in the province. The ratio of claims-based collision records to police reported collisions are 1.91[4], which is somewhat higher than the 1.49 value. However, it is noted that the BC data was limited to highways, where the level of under-reporting is likely higher than compared to an urban centre. This is likely due to the larger distances required to attend a collision on a highway as compared to the distance to attend a collision within a city. As such, it is felt that the multiplier of 1.49 for under-reporting is appropriate.

[4] Sayed, Tarek and de Leur Paul, 2006 Program Evaluation Report, ICBC Road Improvement Program, prepared for the Insurance Corporation of British Columbia (ICBC), pages 57 – 60, December 2006.

4.2.4 Results of Adjustments

The results from the raw collision adjustments for the Capital region are shown in Tables 4.4 and 4.5. Table 4.4 shows the raw collision data for the Capital region study (based on the results that were provided in Table 4.1). Table 4.5 shows the adjusted collision data, based on the three adjustments previously described.

Table 4.4: Raw Collision Data for the Capital Region (2007)

Collision Type	Collision Severity Classification 1 (Collision)			
	Fatal	Injury	PDO	TOTAL
Collisions	42	6,882	39,284	46,208
Fatalities	43			43
Injuries	140	9,145		9,285
Major Injury	44	602		646
Minor Injury	95	8,544		8,639

Table 4.5: Adjusted Collision Data for the Capital Region

Collision Type	Collision Severity Classification 1 (Collision)			
	Fatal	Injury	PDO	TOTAL
Collisions	43	8,517	51,822	60,382
Fatalities	44			44
Injuries	207	13,540		13,746
Major Injury	66	891		956
Minor Injury	141	12,649		12,790

Ideally, it would be beneficial to undertake a detailed and exhaustive analysis of the collision and health services records for the Capital Region in order to verify if the same proportions as those used in the Ontario study are applicable to this study. The numbers of persons reporting to emergency departments in the Capital region as a result of injuries sustained in motor vehicle collisions do suggest that the factors used in the Ontario study to correct for under- or over-reporting are reasonable adjustments for use in the Capital region. However, a more detailed analysis was beyond the scope of this study, and it is not certain that the data is available. Until better information is available, the adjustment factors from the Ontario study provide a reasonable estimate for adjustments to collision cost values for the Capital Region.

5.0 DIRECT COLLISION COSTS FOR THE CAPITAL REGION

This chapter presents the results of the direct collision cost elements of the overall collision cost model. A brief description of each collision cost element will be provided, as well as the assumptions that were used to generate the cost estimates. After the review of the literature associated with the estimation of collision costs, it became very evident that the estimates were based on several assumptions. This is no different for the collision cost estimates prepared for this assignment for CRISP.

The direct collision-cost components considered for the Capital Region estimate:

- Property Damage Costs
- Emergency Response Costs
- Health Services Costs
- Miscellaneous Costs
- Travel Delay Costs
- Productivity / Disruption Costs

5.1 Property Damage Costs

The property damage costs that are associated with the occurrence of a reported motor vehicle collision are generally covered through insurance claims, whether it is vehicle damage or damage to other property. There may be some situations where insurance does not cover the property damages, but it is assumed that this proportion would be very small and have negligible impacts on the overall property costs.

An estimate of the number of vehicles involved in collisions and the amount of vehicle damage is required to estimate property damage costs. Unfortunately, auto insurance collision records and data from the Capital Region that would describe the level of vehicle damage were not available. Therefore, a method was devised to estimate the level of vehicle damage based on the sample of collisions in the Capital Region.

Again, using the previously noted Transport Canada study for the province of Ontario[5], an estimate for the number of vehicles damaged and the extent of the vehicle damage was obtained. The Transport Canada study used data from the Insurance Bureau of Canada [6, 7] to obtain an estimate of the number of vehicles damaged and the level of damage, disaggregated by the collision severity level. The results from the Ontario study are provided in Table 5.1 below.

Table 5.1: Estimate of Vehicle Damage by Severity Level (Ontario Study)

Collision Type	Collision Severity Classification			
	Fatal	Injury	PDO	TOTAL
Collisions (Adjusted)	730	61,814	169,004	231,548
Vehicles Damage				
Demolished	723	13,150	4,107	17,980
Severe Damage	200	27,605	30,903	58,708
Moderate Damage	157	32,436	105,753	138,346
Light Damage	133	32,158	148,879	181,170
No Damage	48	11,258	19,443	30,749

Using the information in Table 5.1, an estimate for vehicle damage (frequency and extent) in the Capital Region can be obtained. These results, which are provided in Table 5.2, are obtained by distributing the number of vehicles damaged in the same proportion as in the Ontario study. For example, to get the number of severely damaged vehicles resulting from a fatal collision, the 43 fatal collisions in the Capital Region is multiplied by 200 and divided by 730 from the Ontario study to predict the 12 severely damaged vehicles (refer to Table 5.2).

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5 Vodden, K, Smith, D, Eaton, F and Mayhew, D., Analysis and Estimation of the Social Cost of Motor Vehicle Collisions in Ontario, Transport Canada, August 2007.

6 Insurance Bureau of Canada, Automobile Insurance Experience: Statistical Compilations and Annual Interpretations, 2004.

7 Insurance Bureau of Canada, FACTS 2008: General Insurance Industry in Canada, 2008.

Table 5.2: Vehicles Damaged by Collision Severity for the Capital Region

Collision Type	Collision Severity Classification				
	Fatal	Major Injury	Minor Injury	PDO	TOTAL
Collisions (Adjusted)	43	646	8,639	36,880	46,208
Number of Vehicles Damaged					
Demolished	43	126	1,686	837	2,693
Severe Damage	12	265	3,539	6,301	10,116
Moderate Damage	9	311	4,158	21,562	26,041
Light Damage	8	308	4,123	30,355	34,794
No Damage	3	108	1,443	3,964	5,518

Within the direct collision cost category of property damage costs, there are several sub-components of property damage costs, including vehicle repair costs, the cost of auto-insurance administration, out-of pocket expenses, and towing services.

5.1.1 Vehicle Damage Costs

Based on the number of vehicles damaged and the damage levels (Table 5.2), an estimate for vehicle damage costs can be determined. Average collision repair costs were obtained from the Insurance Bureau of Canada, which are used in the calculation of the total vehicle damage costs. The average vehicle repair costs are based on 2004 costs and have been inflated to current values by using an inflation rate of 2.75%. The average vehicle repair costs that are used in this study are as follows:

- Demolished Vehicle: $21,772
- Severe Damage: $11,668
- Moderate Damage: $4,952
- Light Damage $1,080

The total and average vehicle-repair costs disaggregated by collision severity classification is shown in Table 5.3 for collision severity classification 1 and Table 5.4 for collision severity classification 2 (victim).

Table 5.3: Vehicle Repair Costs by Collision Severity of the Collision (Classification 1) for the Capital Region

Collision Type	Collision Severity by Collision			
	Fatal	Injury	PDO	TOTAL
Collisions (Adjusted)	42	6,882	39,284	46,208
Vehicles Damage				
Demolished	$920,780	$39,447,109	$19,419,494	$59,787,384
Severe Damage	$136,506	$44,379,316	$78,310,010	$122,825,831
Moderate Damage	$45,479	$22,131,463	$113,736,359	$135,913,301
Light Damage	$8,406	$4,787,298	$34,934,829	$39,730,533
No Damage	$0	$0	$0	$0
TOTAL COST	**$1,111,171**	**$110,745,186**	**$246,400,692**	**$358,257,049**
AVERAGE COST	**$26,456**	**$16,092**	**$6,272**	**N/A**

Table 5.4: Vehicle Repair Costs by Collision Severity of Victim (Classification 2) for the Capital Region

Collision Type	Collision Severity by Victim				
	Fatality	Major Injury	Minor Injury	PDO	TOTAL
Collisions (Adjusted)	43	646	8,639	36,880	46,208
Vehicle Damage Costs					
Demolished	$920,780	$5,489,032	$36,702,593	$19,419,494	$59,787,384
Severe Damage	$136,506	$4,631,509	$61,937,465	$78,310,010	$122,825,831
Moderate Damage	$45,479	$1,539,787	$30,887,514	$113,736,359	$135,913,301
Light Damage	$8,406	$166,537	$4,454,223	$34,934,829	$39,730,533
No Damage	$0	$0	$0	$0	$0
TOTAL COST	**$1,111,171**	**$11,826,865**	**$133,981,795**	**$246,400,692**	**$358,257,049**
AVERAGE COST	**$25,841**	**$18,308**	**$15,509**	**$6,681**	**N/A**

5.1.2 Auto-Insurance Administration Costs

An estimate for the average auto insurance administration was also obtained, which is based on an assumed level of auto insurance administration effort that is associated with vehicle damage. The range of auto insurance administration costs for property damage assumed for the collision cost model is listed below.

- Demolished Vehicle: $2,177 per vehicle
- Severe Damage: $875 per vehicle
- Moderate Damage: $248 per vehicle
- Light Damage: $27 per vehicle

In addition to auto insurance administration costs for property damage, there are also administration costs for injuries. The administration costs for injuries (and fatal collisions) are assumed to be linked to the collision severity level. The range of auto insurance administration costs for injuries and fatalities is listed below.

- Major Injury and Fatal: $2,177 per incident
- Minor Injury: $875 per incident

The total and average auto insurance administration costs for vehicle damage and injuries are shown in Table 5.5 for collision severity classification 1 and Table 5.6 for collision severity classification 2 (victim).

5.1.3 Out-of Pocket Expense Costs

Literature on collision costs discusses out-of-pocket expenses that a person may incur that are beyond what is covered by their auto insurance, including such things as the insurance deductable of the at-fault party, expenses not claimed under insurance (for low dollar value of total claim) and for un-insured drivers. Based on the 1993 General Social Survey by Statistics Canada and cited in the Transport Canada report by Vodden et al, average out-of-pocket expense was estimated to be $719, which was inflated to $1,051 to obtain current dollars. The amount of out-of-pocket expenses was linked to the level of vehicle damage, such that a demolished vehicle would have more out-of-pocket expenses than a vehicle with minimal damage.

The total and average out-of-pocket costs are shown in Table 5.7 for collision severity classification 1 and Table 5.8 for collision severity classification 2 (victim).

Table 5.5: Auto Insurance Administration Costs by Collision Severity (Classification 1) the Capital Region

Collision Type	Collision Severity (Classification 1)			
	Fatal	Injury	PDO	TOTAL
Collisions (Adjusted)	42	6,882	39,284	46,208
Vehicles Damage / Injury Level				
Demolished	$46,039	$1,972,355	$970,975	$2,989,369
Severe Damage	$3,413	$1,109,483	$1,957,750	$3,070,646
Moderate Damage	$568	$276,643	$1,421,704	$1,698,916
Light Damage	$84	$47,873	$349,348	$397,305
Major Injury	$42,930	$581,748	$0	$624,678
Minor Injury	$46,071	$4,130,862	$0	$4,176,932
TOTAL COST	$139,105	$8,118,965	$4,699,778	$12,957,847
AVERAGE COST	**$3,312**	**$1,180**	**$120**	**$280**

Table 5.6: Auto Insurance Administration Costs for Collision Severity by Victim (Classification 2) for the Capital Region

Collision Type	Collision Severity by Victim (Classification 2)				
	Fatality	Major Injury	Minor Injury	PDO	TOTAL
Collisions (Adjusted)	43	646	8639	36880	46208
Vehicles Damage					
Demolished	$46,039	$274,452	$1,835,130	$970,975	$3,126,595
Severe Damage	$3,413	$115,788	$1,548,437	$1,957,750	$3,625,387
Moderate Damage	$568	$19,247	$386,094	$1,421,704	$1,827,614
Light Damage	$84	$1,665	$44,542	$349,348	$395,640
Major Injury	$42,930	$581,748	N/A	$0	$624,678
Minor Injury	$46,071	N/A	$4,130,862	$0	$4,176,932
TOTAL COST	$139,105	$992,900	$7,945,064	$4,699,778	$13,776,847
AVERAGE COST	**$3,235**	**$1,537**	**$920**	**$120**	**$283**

Table 5.7: Out-of-Pocket Expense Costs by Collision Severity for Capital Region

Collision Type	Collision Severity by Collision			
	Fatal	Injury	PDO	TOTAL
Collisions (Adjusted)	42	6,882	39,284	46,208
Vehicles Damage / Injury Level				
Demolished	$44,457	$1,904,570	$937,604	$2,886,631
Severe Damage	$7,379	$2,398,889	$4,232,985	$6,639,253
Moderate Damage	$2,896	$1,409,352	$7,242,839	$8,655,087
Light Damage	$818	$465,758	$3,398,821	$3,865,397
TOTAL COST	$55,549	$6,178,568	$15,812,250	$22,046,367
AVERAGE COST	**$1,323**	**$898**	**$403**	**$477**

Table 5.8: Out-of-Pocket Expense Costs for Collision Severity by Victim for Capital Region

Collision Type	Collision Severity by Victim				
	Fatality	Major Injury	Minor Injury	PDO	TOTAL
Collisions (Adjusted)	43	646	8639	36880	46208
Vehicles Damage					
Demolished	$44,457	$265,019	$1,772,060	$937,604	$2,886,631
Severe Damage	$7,379	$250,353	$3,347,980	$4,232,985	$6,639,253
Moderate Damage	$2,896	$98,055	$1,966,946	$7,242,839	$8,655,087
Light Damage	$818	$16,202	$433,353	$3,398,821	$3,865,397
TOTAL COST	$55,549	$629,629	$7,520,339	$15,812,250	$22,046,367
AVERAGE COST	**$1,292**	**$975**	**$871**	**$429**	**$520**

5.1.4 Towing

A sampling of towing companies and a review of the literature determined that an average tow charge of $400 could be used for the collision cost model, which includes processing and storage fees. Estimates for the percentage of vehicles requiring a tow were based on the collision severity level and are based on information provided in the previously noted report by Vodden et al for Transport Canada. The following tow rates were used together with the vehicle damage rates (Table 5.2) to generate an estimate of the tow costs, using the vehicle damage. Total and average tow costs are shown in Table 5.9 for collision severity classification 1 and Table 5.10 for collision severity classification 2 (victim).

Fatal collision: Requires a tow 86% of the time
Injury collision: Requires a tow 63% of the time
PDO collision: Requires a tow 46% of the time

Table 5.9: Towing Costs for Collision Severity by Collision for the Capital Region

Collision Type	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Collisions (Adjusted)	42	6,882	39,284	46,208
Vehicle Needing a Tow	63	10084	30571	40719
TOTAL COST	$25,270	$4,033,799	$12,228,378	$16,287,447
AVERAGE COST	**$602**	**$586**	**$311**	**$352**

Table 5.10: Towing Costs for Collision Severity by Victim for the Capital Region

Collision Type	Collision Severity by Victim				
	Fatal	Major Injury	Minor Injury	PDO	TOTAL
Collisions (Adjusted)	43	646	8639	36880	46208
Vehicle Needing a Tow	63	827	10893	30571	41053
TOTAL COST	$25,270	$330,705	$4,357,045	$12,289,520	$16,481,007
AVERAGE COST	**$588**	**$512**	**$504**	**$333**	**$368**

5.2 Emergency Response Costs

There are several elements to the emergency response costs that are associated with collisions, including police costs, fire and rescue costs, ambulance costs, and coroner costs for fatal collisions. Each of these elements is described below, including the assumptions that were made in generating the cost estimates.

5.2.1 Police Costs

The estimates for the police costs are based on previous work completed by Edmonton's Office of Traffic Safety (OTS)[8] and some additional information from Transport Canada. The OTS examined the amount of time required to respond and attend to a collision, the type of response unit required and the estimated costs. This information was used for attended collisions only (i.e., the information was obtained directly from Edmonton Police Service (EPS) and not from the collision report). Information from Transport Canada was used for police costs associated with non-attended collisions or self-reported collisions (i.e., report taken at the station).

Using EPS data from January 2007, OTS generated the following information for the effort related to collision response.

Attendance Rate:	Events
- Attended by EPS:	1009
- Community Stations:	828
- Divisional Stations:	420

Attended by EPS:	Calls	Persons	Time (hrs)	Cost ($)
- 1 Person Patrol:	1097	1097	1452	$238,936
- 2 Person Patrol:	540	1080	1598	$262,060
- 1 Person Traffic:	64	64	185	$30,473
- 2 Person Traffic:	5	10	29	$4,761
- Special Unit:	75	75	6	$916

[8] Collision Profile for January 2007 using Edmonton Police Service (EPS) Dispatch Information from the Office of traffic Safety from January 2007.

Using this data, an average hourly rate of $164.57 was calculated for police attended collisions, which is used to determine police costs. A rate of $42.23 is used for non-police attended collisions.

Several assumptions were made to assign police resources by the different collision severity levels. These assumptions and results are provided in Table 5.11.

Table 5.11: Police Costs for Capital Region

Emergency Response Resource:	Collision Severity Classification				
	Fatal	Injury (All)	Major Injury	Minor Injury	PDO
Police Attended					
Attendance Rate	100%	50%	100%	40%	33%
Average Staff Attending	5	4	5	3	2
Average Attendance Time	1.67	0.48	0.88	0.46	0.19
Police-Hours	11.00	2.92	5.38	2.83	1.38
Administration Time	8.25	1.46	3.36	1.42	0.35
Court / Preparation Time	16.50	1.46	5.38	1.42	0.00
Total Resources / Incident	35.75	5.84	14.11	5.67	1.73
TOTAL HOURS:	1501	18096	3040	16328	30494
TOTAL COST:	$247,108	$3,308,955	$1,11,821	$2,388,612	$3,680,276
Self-Reported					
Attendance Rate	0%	50%	0%	60%	67%
Staff Attending	1	1	1	1	1
Attendance Time	2.67	2.67	2.67	2.67	2.67
Total Resources / Incident	2.67	2.67	2.67	2.67	2.67
TOTAL HOURS:	0	10100	0	9397	57651
TOTAL COST:	$0	$387,766	$0	$432,945	$2,966,032
TOTAL (Attended + Self Reported)					
TOTAL COST:	$247,108	$3,696,7212	$1,11,821	$2,821,557	$6,646,308
AVERAGE COST:	$5,884	$537	$2,322	$441	$169

5.2.2 Fire / Rescue and Ambulance Costs

The OTS also provided information on the level of effort for fire / rescue costs and ambulance costs, which are associated with fatal and injury collisions only. The information provided was for the month of January, which was factored up for the entire year. It is interesting to note that the estimated costs for fire / rescue and ambulance for a serious injury collision can be higher than the costs for a

fatal collision, which is contrary to most other costs but seems intuitively correct because of the emergency actions required with this type of incident.

The fire and rescue / ambulance data obtained from OTS is as follows, with the costs inflated to current values:

Attended:	Calls	$/unit	Cost ($)	Rate (%)
- Ambulance:	310	$365	$110,980	30.7
- Fire (pumper):	338	$334	$110,526	33.5
- Fire (aerial):	43	$667	$28,122	4.3

Several assumptions were made to develop the collision cost estimates for both ambulance, and for fire and rescue. These assumptions are provided in Table 5.12 for the different collision severity classifications. The total and average costs are also provided in Table 5.12.

Table 5.12: Fire and Rescue / Ambulance Costs for Capital Region

Emergency Response Resource:	Collision Severity Classification				
	Fatal	**Injury (All)**	**Major Injury**	**Minor Injury**	**PDO**
Ambulance Attended					
Attendance Rate	75%	30%	95%	20%	0%
Events Attended	32	2096	1670	425	0
Severity Factor	2.00	2.00	4.0	1.5	0.0
Unit Cost	$365.16	$365.16	$365	$365	$365
TOTAL COST:	$23,005	$1,530,601	$2,438,663	$233,041	$0
AVERAGE COST:	$548	$222	$3,775	$27	$0
Fire and Rescue Attended (Pumper)					
Attendance Rate	75%	30%	95%	20%	0%
Events Attended	32	2288	614	1728	0
Severity Factor	2.0	2.0	4.0	1.0	0.0
Unit Cost	$334	$334	$334	$334	$334
TOTAL COST:	$21,013	$1,526,237	$818,774	$576,290	$0
Fire and Rescue Attended (Aerial)					
Attendance Rate	10%	4%	12%	3%	0%
Events Attended	4	291	244	47	0
Severity Factor	2.0	4.0	8.0	4.0	0
Unit Cost	$667	$667	$667	$667	$667
TOTAL COST:	$5,347	$388,333	$1,300,852	$125,984	$0
AVERAGE COST:	$626	$278	$3,281	$81	$0

5.2.3 Coroner / Medical Examiner Expenses (Fatal Collisions only)

The final element that is included in the category of emergency response costs is the costs associated with the Coroner's (or Medical Examiner's) office. Obviously, these costs are only associated with fatal collisions. Some assumptions on the wages for coroners and the amount of time required to attend and respond to fatal collisions were made to generate the estimate for coroner costs. Ideally, it would be beneficial to obtain and use coroner information from the area (i.e., local information), however it is noted that this element of the overall collision cost is considered minor.

The following is a summary of the estimate that was generated for the costs for the Coroner / Medical Examiner.

- Attendance Rate:	100%
- Number Attended:	44 fatalities
- Resources (hours):	24
- Hourly Rate:	$73.76 ($55/hr + 34% benefits)
- Operating Factor:	2.3
- TOTAL Cost:	$77,449
- Average Cost:	= $1,844 / fatal collision
	= $1,770 / fatality

5.3 Health Services Costs

Health services costs make up a considerable proportion of the overall direct costs. There are several components to consider: emergency department costs, intensive care unit costs (ICU), acute care hospital costs, rehabilitation costs and long-term care costs. Note that the costs related to home care, community services, and assisted living, were *not* factored into this costing approach. Each of the health care components is presented, including the assumptions and values used to generate the estimates associated with collisions.

The health services costs presented in this section of the report are associated with fatal and injury collisions. There will not be any health services costs associated with PDO collisions. Similar to previous sections, the health services costs are reported by severity of the collision (classification 1) and by the victim injury (classification 2).

5.3.1 Emergency Department Costs

The following assumptions were used to estimate the number of visits to an emergency department resulting from a collision. It should be noted that the following assumptions are based on input from Alberta Health Services:

- 50% of fatal collisions visit an emergency department, noting that not all fatal collisions result in someone dying at the site. Some victims die later, either at the emergency department or after admission to an intensive care unit;
- 100% of major injury collisions are assumed to require a trip to the emergency department;
- 75% of minor injury collisions are assumed to require a trip to the emergency department.

The average cost of an emergency room (ER) visit was estimated to be $231. This is the per-visit amount used by the Alberta Health Care Insurance Plan for billing out-of-province or un-entitled patients [9]. This information is based on a review of the costs associated with outpatient and emergency services, and is a conservative baseline estimate that does not include additional specialized services such as CT scans and medication. The number reflects the basic costs of processing an individual person visiting the ER, and would apply across the injury severity spectrum.

Using information from Table 4.5, together with the information described above, an estimate for the total and average cost of emergency department visits can be determined. The results are summarized in Table 5.13.

Table 5.13: Emergency Department Costs for Capital Region

Emergency Department Costs:	Collision Severity Classification				
	Fatal	Injury	Fatalities	Major Injuries	Minor Injuries
Collisions / Victims (Table 4.5):	42	6882	43	646	8639
Percent requiring ED Visit:	50%	100%	50%	100%	75%
Unit Cost For Emergency:	$231	$231	$231	$231	$231
TOTAL COST:	$44,677	$2,397,188	$44,677	$205,747	$2,191,441
AVERAGE COST:	$1,064	$348	$1,039	$318	$254

[9] Alberta Health and Wellness, 2008. Ministerial Order #26/2008. Office of the Deputy Minister of Alberta Health and Wellness.

5.3.2 Intensive Care Unit (ICU) Costs

The ICU Care costs were estimated in a similar manner as the emergency department costs. The following assumptions were used to estimate the ICU costs resulting from a collision. Note that again, the following assumptions are based on input from Alberta Health Services.

- 50% of the victims from a fatal collision will be transferred to an ICU after visit to emergency;
- Time spent in an ICU before death occurs (for a fatal collision) is assumed to be an average of 8.0 days;
- 100% of the major injury collisions will be transferred to an ICU after visit to the emergency department;
- Time a major injury collision victim spends in an ICU is assumed to be an average of 4.7 days;
- Minor injury collisions are assumed to not require any time in an ICU.

The average cost of an intensive care unit is estimated to be $4,049 per day. This per diem amount for intensive care used by the Alberta Health Care Insurance Plan for billing out-of-province or un-entitled patients [10].

Using the frequency of collision fatalities and injuries from Table 4.5, together with the information described above, an estimate for the total and average cost for the ICU component can be determined. The results are summarized in Table 5.14.

Table 5.14: ICU Care Costs for Injured Victims (Capital Region)

Intensive Care Unit (ICU) Costs:	Collision Severity Classification				
	Fatal	Injury	Fatalities	Major Injuries	Minor Injuries
Collisions / Victims (Table 4.5):	42	6882	43	646	8639
Percent requiring ICU:	50%	100%	50%	100%	0%
Time Spent in ICU (days):	8.0	4.7	8.0	4.7	0
Unit Cost/day for ICU:	$4,049	$4,049	$4,049	$4,049	$4,049
TOTAL COST:	$1,972,757	$17,130,195	$1,972,757	$17,130,195	$0
AVERAGE COST per collision:	$46,970	$2,489	$45,878	$26,517	$0

[10] Alberta Health and Wellness, 2008. Ministerial Order #26/2008. Office of the Deputy Minister of Alberta Health and Wellness.

5.3.3 Acute Care Hospital Costs

In this section, the term "acute care hospital" refers to the care delivered in a typical hospital unit, but not in an intensive care setting. The acute care costs were estimated according to the number of injury victims requiring this level of care, and the time required for recovery. The following assumptions were used to estimate the acute care costs, based on input from Alberta Health Services:

- 0% of fatal collision casualties will spend time in acute care;
- 100% of the major injury collision casualties will spend time in acute care;
- Time that a major injury collision victim spends in acute care is assumed to be an average of 4.7 days;
- Minor injury collision casualties are assumed to not require any time in an acute care.

The average cost per day of acute (non ICU) care is estimated to be $1,261. This per diem amount for intensive care used by the Alberta Health Care Insurance Plan for billing out-of-province or un-entitled patients [11].

Using the frequency of collision fatalities and injuries from Table 4.5, together with the assumptions described above, an estimate for the total and average cost of the acute care length of stay can be determined (Table 5.15).

Table 5.15: Acute Care Hospital Costs for Injured Victims (Capital Region)

Acute Care Hospital Costs:	Collision Severity Classification				
	Fatal	**Injury**	**Fatalities**	**Major Injuries**	**Minor Injuries**
Collisions / Victims (Table 4.5):	42	6882	43	646	8639
Percent requiring Acute Care:	0%	100%	0%	100%	0%
Time Spent in Acute Care (days): (Major Injuries linked to a fatal)	4.7	4.7	0	4.7	0
Unit cost/day for Acute Care:	$1,261	$1,261	$1,261	$1,261	$1,261
TOTAL COST:	$393,693	$5,334,941	$393,693	$5,334,941	$0
AVERAGE COST:	$9,374	$775	$9,156	$8,258	$0

[11] Alberta Health and Wellness, 2008. Ministerial Order #26/2008. Office of the Deputy Minister of Alberta Health and Wellness.

5.3.4 Rehabilitation Costs

Rehabilitation encompasses a wide range of services and varies according the facility or region in which they are delivered. In the Capital Region, rehabilitation generally includes: physical therapy, occupational therapy, speech language therapy and audiology. For people who require intensive and longer term rehabilitation, rehabilitation services may also include services of psychologists and social workers to assist with the return to community living.

To estimate the costs for this study, the consultants obtained data from Alberta Health and Wellness (AHW), Canadian Institute for Health Information (CIHI), and from rehabilitation experts in Alberta. The economic costing methodology is based on the research of Miller and others.[12] While Miller's work is based on the American health system and insurance data, his approach provides a reasonable estimate for individuals who may become disabled as a result of a collision.

The definition of "disability" for costing purposes is usually based on policy guidelines of workers' compensation boards and insurance agencies. The definitions used by Miller are similar to terms used by the Workers' Compensation Board of Alberta.[13] Disability refers to *a restriction in the ability to work for pay or around the home*. [14] The extent to which the disability is partial or total is determined by a physician's assessment and specific medical guidelines. *Permanent total disability* refers to a condition which results in a complete and permanent loss of earning power. *Permanent partial disability* refers to a condition which results in partial recovery, along with a return to some form of employment.[15]

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[12] Miller T, et. al., Data-book on Non-Fatal Injury Incidence Costs and Consequences, The Urban Institute Press, Washington D.C., 1995. p. 26.

[13] Workers' Compensation Board of Alberta. Policy manual [Online].2003 [cited 2010 Jan 7]; Available from: http://www.wcb.ab.ca/public/policy/manual/0404p1.asp

[14] Miller T, et. al. Data-book on Non-Fatal Injury Incidence Costs and Consequences, The Urban Institute Press, Washington D.C., 1995. p. 26.

[15] Ibid.

According to Miller's work, the probability of total and partial disability by collision severity level is estimated as follows:

Incidence of Permanent Disability[16]

Injury Level	TOTAL	PARTIAL
- Major Injury	0.0162	0.1493
- Minor Injury	0.0009	0.0173

Using this information, an estimate of the number of persons that will become permanently disabled, either totally or partially can be calculated for the Capital Region.[17]

Table 5.16: Estimated Number of Victims with Permanent Disabilities (Capital Region)

Disability by Injury Level	Collision Severity Level		
	Fatal	Injury	Total
Injury Level (Raw Data)			
Major	66	891	956
Minor	141	12649	13746
TOTAL	207	13540	13746
No. of Victims with TOTAL Disability			
Major	1.06	14.43	15.49
Minor	0.13	11.38	11.51
TOTAL	**1.19**	**25.81**	**27.00**
No. of Victims with PARTIAL Disability			
Major	9.81	132.98	142.79
Minor	2.44	218.83	221.27
TOTAL	**12.25**	**351.81**	**364.06**

Utilization data for health service areas outside of the acute care hospital are not easily accessed nor is the data linked. In addition, rehabilitation services delivered in the community are funded and provided through many sources, thus the data for outpatient, follow up rehabilitation are not available. This section estimates the rehabilitation services provided in the early stage of recovery of injured victims.

Assumptions about representative patient groups were made to determine the services required injured victims. Patients or victims sustaining injuries to the brain or spinal cord would have the highest probability of permanent *total* disability.

[16] Ibid, pp. 114-115.

[17] The likelihood of a total or partial permanent disability resulting from a minor collision is unlikely given the definition of minor injury in Alberta, however, the calculations were performed to be consistent with the reference used.

Victims who sustain serious orthopedic injuries, such as fractures, would have a likelihood of *partial* permanent disability. Using these assumptions, we can estimate the level of rehabilitation services that are required by injured victims to attain some functional recovery (but not necessarily independence). Note that these service costs would ***not*** include the cost of wheelchairs or other aids to daily living.

- Permanent totally disabled collision injury victims are assumed to require
  - 43 days of acute rehabilitation in a specialized hospital/facility
- Permanent partially disabled collision injury victims are assumed to require:
  - 19 days of rehabilitation in a specialized hospital/facility
- The rehabilitation hospital/facility cost is $972 per day.

Median length of stay hospital data was obtained from the Rehabilitation Database of Canadian Institute of Health Information (CIHI)[18] and confirmed by Alberta Health Services rehabilitation experts. The estimates for rehabilitation facility costs were obtained from Alberta Health and Wellness[19].

Using the frequency of collision fatalities and injuries from Table 4.5, together with the information described above, an estimate can be determined for the total and average costs of service provided in a rehabilitation hospital.

Table 5.17: Rehabilitation Costs by Collision Severity (Capital Region)

Rehabilitation (Hospital) Costs:	Collision Severity Classification				
	Fatal	Injury	Fatalities	Major Injuries	Minor Injuries
Collisions/Victims (From Table 4.5):	42	6882	43	646	8639
No. of victims totally disabled :	1.19	25.81	1.19	14.43	11.38
No. of victims partially disabled:	12.25	351.81	12.25	132.98	218.83
Unit cost/day for Rehab Hospital:	$972	$972	$972	$972	$972
TOTAL COST:	$275,970	$7,575,982	$275,970	$3,058,991	$4,516,991
AVERAGE COST by collision:	**$6571**	**$1101**	**$6418**	**$4735**	**$523**

[18] National Rehabilitation Reporting System, CIHI. Median Length of Stay for Inpatient Rehabilitation Clients by RCG, 2007-2008. Retrieved January 14, 2010. from: http://www.cihi.ca/cihiweb/ dispPage.jsp?cw_page=statistics_source_e

[19] Alberta Health and Wellness, 2008. Ministerial Order #26/2008. Office of the Deputy Minister of Alberta Health and Wellness.

5.3.5 Long-Term Care Costs

Similar to the cost of rehabilitation, the long-term care costs are based on the proportion of persons that are disabled as a result of a motor vehicle collision. Long-term care includes the medical, nursing and supportive care that is delivered within a designated facility. To estimate the time spent in long-term care, information was obtained by using life-expectancy tables and selecting an average life expectancy at the time of a collision (28.8 years, which is described further in Section 5.6 of this report). The assumptions used in generating the estimate of long-term care costs are as follows:

- Totally disabled (permanent) collision injury victims will require long-term care 365 days per year;
- Partially disabled (permanent) collision injury victims will not require long-term care;
- Average life expectancy at time of collision is 28.8 years;
- A net present value factor of 0.187 is used for long-term costs, based on a discount rate of 6% and 28.8 years (i.e., i=6% and n=28.8).

The average daily cost for long-term care is estimated to be $343 per day, according to data provided by Alberta Health and Wellness. The total estimated costs for victims who require long-term care as a result of motor vehicle collisions is provided below.

Table 5.18: Long-term Care Costs for Disabled Victims

Long-Term Care Costs:	Collision Severity Classification				
	Fatal	**Injury**	**Fatalities**	**Major Injuries**	**Minor Injuries**
Collisions (From Table 4.5):	42	6882	43	646	8639
No. of Victims Totally Disabled:	1.19	25.81	1.19	14.43	11.38
Life Expectancy (years):	28.8	28.8	28.8	28.8	28.8
Long-term care days / year:	365	365	365	365	365
Net Present Value factor:	0.187	0.187	0.187	0.187	0.187
Unit Cost /day For Long-Term Care:	$343	$343	$343	$343	$343
TOTAL COST:	$802,187	$17,375,160	$802,187	$9,712,356	$7,662,804
AVERAGE COST:	$19,100	$2,525	$18,656	$15,035	$887

5.4 Legal Costs

There are several elements of legal costs associated with collision costs. Included in the collision cost model are costs associated with correctional services, court costs, legal costs, and funeral costs (for fatal collisions only). Each collision cost element is discussed in this section, including the assumptions and data used to generate the cost estimate.

5.4.1 Cost of Corrections

The costs associated with corrections includes the operating expenditures for federal and provincial correctional facilities and related costs such as probation services that are related to the justice issues associated with the occurrence of a motor vehicle collision. The costs of corrections are based on information from Statistics Canada[20] that provides a proportion of corrections costs in relation to the cost of policing.

Table 5.19: Justice Spending in Canada [13]

Justice Spending	Percent of Total Spending	Percent of Total Police Spending
Police	61%	N/A
Corrections	22%	22 / 61 = 36.1%
Courts	9%	9 / 61) = 14.8%
Legal Aid	5%	5 / 61 = 8.2%
Prosecution	3%	3 / 61 = 4.9%

Using the proportions of justice expenditures shown in Table 5.19 and the estimated police costs determined in Section 5.2.1, an estimate for corrections costs is determined using the following assumptions:

- 50% of fatal incidents and major injury incidents will require corrections;
- 15% of injury collisions will require corrections;
- 5% of minor injury collisions will require corrections
- 0% of PDO collisions will require corrections.

Using the frequency of collisions from Table 4.5, the assumptions listed above, the police costs from Section 5.2.1 and the proportion of justice spending (Table

[20] JURISTAT: Canadian Centre for Justice Statistics of Canada, Catalogue No. 85-002-XE, Volume 19, No. 12.

5.19), an estimate for the total and average cost for correctional services can be obtained. The results from this analysis are summarized in Table 5.20.

Table 5.20: Correctional Services Costs

Correctional Services Costs	Collision Severity Classification					
	Fatal	**Injury**	**PDO**	**Fatalities**	**Major Injuries**	**Minor Injuries**
Collisions (From Table 4.5):	42	6882	39284	43	646	8639
% Requiring Corrections:	50%	15%	0%	50%	50%	5%
Police Costs (Table 5.11):	$247,108	$3,720,974	$6,646,308	$252,992	$1,500,037	$3,806,765
Justice Costs (% of Police):	36.07%	36.07%	36.07%	36.07%	36.07%	36.07%
TOTAL COST:	$44,560	$335,498	$0	$45,621	$270,498	$343,233
AVERAGE COST:	**$1,061**	**$29**	**$0**	**$1,061**	**$419**	**$8**

5.4.2 Court Costs

Court expenditures involve all operating costs for the court system, including salaries and benefits for judges and support staff and the overall operation of the courts system. The court costs are determined in a similar manner as the cost of corrections. Court costs represent 14.7% of the total policing costs and it is assumed that the same proportion of incidents as listed above will require court costs (i.e., 50% for fatal and major injury, 15% for injury, 5% for minor injury and 0% for PDO collisions). The results that were generated to produce an estimate of court costs related to collisions are summarized in Table 5.21.

Table 5.21: Court Costs

Court Costs	Collision Severity Classification					
	Fatal	**Injury**	**PDO**	**Fatalities**	**Major Injuries**	**Minor Injuries**
Collisions (From Table 4.5):	42	6882	39284	43	646	8639
% Requiring Court:	50%	15%	0%	50%	50%	5%
Police Costs (Table 5.11):	$247,108	$3,720,974	$6,646,308	$252,992	$1,500,037	$3,806,765
Justice Costs (% of Police):	14.8%	14.8%	14.8%	14.8%	14.8%	14.8%
TOTAL COST:	$18,229	$137,249	$0	$18,663	$110,658	$140,413
AVERAGE COST:	$434	$12	$0	$434	$171	$3

5.4.3 Legal Aid and Prosecution Costs

Legal aid includes payments to private law firms and legal aid staff for the provision of legal advice and representation in criminal matters associated with motor vehicle collisions. Legal aid and prosecution costs are also determined in a similar manner as the correctional and court costs. The legal aid and prosecution costs represent 13.1% of the total policing costs, and again it is assumed that the same proportion of incidents as listed above will require legal aid and prosecution costs (i.e., 50% for fatal and major injury, 15% for injury collisions, 5% for minor injury and 0% for PDO collisions).

The results that were obtained to produce an estimate of the cost of legal aid and prosecution are summarized in Table 5.22.

Table 5.22: Legal Aid and Prosecution Costs

Legal Aid and Prosecution Costs	Collision Severity Classification					
	Fatal	**Injury**	**PDO**	**Fatalities**	**Major Injuries**	**Minor Injuries**
Collisions (From Table 4.5):	42	6882	39284	43	646	8639
% Legal Aid / Prosecution:	50%	15%	0%	50%	50%	5%
Police Costs (Table 5.11):	$247,108	$3,720,974	$6,646,308	$252,992	$1,500,037	$3,806,765
Justice Costs (% of Police):	13.1%	13.1%	13.1%	13.1%	13.1%	13.1%
TOTAL COST:	$16,204	$121,999	$0	$16,590	$98,363	$124,812
AVERAGE COST by collision:	$386	$11	$0	$386	$152	$3

5.4.4 Funeral Costs

The final miscellaneous cost associated with a collision is the cost of funerals, which obviously only applies to fatal collisions. It is assumed that 75% of persons involved in a fatal collision will have a traditional funeral, which includes the various elements of the funeral process (services, casket, funeral plot, etc.), while the other 25% of fatal collision victims will choose to be cremated, which results in a reduction in the costs when compared to a traditional funeral.

A simple web-based review of a sample of funeral homes and costs was completed to establish an estimate for the cost of a funeral. There are several

elements associated with funeral costs as listed below, together with the associated costs:

-	Professional services:	$2800
-	Casket:	$2600
-	Protective Liner:	$300
-	Cemetery Plot:	$800
-	Plot Preparation:	$700
-	Monument / Headstone:	$1700
-	Plaque:	$800
-	Music for Service:	$200
-	Funeral Preparation:	$200
-	Funeral Notices:	$200
-	Flowers:	$200
	TOTAL	**$10,500**

It is estimated that the average cost for a traditional funeral is approximately $10,500. The cost of cremation is assumed to be 25% of the cost of a traditional funeral, or $2,625. Therefore, the total funeral costs is estimated to be $373,272 and the average cost per fatal collision is $8,887 while the average cost per fatality is $8,741.

5.5 Travel Delay Costs

A significant proportion of the total direct cost of collisions includes costs that are associated with traffic delay, extra fuel consumption, and the increase in air pollution. Local information on the traffic delay costs was not available so a series of assumptions were made to develop an estimate of traffic delay, fuel use and pollution costs, which are described in the following sections.

5.5.1 Traffic Delay Costs

The first step in estimating the cost of traffic delay involved developing assumptions for the average vehicle delay per collision severity type. Obviously the range of delay per incident type can be considerable, but the following delay values are considered typical average delays.

The following average traffic delays per collision severity type were used for the analysis:

- Average delay for a fatal collision = 1.67 hours
- Average delay for a major injury collision = 0.88 hours
- Average delay for a minor injury collision = 0.46 hours
- Average delay for a injury collision = 0.49 hours
- Average delay for a PDO collision = 0.19 hours

The next step was to estimate the number of vehicles that would be affected in the event of a collision, which was estimated based on the time of day and the type of roadway (local, arterial, etc.). This information was available from the Institute of transportation Engineers (ITE), Traffic Engineering Handbook [21]. The ITE handbook provided an hourly distribution of traffic patterns for typical urban environments, showing traffic peaks in the morning and afternoon time periods. The handbook also provided a theoretical capacity of the different types of roadways, which was used as a guideline for estimating the amount of traffic affected. The following traffic volume capacity levels (disaggregated by road classification) were used in the analysis.

- Local road = 1200 vehicles per hour
- Collector Road = 2200 vehicles per hour
- Arterial Roadway = 4000 vehicles per hour
- Expressway Road: = 6000 vehicles per hour

The hourly distribution of the collision data from the Capital Region was then obtained from the Office of Traffic Safety, which was disaggregated by collision severity level. Using this information together with the average delay (by collision severity) and the traffic distribution, it was possible to calculate the average amount of delay (in hours) by hour of the day and by collision severity level, recognizing that this is a calculated value and not a measured value (i.e., data for the level of delay was not available). This ranged from 1.67 hours for a fatal collision during rush hour (e.g., 1700 hours), to virtually zero delay caused by a PDO collision that occurs in the early hours of a morning (e.g., 0300 hours).

[21] Traffic Engineering Handbook, 4th Edition, Institute of Transportation Engineers, Prentice-Hall, 1992.

The next step was to estimate the number of persons that are affected in a delayed vehicle. A vehicle occupant multiplier based on the time of day was used, which ranged from 1.10 during morning commuter traffic to 1.40 during off-peak travel periods. The percent of work trips and non-work trips were also estimated based on the time of day in which travel is occurring. For example, more work trips occur during the morning and afternoon rush hours than compared to midday traffic. Finally, the time value of work trips and non-work trips was estimated. The value of a work trip is estimated to be $23.90/hour and a non-work trip is estimated to have a value of $11.95 (50% of the work trip).

Using all of this information, an estimate for traffic delay caused by the different collision severity types can be calculated. The results for the cost of traffic delay are as follows:

- Fatal Collisions: $16,903
- Injury Collisions: $4,926
- PDO Collisions: $1,937
- Major Injury Collisions: $8,874
- Minor Injury Collisions: $4,648

5.5.2 Extra Fuel Consumption Costs

The extra fuel consumption costs was based on the amount of traffic delay that was estimated in the preceding section. In addition to the vehicle delay, it is assumed that the fuel consumption rate was 3.25 liters per hour, which is based on information from Vodden et al in the Ontario Study[22]. Also used in the estimate of fuel consumption is the average cost of fuel, which was assumed to be $0.85 / liter.

The results for the cost of extra fuel consumption are as follows:

- Fatal Collisions: $2,069
- Injury Collisions: $603
- PDO Collisions: $236
- Major Injury Collisions: $1,086
- Minor Injury Collisions: $569

[22] Vodden, K, Smith, D, Eaton, F and Mayhew, D. Analysis and Estimation of the Social Cost of Motor Vehicle Collisions in Ontario, Transport Canada, August 2007.

5.5.3 Extra Pollution Costs

The final component of traffic delay costs is the environmental impact caused by an increase in vehicle emissions and pollution. There are several components to the additional pollution caused by traffic delay, with the greatest share of emissions made by carbon dioxide (CO_2). Other key motor vehicle pollutants that cost society include hydro carbons (HC), carbon monoxide (CO) and nitrous oxides (NO_x).

Similar to the calculation for extra fuel consumption, the overall traffic delay that was calculated previously is used to calculate the cost of extra pollution. It is assumed that a pollution rate of 245 kg per hour per vehicle (comprehensive value including all pollutants) is directly linked to traffic delay. Furthermore, it is assumed that pollution costs a total of $70 per tonne ($0.07/kg). The estimates for the additional pollution costs are as follows:

- Fatal Collisions: $12,843
- Injury Collisions: $3,743
- PDO Collisions: $1,464
- Major Injury Collisions: $6,742
- Minor Injury Collisions: $3,532

5.6 Lost Productivity Costs

The final element that is included in the category of the direct cost of collisions is the short-term loss of productivity in the workplace due to time missed as a result of the collision. This category of collision costs does not include the long-term loss of productivity and the disruption that is caused by permanent disability (partial or total disability).

5.6.1 Lost Productivity Due to Injury Collisions

The basis for the estimate of short-term productivity costs is the number of workdays that are lost before the full recovery of a person involved in an injury collision. To obtain the number of workdays lost, the number of permanently disabled injury victims is subtracted from the total number of persons injured. This data, which was presented earlier for the rehabilitation and long-tem care health costs, is expanded and presented in Table 5.23.

Table 5.23: Estimate of Injured Persons (NO Disability)

Disability by Injury Level	Collision Severity Level		
	Fatal	Injury	Total
Injury Level (Raw Data)			
Major	66	891	956
Minor	141	12649	13746
TOTAL	207	13540	13746
TOTAL Disability			
Major	1.06	14.43	15.49
Minor	0.13	11.38	11.51
TOTAL	1.19	25.81	27.00
PARTIAL Disability			
Major	9.81	132.98	142.79
Minor	2.44	218.83	221.27
TOTAL	12.25	351.81	364.06
INJURED but NO Disability			
Major	55	743	798
Minor	19	12419	12557
TOTAL	**193**	**13162**	**13355**

The estimate of the permanent disability level is based on the work completed by Ted Miller[23], described in chapter 8 of the Data-book on Non-Fatal Injury Incidence Costs and Consequences.

With the estimated number of persons injured but not permanently disabled (totally or partially disabled), it was then necessary to estimate the number of workdays that would be lost as a result of the injuries sustained in a collision. The assumptions used in the Ontario study by Vodden et al [24] for the number of days lost by collision severity category was also used in this study, which are presented below.

- Major Injuries: 45.0 days lost
- Minor Injuries: 6.5 days lost

23 Miller T, et.al. Data-book on Non-Fatal Injury Incidence Costs and Consequences, Urban Institute Press, Washington D.C., 1995.

24 Vodden, K, Smith, D, Eaton, F and Mayhew, D., Analysis and Estimation of the Social Cost of Motor Vehicle Collisions in Ontario, Transport Canada, August 2007.

It is also necessary to estimate the proportion of the population that was in the workforce and the proportion not in the workforce. This workforce breakdown was available from Census Canada and was also cited in the Vodden study:

- 74.4% of the population is engaged in the workforce;
- 25.6% of the population is not in workforce (students, retirees, etc.)

To determine the value of lost workdays relevant to the Capital Region, it is necessary to assume an average wage for those in the workplace. The average wage is based on the 2007 Alberta Wage and Salary Survey [25], which indicated that the average hourly rate was $23.90 based on a typical 8-hour workday. It is also noted that workplace benefits are associated with workdays, which are assumed to be 34.1% of the hourly rate. A summary of the average daily value for workdays is shown below.

- Average daily value for a workday = $256.40

The total lost workdays as a result of injuries sustained in a motor vehicle collision (i.e., short-term injury involving non-permanent disabling injuries) is shown in Table 5.24. Also included in Table 5.24 is the total cost associated with lost workdays.
The results from Table 5.24 are converted into average costs for the various collision severity classifications that are used for this report and the results are shown in Table 5.25.

It is noted that the lost productivity is based on workdays only and that normal activity days (i.e., non-workdays) are not included in the assessment of the short-term lost productivity. It is often argued that these activity days have value and should be included, but this loss is considered more of an intangible cost, which are included in a subsequent chapter of the report that focuses on willingness to pay costs.

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[25] WAGEinfo, 2007 Alberta Wage and Salary Survey, Commissioned by Service Canada, Workers Compensation Board, Employment, Immigration and Industry and Advanced Education and Technology. Refer to website www.alis.gov.bc.ca/wageinfo

Table 5.24: Lost Productivity for Injury Collisions in the Capital Region

Lost Productivity: Injuries	Collision Severity Level		
	Fatal	Injury	Total
INJURED but NO Disability			
Major Injury:	55	743	798
Minor Injury:	19	12419	12557
TOTAL	193	13162	13355
WORK Days Lost			
Major Injury:	1836.4	24884.7	26721.1
Minor Injury:	669.8	60057.3	60727.1
TOTAL	2506.2	84942.0	87448.2
COST of Lost WORK Days			
Major Injury:	$470,844	$6,380,422	$6,851,266
Minor Injury:	$171,738	$15,398,646	$15,570,384
TOTAL	**$642,582**	**$21,779,067**	**$22,421,650**

Table 5.25: Average Lost Productivity for Injury Collisions in the Capital Region

Lost Productivity Due to: Injury Collisions	Collision Severity Classification				
	Fatal	Injury	Fatalities	Major Injuries	Minor Injuries
Collisions (From Table 4.5):	42	6882	43	646	8639
TOTAL Cost (from Table 5.24):	$642,582	$21,779,067	$642,582	$6,851,266	$15,570,384
AVERAGE COST by collision:	$15,300	$3,165	$14,944	$10,606	$1,802

5.6.2 Lost Productivity Due to Fatalities

There will also be some lost productivity in the workplace as a result of persons who are killed in a motor vehicle collision.

The following assumptions were used to determine the lost productivity for fatal collisions, many of which are similar to the assumptions used for lost productivity due to injury collisions:

- 74.4% of the population is engaged in the workforce;
- 25.6% of the population is not in workforce (students, retirees, etc.)
- Average daily value for a workday = $256.40
- Number of work days lost due to a fatality = 20 days

The average lost productivity cost per fatal collision is $3,975 and the average lost productivity cost per fatality is calculated to be $3,882.

5.6.3 Lost Productivity Due to PDO Incidents

There is also some minor work place productivity loss as a result of a PDO collision that is caused by the delay from the incident. The following assumptions were used to determine the lost productivity for PDO collisions, noting that some of the assumptions are similar to the assumptions used for lost productivity due to injury and fatal collisions:

- 74.4% of the population is engaged in the workforce;
- 25.6% of the population is not in workforce (students, retirees, etc.)
- Average daily value for a workday = $256.40
- Number of work days lost due to a PDO collision = 0.25 days (2 hours)

The average lost productivity cost per PDO collision is estimated to be $48.

5.7 Summary of DIRECT Costs for the Capital Region

This chapter of the report has provided the costing approach and the Capital Region data need to calculate the direct costs associated with a motor vehicle collision. The estimated total costs by collision severity level for the Capital Region are listed below.

DIRECT Collision Costs by Collision:

FATAL Collision:	$181,335
INJURY Collision:	$39,524
PDO Collision:	$10,902

DIRECT Collision Costs by Victim:

FATALITY:	$178,499
MAJOR injury:	$113,624
MINOR Injury:	$30,581
PDO Collision:	$11,367

A summary of the six different categories of collision costs, and 23 specific types of collision costs, is presented in Table 5.26: Summary of Direct Collision Costs for the Capital Region.

Table 5.26: Summary of DIRECT Collision Costs for Capital Region

DIRECT Costs of Collisions		Collision Severity Categories (by Victim)				Collision Severity Categories (by Collision)		
		Fatality	Major Injury	Minor Injury	Property Damage	Fatality	Injury	PDO
1	**Property Damage (Vehicle Related)**							
	Vehicle Repairs	$ 25,841	$ 18,308	$ 15,509	$ 6,681	$ 26,456	$ 16,092	$ 6,272
	Auto-Insurance Administration	$ 3,235	$ 1,537	$ 920	$ 127	$ 3,312	$ 1,180	$ 120
	Out-of-Pocket Expenses (Not covered by insurance)	$ 1,292	$ 975	$ 871	$ 429	$ 1,323	$ 898	$ 403
	Towing Services	$ 588	$ 512	$ 504	$ 333	$ 602	$ 586	$ 311
2	**Emergency Response Costs**							
	Police Costs	$ 5,884	$ 2,322	$ 441	$ 169	$ 5,884	$ 541	$ 169
	Fire / Rescue Costs	$ 628	$ 3,281	$ 81	$ -	$ 628	$ 278	$ -
	Ambulance Costs	$ 548	$ 3,775	$ 27	$ -	$ 548	$ 222	$ -
	Coroners Costs (Fatal Only)	$ 1,812	$ -	$ -	$ -	$ 1,770	$ -	$ -
3	**Health Services Costs**							
	Emergency Room Costs	$ 1,039	$ 318	$ 254	$ -	$ 1,064	$ 348	$ -
	ICU Care Costs	$ 45,878	$ 26,517	$ -	$ -	$ 46,970	$ 2,489	$ -
	Acute Care Costs	$ 9,156	$ 8,258	$ -	$ -	$ 9,374	$ 775	$ -
	Rehabilitation Costs	$ 6,418	$ 4,735	$ 523	$ -	$ 6,571	$ 1,101	$ -
	Long Term Care Costs	$ 18,656	$ 15,035	$ 887	$ -	$ 19,100	$ 2,525	$ -
4	**Legal Costs**							
	Correctional Services	$ 1,061	$ 419	$ 8	$ -	$ 1,061	$ 29	$ -
	Court Costs	$ 434	$ 171	$ 3	$ -	$ 434	$ 12	$ -
	Legal Aid and Prosecution	$ 386	$ 152	$ 3	$ -	$ 386	$ 11	$ -
	Funeral Costs (Fatal Only)	$ 8,887	$ -	$ -	$ -	$ 8,741	$ -	$ -
5	**Travel Delay Costs**							
	Delay Costs Caused by Collision	$ 16,903	$ 8,874	$ 4,648	$ 1,927	$ 16,903	$ 4,926	$ 1,927
	Extra Fuel Consumption	$ 2,069	$ 1,086	$ 569	$ 236	$ 2,069	$ 603	$ 236
	Environmental / Pollution Costs	$ 12,843	$ 6,742	$ 3,532	$ 1,464	$ 12,843	$ 3,743	$ 1,464
6	**Productivity / Disruption Costs**							
	Short-Term Work-Place Productivity Costs (Injuries)	$ 14,944	$ 10,606	$ 1,802	$ -	$ 15,300	$ 3,165	$ -
	Short-Term Work-Place Productivity Costs (Fatalities)	$ 3,882	$ -	$ -	$ -	$ 3,975	$ -	$ -
	Short-Term Work-Place Productivity Costs (PDO)	$ -	$ -	$ -	$ 48	$ -	$ -	$ 48
	TOTAL for DIRECT Costs:	**$ 178,499**	**$ 113,624**	**$ 30,581**	**$ 11,367**	**$ 181,335**	**$ 39,524**	**$ 10,902**

6.0 INDIRECT COSTS: HUMAN CAPITAL COSTS

The next category of collision costs that were generated for the collision cost model for the Capital Region are the human capital costs, which is considered an *indirect* collision cost. As stated earlier in this report, the majority of the focus for this assignment was on the direct collision costs that were presented in the preceding chapter. However, in the interest of completeness, an estimate for human capital costs and the willingness to pay costs (to be presented in Chapter 7) will be provided.

There are two categories for the human capital costs associated with collisions, including 1) the discounted future earnings of the persons affected by the collision and 2) the pain, suffering and grief for the individuals that are affected by an injury or fatal collision.

The human capital approach does not explicitly account for the value and enjoyment of a life that is either lost (in the case of a fatality) or a life that is compromised as a result of permanent injuries sustained in a collision. Because of this, it is sometimes suggested that the human capital approach under-estimates the comprehensive cost of collisions. To account for this potential limitation, a pain, suffering and grief component is also used to represent the "human costs".

6.1 Human Capital Costs - Discounted Future Earnings

The discounted future earnings component of the human capital costs involves estimating the present value of earnings that the individual would have made had he/she not been involved in a collision. These are the long-term earnings that a victim would have received if the collision did not occur. It is noted that these are not the short-term productivity losses arising from a collision that were described previously in Section 5.6.

For the future earnings, there are three sub-categories where an estimate for the collision costs will be generated. The first will be the long-term income loss for the person who is involved in a fatal incident. The second category is the long-term income loss for persons involved in a permanently disabling injury collision. The third sub-category is the household productivity and disruption costs for the family or caregiver of the person involved in an injury of fatal collision.

6.1.1 Long-Term Income Loss for Fatal Collision Victims

The first step in calculating the long-term income loss for the victim of a fatal collision was to establish life expectancy for males and females. A life expectancy table was obtained [26], which showed the number of years of life remaining by gender for all possible ages (1 to 119 years). For example, a male at age 20 is expected to have 55.88 years of life remaining. This information is used to select the ages at which a victim of a fatal collision would be earning an income. For this analysis, it was assumed that meaningful incomes are earned by persons between the ages of 16 and 65.

A workforce adjustment factor was estimated based on the age and gender of the member of the workforce. This was to account for the likelihood that not all age and gender groups would be engaged in the workforce. For example, persons between 16 and 25 are quite likely to be attending school / university and as such, may not be in the workforce. Another example would be females between the ages of 20 and 40, who may not be included in the workforce as they may be on maternity leave / child care (although it is recognized that the activity of parenting provides value to a society).

Using the estimated years of life remaining that has earning potential (by age and gender) and the workforce adjustment factor, the lost years of employment can be calculated. Then, the average salary (by age and gender) is required to calculate the total loss of income over the lifetime remaining. Information from Canadian Business Magazine (on-line) [27] was found, which provided the average salaries in Canadian provinces. The results for the province of Alberta are provided below. The results are for 2006, but these values were converted to current day using an inflation rate of 2%. Average salaries were also adjusted to account for workplace benefits using a multiplier of 1.341.

Age Group	Male Salary	Female Salary
- Ages 0 – 34:	$34,216	$20,574
- Ages 35 – 44:	$65,843	$33,735
- Ages 45 – 54:	$80,801	$40,312
- Ages 55 – 64:	$74,665	$32,829

[26] Actuarial Publications, Average Life Expectancy Table, Refer to website: www.ssa.gov/OACT

[27] Refer to website: www.Canadianbusiness.com/my_money/planning/article

The lost income is calculated for males and females at yearly intervals for the ages from 1 to 65, recognizing that children (below the assumed working age of 16) will also have lost future income potential. The future earnings are discounted using a rate of 4% (the discount rate is simply the rate in which future values can be presented as current values).

The next step to estimate the future discount earnings was to use the distribution of collision fatalities by age, which was provided by the Office of Traffic Safety. In addition, the proportion of fatal collision by gender was also required. It was assumed that a total of 78% of fatal collisions involve a male driver and 22% of fatal collisions involve a female driver [28].

The results for the lost discounted future earning for fatal collisions is as follows:

- Lost Earnings per Fatal collision: $1,414,927
- Lost Earnings per Fatality: $1,392,531

6.1.2 Long-Term Income Loss for Permanently Disabled Victims

Using the estimate for the number of collisions that result in permanent disabilities (total disability and partial disability) as shown below in Table 6.1, it is possible to estimate the lost future earning potential for these collision victims.

Table 6.1: Number of Collisions resulting in Permanent Disabilities for the Capital Region

Disability by Injury Level	Collision Severity Level		
	Fatal	Injury	Total
No. of victims with TOTAL Disability			
Major	1.06	14.43	15.49
Minor	0.13	11.38	11.51
TOTAL	**1.19**	**25.81**	**27.00**
No. of victims with PARTIAL Disability			
Major	9.81	132.98	142.79
Minor	2.44	218.83	221.27
TOTAL	**12.25**	**351.81**	**364.06**

[28] Idaho Department of Transportation. Refer to website: http://itd.idaho.goc/ohs/stats

This analysis assumes that a totally disabled collision victim cannot return to work and therefore, has the same loss of earning potential as a person that dies as a result of a collision. In contrast, a person that only suffers a partial, permanent disability is expected to have 17.2% of the earning potential loss compared to someone who is totally disabled or dies as a result of a collision [29].

The results for the loss of potential future discounted earnings for persons who suffer permanent disabling injuries are provided in Table 6.2.

Table 6.2: Lost Future Earnings due to Permanent Disabilities (Capital Region)

Lost Future Earnings Due to: Permanent Disabilities	Collision Severity Classification				
	Fatal	Injury	Fatalities	Major Injuries	Minor Injuries
Collisions/victims (Table 4.5):	42	6882	43	646	8639
TOTAL Future Earnings:	$4,557,549	$119,154,794	$4,557,549	$51,540,829	$67,613,965
AVERAGE cost per collision:	$108,513	$17,314	$105,990	$79,785	$7,827

6.1.3 Long-Term Household Productivity Loss

There are some long-term household productivity losses that arise as a result of the disabling injuries for persons involved in motor vehicle collisions. In addition, quite often a spouse or another family member may either quit their job or reduce their employment level to attend to a loved one that has become permanently disabled as a result of a collision.

The calculation of the loss of future earnings for a caregiver is computed using the same assumptions and values that were used for the victim (Section 6.1.2). The lost future earnings for caregivers is less than that for the victim since more males are the victims in serious collisions and thus, it is likely that caregivers are women, who typically earn less than males.

The results for the loss of potential future earnings for the household caregivers of persons who suffer permanent disabling injuries are provided in Table 6.3.

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[29] Vodden, K, Smith, D, Eaton, F and Mayhew, D., Analysis and Estimation of the Social Cost of Motor Vehicle Collisions in Ontario, Transport Canada, August 2007, page 140.

Table 6.3: Lost Discount Future Earnings for Caregivers (Capital Region)

Lost Future Earning Due for Caregivers	Collision Severity Classification				
	Fatal	Injury	Fatalities	Major Injuries	Minor Injuries
No. of Collisions (Table 4.5):	42	6882	43	646	8639
TOTAL Future Earnings:	$3,223,136	$90,522,667	$3,223,136	$35,336,385	$55,186,282
AVERAGE COST per collision:	$76,741	$13,154	$74,957	$54,700	$6,388

6.2 Human Capital Costs - Pain, Suffering and Grief

The information contained in the collision costing literature on the pain, suffering and grief component of human capital costs is highly varied, which produces a wide range of results. Furthermore, the approach used to formulate the estimate for pain, suffering and grief appears to be largely abstract and highly subjective or arbitrary, even as this "cost" element is often the most important one to those directly involved in, or bearing the consequences of, motor vehicle collisions. As such, all dollar estimates of this cost element should be interpreted with great caution, since the impacts of concern are fundamentally, qualitatively different from commodities such as labour, towing services, and pharmaceuticals.

To obtain an estimate for pain, suffering and grief, a study by the Transportation Research Laboratory (TRL) from the United Kingdom was used. The TRL study [30], which was cited in a report by the International Road Assessment Program (referred to as iRAP) [31], recommends the following values for the pain, suffering and grief components of human capital costs. The results for the cost of the pain, suffering and grief component of human costs is provided in Table 6.4.

- 38% of the total cost of the direct costs for fatal collisions
- 28% of the total cost of the direct costs for injury collisions
- 100% of the total cost of the direct costs for major injury collisions
- 8% of the total cost of the direct costs for minor injury collisions

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[30] Overseas Road Note 10: Costing Road Accidents in Developing Countries, TRL Transportation Research Laboratory, Dr. G. D. Jacobs, Berkshire, United Kingdom, 1995.

[31] McMahon, K., and Dahdah, S., The True Cost of Road Crashes: Valuing Life and the Cost of Serious Injuries, International Road Assessment Program (iRAP), 2007.

Table 6.4: Pain, Suffering and Grief

Pain, Suffering and Grief:	Collision Severity Classification				
	Fatal	Injury	Fatalities	Major Injuries	Minor Injuries
TOTAL Direct Costs:	$181,335	$39,524	$178,499	$113,624	$30,581
% For Pain and Suffering:	38%	28%	38%	100%	8%
AVERAGE COST:	$68,907	$11,067	$67,830	$113,624	$2,446

6.3 Summary of HUMAN CAPITAL Costs for Collisions in the Capital Region

This chapter of the report has presented the human capital costs associated with a motor vehicle collision. The human costs were separated into two categories of collision costs, with 4 sub-categories of collision costs evaluated. The results are summarized in Table 6.5 and the average costs, listed by collision severity level, are provided below. Also included below are the average costs of the human capital costs plus the direct costs.

HUMAN CAPITAL Collision Costs by Collision:

FATAL Collision: $1,669,088
INJURY Collision: $41,535
PDO Collision: $0

HUMAN CAPITAL Collision Costs by Victim:

FATALITY: $1,640,324
MAJOR injury: $246,277
MINOR Injury: $16,641
PDO Collision: $0

DIRECT + HUMAN CAPITAL Collision Costs by Collision:

FATAL Collision: $1,850,423
INJURY Collision: $81,059
PDO Collision: $10,902

DIRECT + HUMAN CAPITAL Collision Costs by Victim:

FATALITY: $1,819,807
MAJOR injury: $361,733
MINOR Injury: $47,242
PDO Collision: $11,367

Table 6.5: Summary of HUMAN CAPITAL Collision Costs for the Capital Region

Human Capital Costs of Collisions		Collision Severity Categories (by Victim)				Collision Severity Categories (by Collision)		
		Fatality	Major Injury	Minor Injury	Property Damage	Fatality	Injury	PDO
1	**Discount Future Earnings**							
	Long-Term Income Loss (Fatal Collision Victim)	$ 1,392,531	$ -	$ -	$ -	$ 1,414,927	$ -	$ -
	Long-Term Income Loss (Disabled Injury Victim)	$ 105,990	$ 79,785	$ 7,827	$ -	$ 108,513	$ 17,314	$ -
	House-Hold Productivity / Disruption Costs	$ 74,957	$ 54,700	$ 6,388	$ -	$ 76,741	$ 13,154	$ -
2	**Human Capital: Pain, Suffering and Grief**							
	Pain, Suffering and Grief	$ 67,830	$ 113,624	$ 2,446	$ -	$ 68,907	$ 11,067	$ -
	TOTAL for HUMAN CAPITAL Costs:	**$ 1,641,308**	**$ 248,109**	**$ 16,661**	**$ -**	**$ 1,669,088**	**$ 41,535**	**$ -**
	TOTAL for HUMAN CAPITAL + DIRECT Costs:	**$ 1,819,807**	**$ 361,733**	**$ 47,242**	**$ 11,367**	**$ 1,850,423**	**$ 81,059**	**$ 10,902**

7.0 INDIRECT COLLISION COSTS: WILLINGNESS-TO-PAY (WTP) COSTS

The final category of collision costs that was generated for the collision cost model for the Capital Region and the CRISP Committee is the willingness-to-pay component of collision costs. As stated earlier in the preceding chapter on human capital costs, the majority of the focus for this assignment was on the direct collision costs that were presented in Chapter 5. However, in the interest of completeness, an estimate of the willingness-to-pay cost of collisions will also be provided.

The estimate for the willingness-to-pay costs associated with a motor vehicle collision is far from straight forward. The WTP approach normally involves obtaining estimates from persons within a population and assesses their trade-offs between wealth / income and the potential for physical risk and harm. Often, analysts will use complex questionnaires to ascertain how much money an individual would be willing to forfeit in order to obtain a small reduction in their own (or another person's) risk. For example, an individual or group of respondents (i.e., motorists) might reply to a questionnaire by stating that they would be willing to pay, on average, $5 to be assured a risk level of 1:500,000 that they would be killed on a specific trip. Then the 'value of an average life' in this case would be $2,500,000 ($5 x 500,000) [32].

It must be noted that the design, distribution, compilation and analysis of sophisticated questionnaires and surveys to quantify willingness-to-pay are far beyond the scope of this assignment as determined by CRISP.

Two approaches were used to generate an estimate for the willingness-to-pay costs for collisions, including:

1) Using results from Canadian studies that examined and quantified the value of statistical life (VoSL), and,
2) Using results from regression analysis of willingness-to-pay studies and economic indicators for a region.

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[32] Overseas Road Note 10: Costing Road Accidents in Developing Countries, TRL Transportation Research Laboratory, Dr. G. D. Jacobs, Berkshire, United Kingdom, 1995.

7.1 Value of Statistical Life (Fatal Collisions)

Using a research report that was prepared for the Canadian Research Chair in Risk Management [33], an understanding of the range of values for the value of a statistical life (VoSL) can be understood. The results, which are shown below in Table 7.1, show seven different studies conducted in Canada between 1989 and 2001 that provided a value for the VoSL. The values in the table include both the reported value from the source and the value after conversion to 2007 dollars. The author for the report, the standard error for the VoSL estimate, and the sample size used in the study are also included in the table.

Table 7.1: Summary of Reported Values for the Value of Statistical Life (VoSL)

Author	Year	Reported VoSL	2007 VoSL	Standard Error	Sample Size
Meng	1989	$4,041,961	$8,188,271	$2,336,394	718
Meng and Smith	1990	$1,216,395	$2,369,416	$2,252,583	777
Cousineau et al	1992	$4,804,628	$8,652,864	$464,664	32713
Martinello and Meng	1992	$3,144,141	$5,662,420	$949,892	4352
Lanoie et al	1995	$24,198,149	$38,742,016	$7,657,642	62
Meng and Smith	1999	$2,353,931	$3,221,517	$609,827	1503
Gunderson and Hyatt	2001	$24,361,374	$30,824,910	$3,460,422	2014

It becomes very evident that there is a huge range in the values determined for the VoSL, which shows a 10-fold magnitude difference between the lowest and highest estimate.

For this study, it was decided that a simple average of the 2007 values for the VoSL could be used as an estimate for the willingness-to-pay for fatal collisions. The value per fatal collision and per fatality is provided below.

- WTP to prevent a Fatal Collision: $5,752,681
- WTP to prevent a Fatality: $5,618,898

[33] Bellavance, F, Dionne, G, ad Lebeau, M, The Value of a Statistical Life: A meta-Analysis with Mixed Effects Regression Model, Canada Research Chair in Risk Management, Working Paper 06-12, Montreal, Canada, January 7, 2007.

7.2 Regression Analysis

The second approach to determine the willingness-to-pay collision cost values used regression analysis of different studies that estimated the willingness-to-pay values and typical economic indicators from the corresponding jurisdiction. This analysis was completed because it was felt that the response to the valuation of life and disabling injury would be different by jurisdiction and would be affected by income level or the gross domestic product (GDP) per capita. The approach was detailed in a report for the International Road Assessment Program (iRAP), entitled, The True Cost of Road Crashes: Valuing Life and the Cost of Serious Injuries [34].

The regression models from the iRAP study produced the following relationships for the willingness-to-pay value of a fatality and for a serious injury:

- WTP to prevent a Fatality = 70.0*GDP/Capita
- WTP to prevent a Serious Injury = 17.0*GDP/Capita

An on-line search was completed to determine the GDP/capita for Alberta such that the WTP values could be determined. An information source from Alex Carrick, Chief Economist from RCD (Reed Construction Data) [35] indicated that the GDP/capita for the province of Alberta was $74,825 in 2007.

Using this data, the value for the WTP for a fatality and a serious injury can be determined. The computed values are listed below.

- WTP to prevent a Fatal Collision: $5,752,681
- WTP to prevent a Fatality: $5,362,458
- WTP to prevent a Major Injury Collision: $1,365,894
- WTP to prevent a Major Injuries: $1,272,025

It is interesting to note that the WTP estimate value for a fatality between the two approaches is very similar. In fact, there is only a 7% difference in the values ($5.62M and $5.24M), which is considered minimal, given the range of estimates that exist for WTP. As such, it was decided that the approach recommended by

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34 McMahon, Kate and Daddah, Said, The True Cost of Road Crashes: Valuing Life and the Cost of Serious Injury, prepared for the International Road Assessment Program (iRAP), 2007.

35 Refer to website: http://www.reedconstructiondata.com/alex-carrick

the iRAP Report be used for the WTP collision cost estimates for the Capital Region study.

7.3 Summary of Willingness-to-Pay Costs

This chapter of the report has presented the willingness-to-pay costs associated with a motor vehicle collision. Two techniques were explored in the effort to formulate an estimate for the WTP values, including using a simple average of WTP values from previous Canadian studies (value of statistical life for fatal collisions only) and a technique that used regression models from previous studies and economic indicators from different jurisdictions. The results which apply to the Capital Region, are summarized in Table 7.1. (See p. 72) The average costs by severity level for WTP alone, and by adding the WTP with direct costs, are provided below:

WTP Collision Costs (by Collision):

FATAL Collision:	$5,362,458
INJURY Collision:	$95,032
PDO Collision:	$0

WTP Collision Costs (by Victim):

FATALITY:	$5,237,750
MAJOR injury:	$1,272,025
MINOR Injury:	$0
PDO Collision:	$0

DIRECT + WTP Collision Costs (by Collision):

FATAL Collision:	$5,543,793
INJURY Collision:	$134,556
PDO Collision:	$10,902

DIRECT + WTP Collision Costs (by Victim):

FATALITY:	$5,416,249
MAJOR injury:	$1,385,649
MINOR Injury:	$30,581
PDO Collision:	$11,369

Table 7.2: Summary of WILLINGNESS-to-PAY Collision Costs for the Capital Region

Willingness to Pay costs		Collision Severity Categories (by Victim)				Collision Severity Categories (by Collision)		
		Fatality	Major Injury	Minor Injury	Property Damage	Fatality	Injury	PDO
1	**Value of Statistical Life**							
	Valuation of Statistical Life (VoSL) (FATAL Only)	$ 5,237,750	$ -	$ -	$ -	$ 5,362,458	$ -	$ -
2	**Valuation of Major Injuries**							
	Valuation of Injuries (MAJOR Injuries Only)	$ -	$ 1,272,025	$ -	$ -	$ -	$ 95,032	$ -
	TOTAL for WILLINGNESS TO PAY Costs:	**$ 5,237,750**	**$ 1,272,025**	**$ -**	**$ -**	**$ 5,362,458**	**$ 95,032**	**$ -**
	TOTAL for WILLINGNESS TO PAY and DIRECT Costs:	**$ 5,416,249**	**$ 1,385,649**	**$ 30,581**	**$ 11,369**	**$ 5,543,793**	**$ 134,556**	**$ 10,902**

8.0 SUMMARY

This final chapter provides a brief overview of each chapter and presents the final results of the collision cost model for the Capital Region of Alberta.

8.1 Project Objective / Overview

The objective of this assignment was to review the different collision cost models that exist, as well as the data inputs required for the models, to determine which costing model would be the most appropriate, and to use the model to calculate collision costs for the Capital Region.

In general, the elements of a collision cost model are categorized into 3 types of costs including: 1) Direct Costs, 2) Human Capital Costs and 3) Willingness-to-Pay (WTP) Costs.

It was understood that the members of the CRISP committee would be most interested in the direct collision costs, but would also like to have some indication of the Human Capital costs and Willingness-to-Pay costs. As such, most of the attention was given to establishing the various elements associated with direct collision costs, while less effort was dedicated to the determination of the HC and WTP collision costs.

8.2 Literature Review / Critical Review

The literature review described several different methods that have been used to produce collision cost estimates. The components of the collision cost estimates range from quite definitive direct costs (e.g., property damage, emergency response costs, etc.) to very abstract, non-tangible indirect costs.

Due to the wide variety of the collision costing methods, there is a wide range in the values that have been generated for collision costs, which can vary from a low of approximately $1M to a high of nearly $20M for a fatal collision. This range is partly due to the differences in the collision cost model used, but it is believed that the differences are also due to data accuracy, data availability and the interests of the agency examining collision costs.

8.3 Classification of Collision Severity

The third charter of the report discussed the different ways in which collisions can be classified based on the level of severity. This is particularly important in how the collision cost model would be developed and how the final results would be presented.

For this assignment, the collision severity categories are based on per collision and on per victim. As such the following collision severity classification scheme was used, and is based on the classification system used in Alberta.

1) By Collision (Classification 1):
    - Fatal Collision
    - Injury Collision
    - Property Damage Only (PDO)
2) By Victim (Classification 2):
    - Fatality
    - Major Injury
    - Minor Injury
    - PDO

8.4 Baseline Collision Data

Chapter 4 of this report presented the baseline collision data that would form the basis for the collision cost model that was developed. The raw collision data from the government of Alberta and Edmonton's Office of Traffic Safety was obtained for the Capital Region, although not all communities in the Capital Region were included.

Several adjustments had to be made to the raw data to account for the under-reporting and misreporting of collisions. Making such corrections is a very common practice when collision-costing models are developed, and allows for a better representation of the true collision experience. The adjustment process for the raw collision data was fully documented in chapter 4, noting that the adjustment factors were obtained from literature sources. If local information becomes available to correct for the necessary collision adjustments, they can easily be input into the Capital Region collision cost model.

8.5 Collision Cost Results

The results for the collision cost model are divided into three categories, which correspond to the 3 types of costs (i.e., direct costs, human capital costs and willingness-to-pay costs). The specific elements associated with each type of collision cost are discussed in the body of the report, so the reader is directed to chapter 5 for the direct collision cost elements, chapter 6 for the human capital costs elements and chapter 7 for the willingness-to-pay collision cost elements.

8.5.1 Direct Collision Costs

The direct collision cost elements of the model include the following and the results are provided in Table 8.1.

- Property Damage Costs
  - Vehicle Damage Costs
  - Auto-Insurance Administration Costs
  - Out-of-Pocket Costs
  - Towing Costs
- Emergency Response Costs
  - Police Costs
  - Fire / Rescue and Ambulance Costs
  - Coroner / Medical Examiner Costs
- Health Services Costs
  - Emergency Department Costs
  - Intensive Care Unit Costs
  - Acute Care Hospital Costs
  - Rehabilitation Costs
  - Long Term Care Costs
- Legal Costs
  - Cost of Correctional Services
  - Court Costs
  - Legal Aid and Prosecution Costs
  - Funeral Costs
- Travel Delay / Environmental Costs
  - Traffic Delay Costs and Extra Fuel Consumption Costs
  - Extra Pollution Costs
- Productivity
  - Lost Productivity Due to Injury Collisions
  - Lost productivity Due to Fatalities
  - Lost Productivity Due to PDO Incidents

8.5.2 Human Capital Costs

The human capital collision cost elements of the collision cost model include the following components. Results are provided in Table 8.1 on the following page.

- Human Capital Costs
  - Discounted Future Earnings
    - Long-Term Income Loss for Fatal Collision Victims
    - Long-Term Income Loss for Permanently Disabled Victims
    - Long-Term Household Productivity Loss
  - Pain, Suffering and Grief

8.5.3 Willingness-to-Pay Costs

The willingness-to-pay elements of the cost model include the following and the results are provided in Table 8.1.

- Willingness-to-Pay Costs
  - Value of Statistical Life (VoSL)
  - Valuation of Injuries

8.5.4 Summary of Collision Cost Model Results

The following are the final results of the collision cost model (rounded), and the human capital and willingness-to-pay results include the direct collision costs.

Direct Costs:

Fatal Collision:	$181,000	Fatality:	$178,500
Injury Collision:	$39,500	Major Injury:	$113,600
PDO:	$10,900	Minor Injury:	$30,600
		PDO:	$11,400

Human Capital Costs:

Fatal Collision:	$1,846,800	Fatality:	$1,640,300
Injury Collision:	$108,500	Major Injury:	$246,300
PDO:	$10,900	Minor Injury:	$00
		PDO:	$11,400

Willingness-to-Pay Costs:

Fatal Collision:	$5,362,500	Fatality:	$5,237,800
Injury Collision:	$95,000	Major Injury	$1,272,000
PDO:	$0	Minor Injury:	$0
		PDO:	$0

Table 8.1: Summary of Collision Costs for the Capital Region

DIRECT Collision Costs		Collision Costs (by Victim)				Collision Costs (by Collision)		
		Fatality	Major Injury	Minor Injury	Property Damage	Fatal	Injury	PDO
1	**Property Damage (Vehicle Related)**							
	Vehicle Repairs	$25,841	$18,308	$15,509	$6,681	$26,456	$16,092	$6,272
	Auto-Insurance Administration	$3,235	$1,537	$920	$127	$3,312	$1,180	$120
	Out-of Pocket Expenses	$1,292	$975	$871	$429	$1,323	$898	$403
	Towing Services	$588	$512	$504	$333	$602	$586	$311
2	**Emergency Response Costs**							
	Police Costs	$5,884	$2,322	$441	$169	$5,884	$541	$169
	Fire / Rescue Costs	$628	$3,281	$81	$0	$628	$278	$0
	Ambulance Costs	$548	$3,775	$27	$0	$548	$222	$0
	Coroners Costs (Fatal Only)	$1,812	$0	$0	$0	$1,770	$0	$0
3	**Health Service Costs**							
	Emergency Room Costs	$1,039	$318	$254	$0	$1,064	$348	$0
	ICU Care Costs	$45,878	$26,517	$0	$0	$46,970	$2,489	$0
	Acute Care Costs	$9,156	$8,258	$0	$0	$9,374	$775	$0
	Rehabilitation Costs	$6,418	$4,735	$523	$0	$6,571	$1,101	$0
	Long Term Care Costs	$18,656	$15,035	$887	$0	$19,100	$2,525	$0
4	**Legal Costs**							
	Correctional Services	$1,061	$419	$8	$0	$1,061	$29	$0
	Court Costs	$434	$171	$3	$0	$434	$12	$0
	Legal Aid and Prosecution	$386	$152	$3	$0	$386	$11	$0
	Funeral Costs (Fatal Only)	$8,887	$0	$0	$0	$8,741	$0	$0
5	**Travel Delay Costs**							
	Delay Costs Caused by Collision	$16,903	$8,874	$4,648	$1,927	$16,903	$4,926	$1,927
	Extra Fuel Consumption	$2,069	$1,086	$569	$236	$2,069	$603	$236
	Environmental / Pollution Costs	$12,843	$6,742	$3,532	$1,464	$12,843	$3,743	$1,464
6	**Productivity / Disruption Costs**							
	Short-Term Work-Place (Injury)	$14,944	$10,606	$1,802	$0	$15,300	$3,165	$0
	Short-Term Work-Place (Fatal)	$3,882	$0	$0	$0	$3,975	$0	$0
	Short-Term Work-Place (PDO)	$0	$0	$0	$48	$0	$0	$48
	TOTAL for DIRECT Costs:	**$178,499**	**$113,624**	**$30,581**	**$11,367**	**$181,335**	**$39,524**	**$10,902**

Human Capital Costs of Collisions		Collision Costs (by Victim)				Collision Costs (by Collision)		
		Fatality	Major Injury	Minor Injury	Property Damage	Fatality	Injury	PDO
1	**Discount Future Earnings**							
	Long-Term Income Loss (Fatal Collision Victim)	$1,392,531	$0	$0	$0	$1,414,927	$0	$0
	Long-Term Income Loss (Disabled Injury Victim)	$105,990	$79,785	$7,827	$0	$108,513	$17,314	$0
	House-Hold Productivity and Disruption Costs	$74,957	$54,700	$6,388	$0	$76,741	$13,154	$0
2	**Pain, Suffering and Grief**							
	Pain, Suffering and Grief	$67,830	$113,624	$2,446	$0	$68,907	$11,067	$0
	TOTAL for HUMAN CAPITAL Costs:	**$1,641,308**	**$248,109**	**$16,661**	$0	**$1,669,088**	**$41,535**	$0

TOTAL for HUMAN CAPITAL + DIRECT Costs:	**$1,819,807**	**$361,733**	**$47,242**	**$11,367**		**$1,850,771**	**$81,059**	**$10,902**

Willingness to Pay Costs		Collision Cost (by Victim)					Collision Costs (by Collision)		
		Fatality	Major Injury	Minor Injury	Property Damage		Fatality	Injury	PDO
1	**Value of Statistical Life**								
	Valuation of Statistical Life (VoSL) (FATAL Only)	$5,237,750	$0	$0	$0		$5,362,458	$0	$0
2	**Valuation of Major Injuries**								
	Valuation of Injures (MAJOR Injuries Only)	$0	$1,272,025	$0	$0		$0	$95,032	$0
	TOTAL for WILLINGNESS TO PAY Costs:	**$5,237,750**	**$1,272,025**	**$0**	**$0**		**$5,362,458**	**$95,032**	**$0**

TOTAL: WILLINGNESS TO PAY + DIRECT Cost:	**$5,416,249**	**$1,385,649**	**$30,581**	**$11,369**		**$5,543,793**	**$134,556**	**$10,902**

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APPENDIX 1: Detailed Review of Selected Literature

A.1 The Alberta GPI Accounts: Auto Crashes and Injuries (Anielski, 2001).

Report Title: The Alberta GPI Accounts: Auto Crashes and Injuries

Author(s): Anielski (2001)

Jurisdiction: Alberta, Canada

Brief Overview

The study is one of 28 reports that provide the background for the Genuine Progress Indicators (GPI) System of Sustainable Well-being Accounts. The incidence of auto collisions is among a series of social and human health indicators in the 51-indicator GPI accounts for Alberta. The report examines the trends in deaths and injuries due to auto collisions in Alberta from 1961 to 1999. It also estimates the full direct and indirect costs of auto collisions during this time period. In the GPI accounting system, auto collisions are considered a regrettable cost to human health and social wellbeing.

Costs

- The Urban Institute, on behalf of the British Columbia Ministry of Transportation and Highways calibrated a U.S. collision-cost model using B.C. data; they estimated the cost of a fatal collision at $2,900,000 ($2,800,000 per statistical life, $156,000 in direct costs and $73,000 in forgone income taxes), the cost of an injury at $100,000 and the cost of property damage only at $6,000.
- KPMG Consultants were commissioned in 1994 by Alberta Transportation and Utilities to examine a suitable approach to estimate the societal costs of collisions in Alberta. They examined three cost options and proposed figures of $3.8-million per fatality, $100,000 per injury and $12,000 per property damage only, higher than those used by the B.C. Ministry.
- The Alberta Motorist Association (AMA) estimated the full costs of auto collisions, based on the B.C. and U.S. estimates. The collision costs were estimated as $2.9-million per single fatality (the value of a statistical life), $100,000 per injury, and $7,000-$8,000 per property damage incident due to a collision.

Model Approach

The $2.9-million fatality estimate is based on the willingness-to-pay or comprehensive concept where total societal costs include the value of the individual's life, and the cost saved by the rest of society in preventing an injury. The willingness-to-pay method attempts to put a dollar value on pain and suffering.

Parameters used in the Model / How Parameters were Calculated

The AMA cost of automobile collisions was based on estimates by economist Ted Miller who has developed a full costing model that includes estimates of the cost of lost labour productivity due to fatalities and other direct costs. Miller's estimates are sometimes considered conservative, particularly the estimates of direct costs, including health care expenditures, policy costs, property damage and other costs. However, it was argued that there is less confidence in Miller's B.C. estimates of direct and indirect costs when applied to Alberta.

In the cost of a fatal collision estimated by Miller and the Urban Institute for B.C. at $2.9-million per fatality, 35 percent consists of direct or hard costs related to medical care, property damage, and lost production and 65 percent is the cost associated with pain, suffering and the value of a statistical life. According to the Workers Compensation Board of Alberta, the loss of labour productivity due to auto collisions is significant, accounting for about 30 percent of total down time for injured workers.

The 1998 direct cost estimates provided by the AMA were used in the study and a real constant cost of the GPI accounting period 1961 to 1999 was assumed and applied to the auto collision fatality, injury and property damage data time series provided by Alberta Infrastructure. The cost estimates used in the study included only direct costs and forgone income taxes resulting from fatalities plus the direct costs of injuries and property damage. All costs were expressed in 1998 constant dollars.

A.2 Crashes vs. Congestion - What's the Cost to Society? (Meyer, 2008)

Report Title: Crashes vs. Congestion - What's the Cost to Society?

Author(s): Meyer (2008)

Jurisdiction: United States (85 urban areas used by the Texas Transportation Institute)

Brief Overview

This study compares the costs of collisions to the costs of congestion by calculating a per person cost for collisions and multiplying this value by the population figures in the same 85 urban areas used by the Texas Transportation Institute (TTI) in the annual *Urban Mobility Report*.

Costs

Using the Federal Highway Administration (FHWA) approach (in 2005 equivalent dollars) the comprehensive cost per person for a fatality is $3,246,192 and the cost for an injury is $68,170.

Model approach

The estimated costs for collisions were based on the Federal Highway Administration's (FHWA) comprehensive costs for traffic fatalities and injuries.

Parameters used in the Model / How Parameters were Calculated

The approach places a dollar value on 11 cost components, namely: property damage; lost earnings; lost household production (non-market activities occurring in the home); medical costs; emergency services; travel delay; vocational rehabilitation; workplace costs; administrative; legal; and pain and lost quality of life. The congestion costs, as reported in the *Urban Mobility Report*, were based on delay estimates combined with value of time and fuel costs.

A.3 Costs of Alcohol-Related Crashes in New Zealand Estimates and Suggested Measures for Use Internationally (Miller and Blewden, 2001)

Report Title: Costs of Alcohol-Related Crashes: New Zealand Estimates and Suggested Measures for Use Internationally

Author(s): Miller & Blewden (2001)

Jurisdiction: New Zealand

Brief Overview

The paper estimates the costs associated with alcohol-related collisions in New Zealand. The study uses two types of data: alcohol collision costs and counts. Alcohol collision costs are computed from official collision reports. Collision/injury counts (adjusted for under-reporting) are computed from police reports.

Costs

Table (1) summarizes the costs per collision victim (or per collision in the case of legal and property damage costs) by injury severity and cost category. To get total alcohol related collision costs, unit costs were multiplied by 1996 alcohol-related collision or victim counts by injury severity.

Table A-1: Collision Cost Values

	Fatal	Serious injury	Minor injury	PDO crash
Per injury				
Medical	4800	10 700	600	0
Lost work/quality of life	2 151 800	172 500	8700	0
Legal and court	3300	400	200	30
Property damage	3600	2400	2600	1600
Total	2 163 500	186 000	12 100	1630
Accident Compensation	59 000	1900	1900	0
External costs (not paid by the drinking driver)	914 400	90 500	7500	1000
Per crash				
Medical	10 900	13 100	900	0
Lost work/quality of life	2 581 100	211 400	11 700	0
Legal and court	4200	600	300	30
Property damage	6700	4400	3500	1600
Total	2 602 900	229 500	16 400	1630

Model Approach

The paper uses the highway safety definition to define external costs; which are costs that are paid by people other than the drinking driver. All costs borne by the family due to injuries of a drinking driver or non-occupant are treated as internal. All other costs including costs of injuries to other family members are external. External costs are calculated using willingness to pay (WTP) approach. A WTP framework is the appropriate choice for costs intended for benefit-cost or regulatory analysis. Productivity losses, even if stated explicitly, are merely a component of a family's WTP for the life and safety of a family member. They are not intended to measure the impact of earnings loss on society but rather are part of the impact on the victim so it is irrelevant if someone's death creates a job for someone else.

Parameters used in the Model / How Parameters were Calculated

To compute the costs of alcohol-related collisions, official costs per collision victim by injury were estimated from the Land Transport Safety Administration (LTSA) police collision report files. The costs fall into four major categories; (1) medical costs including ambulance, acute care, follow-on medical and rehabilitation services, (2) law enforcement costs including police and court services, (3) property damage costs and (4) a combined measure of the value of lost work and quality of life, which comes from a New Zealand household survey.

A.4 Long-Term Medical Costs of Motor Vehicle Casualties in Alberta 1999: A Population-Based Incidence Approach (Jacobs et al, 2004)

Report Title: Long-Term Medical Costs of Motor Vehicle Casualties in Alberta (1999): A Population - Based, Incidence Approach

Author(s): Jacobs, P., Lier, D., and Schopflocher, D. (2004)

Jurisdiction: Alberta, Canada

Brief Overview

The paper estimates the short and long term medical costs attributable to motor vehicle collisions for all persons in Alberta, Canada in 1999, primarily using observational data. Injury claims for 1999 were reported by the automobile insurance companies. These records were linked to the provincial health registry thereby identifying all inpatient and outpatient (including emergency room) visits, physician services, and other health records. Actual costs were obtained for 3 years, and longer-term costs were projected for subsequent years. Costs were derived for all casualties who were admitted to hospital or seen in an emergency room, and a sample of matched controls (no casualty) was derived and their costs were also estimated.

Costs

A summary of the frequencies and long-term medical costs by the level of injury is shown in table 2 below.

Table A-2: Summary of Frequencies and Costs by Level of Injury (1999 Casualties)

Summary statistics of frequencies and costs by level of injury, Alberta, 1999 casualties

Severity level	Hospitalized	Emergency room only	Other	Total
Unduplicated count of casualties	2237 (5.4%)	17,686 (43.0%)	21,161 (51.5%)	41,084 (100%)
Average net cost year 1	14,211	1024	157	–
Average[a] net Cost Years 2–3	3430	1073	0	–
Average[a] net cost years 4–10	3851	1377	0	–
Average[a] net cost years 11–50	1470	92	0	–
All years	22,962	3566	157	–
Total	51,366,000 (43.6%)	63,068,000 (53.5%)	3,322,000 (2.8%)	117,756,000 (100%)

[a] Average net cost per casualty for all years in the range.

Model Approach

Not available in article reviewed.

Parameters used in the Model / How Parameters were Calculated

Short-term costs were computed from two databases, namely: Insurance Bureau of Canada (IBC) and provincial hospital and emergency room databases. IBC database includes specific data (name of claimant, date of birth, date of collision) on claims for an collision that occurred in 1999. Using this information, a match between the persons who made these claims with personal identifiers in the provincial health registry was made, using the first name, last name and date of birth of the claimant.

In order to supplement the motor vehicle collision casualties identified from IBC data a second source was used. Both provincial hospital and emergency room databases were searched for any admission or visit, during 1999, that was identified as being a motor vehicle collision related. The personal health numbers from the resulting records were obtained and the provincial health databases were searched for any other utilization encounter for those persons who were identified with a motor vehicle collision. The use of these two sources provided virtually the entire enumeration of persons who had a motor vehicle collision related emergency visit or inpatient admission in 1999. These cases comprised the two highest severity levels in the study. A matched control (no casualty) for each motor vehicle collision casualty was obtained. Randomly, each person was matched with one of identical age, sex and region of residence, who was not involved in a motor vehicle collision in 1999. Data for all hospital and medical services for each casualty and match were obtained for one year beyond the collision or index date.

Costs were assigned to each service using 1999 hospital – specific per diem costs. The facility component of hospital outpatient visits, including emergency room visits, was evaluated using standard 1999 provincial costs per visit. All hospital costs were measured by rates developed in conjunction with the Interprovincial Health Insurance Agreements Coordinating Committee of Health Canada. All other costs, including those for all physician services within and out of the hospital, were evaluated with provincial fees (Alberta Health and Wellness, 1999). A cost for each person, casualty and match, was obtained for the year by summing the dollar values for services used by each person. The differences between the costs for the two groups (casualty and matched sample) were deemed to be short-term costs (STC) that were "attributable" to the motor vehicle collisions.

Long-term cost estimates were based on a combination of observation and modeling techniques. In order to obtain a sufficient length of time for the observed data series (12 quarters following the date of collision) casualties and matched controls from 1997 were selected by personal health numbers as stated above. Emergency room data was not collected before 1997, and so this was the longest observational period available.
A long term cost factor (LTCF) was calculated for each study and severity group (e.g., hospital collision casualties), defined as the health service cost for years 2 through 50

divided by year 1 costs. The LTCF was used to forecast average long-term cost (LTC) per person as the product of the average STC and the LTCF. For each of the hospital and emergency-room severity groups, the average LTC was equal to the difference in costs between the casualty and control group costs. In calculating the LTCF, the expected cost for each year was equal to the product of the average cost per person and the cumulative survival. For some pairs, the survival time for the control exceeded that of corresponding casualty. Observed data was used to calculate average LTC for years 1 to 3, whereas, modeling was used for years 4 through 50. Average cost for each of the casualty hospital and emergency room severity groups was forecast using a double-log polynomial regression on group-level data, with grouped average cost per quarter as the dependent variable and time (in quarters) as the independent variable. For the controls, average cost for years 4 through 50 was assumed to equal the average of the first three years.

All cost data used in the long-term analysis were expressed in constant 1999 dollars and converted to 1999 present value using a 3% real discount rate. For years 1–3, observed survival was used for casualties; however, for controls the general population age-sex specific survival rates (from the 2000 Alberta Life Tables) were used to estimate the cumulative survival. For years 4 through 50, for both casualty and control groups, cumulative survival was forecast using age-sex specific rates from the general population life tables.

A.5 Crash Costs in the United States by Crash Geometry (Zaloshnja et al, 2006)

Report Title: Crash Costs in the United States by Crash Geometry

Author(s): Zaloshnja et al (2006) *(Note that there are numerous papers and reports written by the same authors that use the same methodology)*

Jurisdiction United States

Brief Overview

This paper estimates the costs per collision for three police-coded collision severity groupings within 16 selected collision geometry types and within two speed limit categories. Previously developed costs per victim (by injury scale) were merged into U.S. collision data files that scored injuries to estimate injury costs, then aggregated the estimates into costs per collision by maximum injury severity. The authors claim that the costs are in an appropriate form for economic analysis of countermeasures addressing locally defined problems identified by analyzing police collision reports.

Costs

To compute costs per collision, the total costs by collision geometry, speed limit, and the maximum severity in the collision were divided by the corresponding collision counts. Mean costs were averaged to arrive at overall mean costs. The study investigated different collision types, 3 severity classes, and 2 speed limit categories. The collision costs and counts are shown in tables located on pages 13 and 14. Table 3 describes single-vehicle collisions and Table 4 describes multi-vehicle collisions.

Model Approach

Following Miller (Miller et al, 1995), Zaloshnja (Zaloshnja et al, 2004) based quality of life loss on physicians' estimates of the functional capacity lost over time by injury diagnosis and a systematic review of the survey literature concerning the loss in value of life that results from different functional losses. These losses were cost-based on meta-analyses (Miller, 1990, 2000; Viscusi and Aldy, 2003) examining what people pay for small changes in fatality risk and surveys on what they state they are willing to pay. The mean value of statistical life recommended by Miller (Miller, 1990) – $3.3 million (in $2001) – and subsequently adopted for official use by NHTSA was used in Zaloshnja's (Zaloshnja et al, 2004) quality of life loss cost calculations.

Parameters used in the Model / How Parameters were Calculated

The paper estimates average collision costs by first generating estimates of collision costs by severity. The injury costs were adopted from Zaloshnja (Zaloshnja et al, 2004) where costs per victim were given in 2000 dollars. The following cost categories were included: (1) medically related; (2) emergency services; (3) property damage; (4) lost productivity (wage and household work); and (5) the monetized value of pain, suffering, and lost quality of life. The costs were updated to 2001 dollars and the present value was computed at a 4% discount rate, of all costs that result from a collision over the victim's expected life span. This discount rate was chosen in order to be consistent with the NHTSA's and FHWA's methodology. A sensitivity analysis was conducted with two other discount rates (3% and 7%).

Zaloshnja's (Zaloshnja et al, 2004) medical cost estimates drew on data from 1992 to 1994 Civilian Health and Medical Program of the Uniformed Service data for physician and emergency department fees, 1994–1995 data on hospital costs in MD and NY (the only two states where costs, not charges or payments were known), and 1987 National Medical Expenditure Survey and 1979–1987 National Council on Compensation Insurance data on the percentage of costs that occur more than 6 months post injury.

Zaloshnja (Zaloshnja et al, 2004) based short-term productivity loss on information from the collision worthiness data system CDS (1988–1991 and 1993–1999) about the probability an employed person would lose work for a specific injury and the 1993 Survey of Occupational Injury and Illness of the U.S. Bureau of Labor Statistics on the days of work lost per person who lost work. Mean probabilities of work loss were estimated from just those CDS records that had the relevant information, which frequently was missing. Sample size considerations drove the decision to pool several years of CDS data. Long-term productivity loss by diagnosis was based on 1979–1987 NCCI Detailed Claims Information data on the probability that injuries would cause permanent partial/total disability and 1997 Detailed Claims Information data on the percentage loss of earning power for partially disabled injury victims.

Zaloshnja et al. (2004) included a variety of other direct costs. Among them were emergency services, property damage, travel delay, insurance claims administration, legal and court costs, and workplace disruption costs. These estimates used insurance data, recent data on travel delay that collisions cause motorists whose vehicles did not collision, and data from prior NHTSA studies.

A.6 The Economic Costs of Road Traffic Crashes: Australia, States and the Territories (Connelly and Supangan 2006)

Report Title: The Economic Cost of Road Traffic Crashes: Australia, States and Territories

Author(s): Connelly and Supangan (2006)

Jurisdiction: Australia (eight state and territory jurisdictions)

Brief Overview

The paper estimates and compares the economic impact of traffic collisions across eight states in Australia. Furthermore, the paper provides a detailed breakdown of estimated collision casualties, by state and territory regions in Australia and also presents the first sub-national breakdown of collision costs for Australia.

Costs

The Australian Bureau of Transport Economics (ABTE) estimates of the average costs by casualty/collision type, expressed in 2003 Australian dollar values, are as follows:

- Fatality: $1,832,310
- Serious injury: $397,000
- Minor injury: $14,183
- Property damage only collision: $7329

Model Approach

The analytical approach used in the paper is based on the ABTE (ABTE, 2000). Using collision data for 1996, the BTE designed a methodology based on the Human Capital Approach (HCA) to compute the "economic losses" (expressed in terms for lost earnings, only) associated with traffic collisions.

Briefly, the Human Capital Approach involves estimating the (present value) lifetime earnings foregone as the result of a productivity-reducing disability. The application of this approach involves an implicit assumption that the value of lost production (output, income, value added) to the economy is equal to the sum of such losses to the individuals whose productivity is lowered by traffic collisions. Conceptually, this essentially means that an individual's lost productive value is irrecoverable from the point of view of the economy at large.

Parameters used in the Model / How Parameters were Calculated

The methodology used actuarial data from three compulsory third-party personal insurance schemes to produce estimates of the "non-economic losses" associated with lost quality of life (such as "pain and suffering" and "general damages"). The ABTE estimates of injuries and deaths caused by traffic collisions are thus higher than the commonly applied HCA estimates, yet lower than the stated or revealed preference approaches (such as willingness-to-pay or willingness-to-accept etc.). In addition to these costs, the ABTE produced detailed property damage estimates and estimates of other important categories of cost (e.g., emergency services) that are associated with traffic collisions.

Table 5 below presents the cost categories that were measured by the ABTE (ATBE, 2000) in its national estimates of road collision costs and their relative magnitudes. Costs of traffic collisions are disaggregated into three broad categories: Human costs, Vehicle costs and General costs. Columns 2 and 3 indicate the proportion each cost item accounts for within its cost category and as a proportion of total costs, respectively.

Table A-3: Categories of Cost to Estimate the Cost of Road Collisions in Australia (ABTE)

Cost category	Percentage of cost category	Percentage of total costs
Human costs		
Medical, ambulance and rehabilitation	4.31	2.41
Long-term care	23.73	13.28
Labour in the workplace	19.38	10.85
Labour in the household	17.81	9.97
Quality of life	21.10	11.81
Legal	9.70	5.43
Correctional services	0.20	0.11
Workplace disruption and staff replacement	3.73	2.09
Funeral	0.04	0.02
Coroner	0.01	0.01
Total human costs	100.00	55.97
Vehicle costs		
Vehicle repairs	94.53	25.93
Unavailability of vehicles	4.43	1.21
Towing	1.05	0.29
Total vehicle costs	100.00	27.44
General costs		
Travel delays	58.15	9.65
Insurance administration	37.26	6.18
Police	2.98	0.49
Non-vehicle property damage	1.21	0.20
Fire and emergency services	0.40	0.07
Total general costs	100.00	16.59

Source: Derived from BTE (2000, p. xi). *Note*: Percentages have been rounded to two decimal places.

The BTE (2000) produced two sets of average cost estimates, one set of which is based on collision type: (i) average cost per fatal collision; (ii) average cost per serious injury collision; (iii) average cost per minor injury collision; and (iv) average cost per property damage only (PDO) collision. The second set of cost estimates is based on the costs per fatality and injury: (v) average cost per fatality; (vi) average cost per serious injury; and (vii) average cost per minor injury. In other words, the denominator in the case of categories (i) to (iv) is the number of collisions; while the denominators for categories (v) to (vii) are the numbers of fatalities, serious injuries and minor injuries.

Serious injury was distinguished from minor injury by a hospital admission for 24 hours or more. In other words, an injury is considered serious if an individual involved in the collision was admitted to hospital and minor if first aid was given at the scene of the collision and/or medical treatment, including a hospital admission less than 24 hour was given.

A.7 Analysis and Estimation of the Social Cost of Motor Vehicle Collisions in Ontario (Vodden et al, 2007)

Report Title: Analysis and Estimation of the Social Cost of Motor Vehicle Collisions in Ontario

Author(s): Vodden, K, Smith, D., Eaton, D, and Mayhew, D. (2007)

Jurisdiction: Ontario, Canada

Brief Overview

The study was used to determine the social costs of motor vehicle collisions in Ontario. The study used social costs models to produce estimates of human consequences due to motor vehicle collisions.

Costs

The collision costs model estimates (by model) are presented in Tables 6 and 7 below.

Table A-4: Core Willingness to Pay Parameters for Human Consequences ($2004)

	Value by type of effect by scenario:		
Type of effect	**Upper bound**	**Lower bound**	**Mean value**
Death	$19.7 million	$7.5 million	$13.6 million
Activity day used for short term disabling injury below:	$2,885	$577	$1,730
Per major injury	$215,510	$43,102	$129,231
Per minor injury	$43,275	$8,655	$25,950
Per minimal injury	$2,308	$462	$1,384
Partial disability	$1,201,977	$240,395	$721,186
Total disability	$2,403,954	$480,790	$1,442,372

Table A-5: Discount Future Earning Estimates for Human Consequences ($2004)

Injury Severity	Average/case
Fatality	$1.1 million
Permanent Total Disability	$1.1 million
Permanent Partial Disability	$189,081
Major Injury*	$7,709
Minor Injury*	$1,136
Minimal Injury*	$36

* Excluding those resulting in permanent disability.

Model Approach

Two modeling approaches were used namely: the willingness-to-pay (WTP) and discount future earnings (DFE) models. First, willingness-to-pay estimates were divided into three categories: upper bound, lower bound and average.

The upper bound estimates were based on the recent Canadian work on the estimation of value of statistical life by Gunderson and Hyatt (Gunderson and Hyatt, 2001). Gunderson and Hyatt estimated that the benefits to society of reducing the risks that would lead to one fatality are as high as $13 million while the benefits of reducing the risks that would lead to one non-fatal injury are approximately $20,000 (expressed 1988 Canadian dollars). Albeit the number is considered on the high end, the results have not been challenged in the economics literature. Their central point is that earlier estimates of the value of a statistical life may under-estimate the true value of this variable. The potential bias occurs because other models fail to account for risk preferences that may vary with income and do not control for selection factors based on risk preferences. In the case of the selection issue, this means that workers with less risk aversion will accept (self-select into) higher risk jobs and because they are less risk averse will demand a smaller compensating wage differential for exposure to risk. The smaller compensating wage differential then underestimates the required compensation of "average" members of the population for exposure to risk, thereby under-estimating the costs associated with workplace and other risks including motor vehicle risks.

The lower bound estimates are based on the updated values proposed by Vodden (Vodden et al, 1994). The values were estimated using data from Statistics Canada's 1987 Labour Market Activity Survey and were updated to 2004. The dependent variable in these regression model estimates is the wage rate so that the 1987 value of $4.7 million have been inflated to $7.8 million using Statistics Canada data on wage rates. This adjustment includes an inflation adjustment to retain the real value of the value of statistical life variable and also includes an increasing real wage factor that captures the positive income elasticity of the demand for safety. The lower bound for the activity day variable and the severe injury variable are calculated in the same way.

The mean value of the upper and lower bound estimates provides the central estimating result used in the analysis. Based on these methods the core parameters for the human consequences (death, activity day, partial and total disability) of motor vehicle collisions was provided. Second, the discounted future earnings approach measures losses in productive activity in the workplace and in household activity for those affected by collisions. Losses through 3 main types of human consequences are measured: fatalities, permanent disabilities (total and partial), and temporary disabilities and injuries.

Parameters used in the Model / How Parameters were Calculated

Hospital / Health Care Facilities Cost

A series of studies following a methodology established by the Health Services Restructuring Committee have been conducted of costs in Ontario hospitals. Using 17 such studies average values were computed. Cost associated with a patient day is $216.29 and per emergency room visit $84.33 respectively, both in 2000 dollars. In 2004 dollars these costs are $243 and $95 respectively. These represent costs for use of health care facilities, equipment and supplies and exclude a value for time by health care workers.

Health Care Professional Cost

The following approximate values related to the health care categories in the Chipman (1990) analysis were assigned:

- Primary MD: $100
- Specialist: $150
- Nurse: $40
- Physiotherapist: $75
- Chiropractor: $75
- Other categories: $75

The study estimates the health care professional cost for minor injuries and major injuries as $920 and $4600, respectively.

Police Costs

The Ontario Provincial Police charge-back municipalities for the cost of police services provided. The model used by the police was used in this study to estimate policing costs. The model provides the 2006 base and fully-loaded costs for each level of staff. In addition to base salaries, allocated items in the fully-loaded cost calculated by the model include overtime (based on provincial averages), contractual payouts, benefits, allocated other staff, and direct operating expenses (vehicle use, office and equipment, uniform, and equipment).

The fully loaded costs were applied to the mix of police staff hours to identify a fully loaded average cost per police hour of activity that was expended in relation to motor vehicle collisions. The fully loaded weighted average cost was calculated to be $82.73 ($2006) or $78 in 2004.

Court Activities

Data from the Canadian Centre for Justice Statistics of Statistics Canada provide an estimate of court costs to police costs over a five-year period based on the total expenditures by each. Using this percentage (14.7%) and the fully loaded police costs noted earlier a cost for court proceedings related to motor vehicle collisions was estimated.

Fire Department Costs

The Ontario Fire Marshall's Office provided 2003 data on operating expenditures ($1.118 billion) and total responses (447,181) by fire departments in Ontario. This resulted in an average total cost per response of $2,501 (2003 $). The figure was converted to 2004 dollars resulting in an average response cost of $2,548.

Ambulance Costs

A cost of $783 (in 2005 $) per transported patient was used for ambulance costs. The value was estimated based on data provided by the City of Toronto website. This average value includes both fixed overheads and variable components of costs. In 2004 dollars the cost per land-based transport by ambulance is $754. A similar value was used for water ambulance service due to lack of data. A value of one-half was assumed for transport by the Coroner. An average cost of approximately $5,000 per person was used if air ambulance service was used.

Additional costs relating to tow trucks, property damages, out-of-pocket expenses, and traffic delays were also developed.

A.8 Calculating External Costs of Transportation in Norway (Eriksen, 2000)

Report Title: Calculating External Costs of Transportation in Norway

Author(s): Eriksen (2000)

Jurisdiction: Norway

Brief Overview

The study attempts to assign a dollar value to some of the external effects that are related to transport activities. The external effects included in the analysis were: a) emissions to air, b) noise, c) traffic collisions, d) wear of infrastructure and e) congestion. External costs were expressed as a function of transport volume, intensity of the effect, degree of harm of the effect and unit cost of harm.

Costs

The estimation methods and the basic unit collision cost (in Euros and by area) are shown in the table below.

Table A-6: Estimation Methods and Basic Unit Costs (External Costs)

Table 1. Estimation methods and basic unit costs after type of external cost (Euro)

	per unit	*estimation method*	Big cities	Other built-up areas	Rural areas
			Local emissions		
SO_2	kg	WTP	8.75	8.75	2.12
NO_X	kg	meta-analysis	8.25	8.25	4.12
VOC	kg	meta-analysis	8.25	8.25	4.12
PM10	kg	WTP	212.5	25	0
			Global emissions		
CO_2 (and equivalents)	ton	shadow price	46.25	46.25	46.25
			Noise		
Road transport	20%*	WTP	146.25	146.25	0
Rail transport	50%*	hedonic price	137.50	137.50	0
Air transport	50%*	WTP	125.00	125.00	125.00
			Accidents		
Statistical death	case	WTP + mat **	2 150 000	2 150 000	2 150 000
Very serious injury	case	WTP + mat **	860 000	860 000	860 000
Serious injury	case	WTP + mat **	282 000	282 000	282 000
Light injury	case	WTP + mat **	24 000	24 000	24 000
			Congestion		
Passenger car unit	km	simulations	0.105	0	0

* Reduction in 'subjective' noise.
** Material and administrative costs

Model Approach

The study used the willingness-to-pay modeling approach.

Parameters used in the Model / How Parameters were Calculated

The study investigated three types of collision costs:

- Costs of loss of human life and reduced health condition
- Lost income and expenses due to collisions
- Material costs

The parties that bear these costs are injured persons, their family members, vehicle owners, private third parties and the public sector. The costs for all these parties together make the total social costs of traffic collisions. It is unclear from the text how all the parameters were calculated but it seems that the values were based on similar studies conducted in Europe.

A.9 International Comparison of Costs of a Fatal Casualty of Road Accidents in 1990 and 1999 (Trawen et al, 2002)

Report Title: International Comparison of Costs of a Fatal Casualty of Road Accidents in 1990 and 1999

Author(s): Trawen et al. (2002)

Jurisdictions: Australia (AU), Austria (AT), Finland (FI), Germany (GE), Great Britain (GB), the Netherlands (NL), New Zealand (NZ), Norway (NO), Sweden (SE), Switzerland (CH) and the US

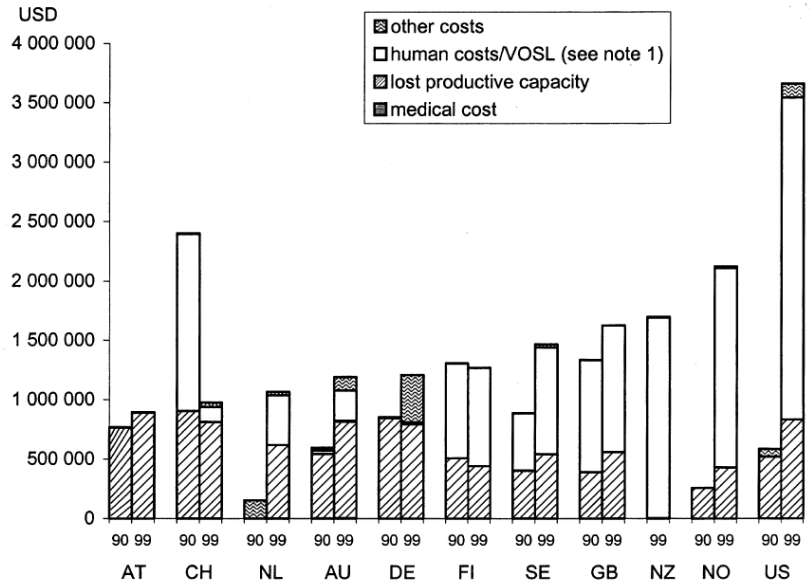
Brief Overview

The study assembles information of costs per fatal casualty in traffic collisions as adopted by authorities in different countries. The paper provides an analysis and comparison of the different cost figures as well as the methods used for estimating the cost values. The costs per fatality, usually defined as direct and indirect costs plus a value of safety are compared both between countries and over time (1990 and 1999) for each country.

Costs

The fatal collision cost by country is shown in the Figure 1 below.

Figure A-1: Summary of Fatal Collision Costs By European Country and the US



Model Approach

A variety of methods were used to estimate the costs per fatal collision. The three most common valuation methods included: the cost of restitution method, the human capital approach and the WTP approach. The cost of restitution method represents the direct costs generated by collisions (administrative unit prices or market prices).

The human capital approach (HCA) measures the loss to society due to a fatal collision, based on future productive potential of the victim. To estimate the HCA three methods are generally used: (a) gross loss of production, (b) net loss of production, where lost consumption is excluded and (c) value of lost life expectancy that includes the value of working years left as well as the cost of the loss of leisure.

The WTP approach is based on preferences stated or implicitly revealed by individuals or society. The individual WTP may be estimated by questionnaires, where the respondents give their maximum WTP for a risk reduction (the contingent valuation method), or by studying behavior in situations, where reduced risk must be traded off against other commodities (the revealed preferences method). The social WTP is obtained from implicit valuations in public decision-making.

Parameters used in the Model / How Parameters were Calculated

Definitions of the cost-elements came from the COST 313 (1994) report, which simplified cost comparison. Unfortunately, in some cases, definitions differed between countries.

Medical costs are health care costs for persons injured in a traffic collision. They include: costs of first aid, ambulance transport, ambulatory care and in-patient treatment. Other costs included: costs of administration for insurance companies, police and court due to the collision, and property damages on vehicles, roads and buildings, etc.

Lost productive capacity means the value of lost production due to a fatal injury in road traffic. Gross lost production is often estimated as income loss for the dead person and social security contribution. Net lost production refers to the value of gross lost production minus the value of the individuals' consumption lost.

There are at least four circumstances that influence the results when estimating the lost productive capacity: (1) if the estimates include only the workforce and exclude the value of the household market, (2) if the costs for lost productive capacity include lost consumption or not (if they refer to gross or net costs), (3) if future loss of earnings are discounted and the level of the discount rate and (4) if an assumed growth rate for income or output is made explicit and the level of this growth rate.

The value of a statistical life (VSL) is estimated in studies where hypothetical markets are constructed and, where individuals give their maximum WTP for a marginal risk reduction of a fatal injury. The VSL can be estimated from a population's observed average WTP divided by the individual risk reduction. For example, if the affected individuals on average are willing to pay USD 13 for a 1/100,000 reduction in the probability of death, then the VSL is USD 1.3 (million) and would reflect the populations' value of a safety improvement involving the avoidance of one statistical traffic death.

Human cost often refers to the pain, grief and suffering components that follow from a fatal injury. The human cost is in some countries, e.g., in Great Britain and Sweden, reflecting the difference between the VSL and the net lost production. In these countries, VSL is taken to include the value of lost consumption and therefore, adding VSL on top of gross lost production would have resulted in double counting. In some other countries, e.g., Australia, Austria, Germany and Switzerland, the human cost has been estimated independently of consumption loss and thus reflects a value of risk aversion in general. When considering total costs of a fatal injury, it is important to distinguish between human cost and VSL and how to add these elements to the lost production estimate, in order to avoid double counting.

A.10 Cost of Road Crashes: A Comparison of Methods and Recent Australian Estimates (Giles, 2003)

Report Title: The Cost of Road Crashes: A Comparison of Methods and the Recent Australian Estimates

Author(s): Giles (2003)

Jurisdiction: Australia

Brief Overview

The paper argues that the estimations of road collision costs in Australia over recent decades are deficient for two reasons. First, estimations use an ex post (human capital) approach, despite economic theory recommending the ex ante (willingness-to-pay) approach as the preferred means of placing dollar values on lives saved. Second, if the human capital approach is used in the absence of ex ante measures, then the derivation of human capital (forgone earnings) measures needs to comprehend factors such as age and gender, educational attainment, labour force experience and sector of employment, which are currently ignored. The paper concludes by highlighting the differences between ex ante and ex post estimates of annual road collision costs in Australia.

Costs

The estimated collision costs based on the Human Capital Approach and the Willingness-to-Pay or Willingness-to-Accept approach are provided in Table 8 and Table 9 on the following pages.

Table A-7: Cost Estimates Based on Human Capital Approach

Author	*Date of Publication*	*Included Costs*	*Base Year*	Ex Post *Cost Estimate**
Troy and Butlin	1971	ACT only	1963	A$4.1m
Atkins	1981	Australia	1978	A$1,591.1m
Steadman and Bryan	1988	Australia	1985	A$5,233.7m
BTCE	1992	Australia	1988	A$6,130.8m
BTE	2000	Australia	1996	A$14,980.0m

Notes: *Represents total *ex post* costs, including *ex post* values of life (lost production/forgone income).

Table A-8: Cost Estimates: Stated Preference (Willingness-to-Pay or Willingness-to-Accept)

Author	*Date of Publication*	*Country*	*Method*	*Type of Risk*	*Base Year*	*Estimate*
Blomquist	1979	US	Revealed preference	Fatality	1978	US$370,000
Blomquist	1996	US	Revealed preference	Fatality Non-fatal (moderate to serious) injury	1991	US$2 million US$70,000
DOT (UK)[a]	1991	UK	Contingent valuation	Fatality Non-fatal injury[f]	1990	£664,940 20,160
DOT (UK)[b]	1994	UK	Standard gamble	Non-fatal injury	1992	£74,480
DOT(UK)	1996	UK	Contingent valuation	Fatality Serious casualty Slight casualty	1995	£812,010 £92,570 £7,170
DETR (UK)	2000	UK	Contingent valuation	Fatality Serious casualty Slight casualty	1999	£1.089m £122,380 £9,440
DTLR (UK)	2001	UK	Contingent valuation	Fatality Serious casualty Slight casualty	2000	£1.145m £128,650 £9,920
Jones-Lee	1993	UK	Contingent valuation Revealed preference	Fatality	1991	£2.03–3.21m £1.05–2.34m
Jones-Lee	1995	UK	Standard gamble	Serious non-fatal injury	1990	£70,000
Kneisner and Leeth[c]	1991	Australia	Revealed preference	Fatality	1995	US$2.126m[g]
Landefeld and Seskin	1982	US	Contingent valuation	Fatality	1973	US$37,000
Miller[d]	1990	US	Contingent valuation	Fatality	1995	US$3.472m[h]
Thaler and Rosen[e]	1976	US	Revealed preference	Fatality	1980	US$494,000

Notes:

[a]As reported in Haight (1994). [b]As reported in Jones-Lee (1995: 692). [c]As updated by Miller (2000). [d]As updated by Miller (2000). [e]As updated in Blomquist (1982). [f]As reported in Jones-Lee (1995: 692). [g]Mean after-tax value. [h]Mean after-tax value.

Model Approach

The paper compares two approaches to estimate the collision costs in Australia. First, with the *ex ante* (willingness-to-pay) method, attempts are made to value society's willingness-to-pay to avoid incurring the death, injury, and damage outcomes of road collisions or the compensation the society is prepared to accept to incur the risk of premature death.

Second, there is an *ex post* (human capital) method in which actual values are estimated for the various components of the total cost of road collisions, such as the value of human life based on potential earnings.

Parameters used in the Model / How Parameters were Calculated: N/A

A.11 Collision Cost Prediction Model: System Dynamics Approach (Partheeban, 2008)

Report Title: Road Accident Cost Prediction Model using System Dynamics Approach

Author(s): Partheeban et al. (2008)

Jurisdiction: Chennai, India

Brief Overview

The paper develops a model for road collisions using a systems dynamics approach. To build a collision model, various factors causing the road collision and the associated costs were identified. The model is capable of calculating the collision rate and the collision costs for the future. Only bus-related collisions were considered. The collision model is built on the year 2000 data and predicted the collisions up to 2020 for every 5-year interval.

Costs

The average value for the factors associated with collision costs are provided in the table below.

Table A-9: Average Values of Factors of Collision Cost

Table 1. Average values of factors of accident cost (1 US$ = 46 INR)

Sl. No.	Description	Average Value		
		Fatal Accident	Serious Accident	Minor Accident
1	Expectation of life (years)	60	60	60
2	Average age of accident victim (years)	30	30	30
3	Income per month (Rs.)	5 200	5 200	5 200
4	Period of loss	30 years	60 days	7 days
5	Period of hospitalization (days)	5	25	1
6	Daily hospital Expenses (Rs.)	400	350	100
7	First time payment in the hospital (Rs.)	1 000	8 000	800
8	Court related expenses (Rs.)	2 450	2 500	500
9	Administrative expenses of Police, Insurance etc., (Rs.)	3 110	3 000	400
10	Consumption per month (Rs.)	1 700	1 700	1 700

Model Approach

Collision costs were composed of 1) public cost (human capital cost and resource cost) and 2) private cost or human suffering cost. The human capital approach was used to determine the social costs.

Parameters used in the Model / How Parameters were Calculated

Medical Costs included emergency transport, medical, hospital, rehabilitation, mental health, pharmaceutical, ancillary, and related treatment costs, as well as funeral/ coroner expenses for fatalities and administrative costs of processing medical payments to providers.

Other costs include police, fire, legal/court, and victim services (e.g., foster care, child protective services), plus the costs of property damage or loss in injury incidents. Work Loss Costs value productivity losses. They include victims lost wages and the replacement cost of lost household work, as well as fringe benefits and the administrative costs of processing compensation for lost earnings through litigation, insurance, or public welfare programs. As well as victim work losses from death or permanent disability and from short-term disability, this category includes work losses by family and friends who care for sick children, travel delay for uninjured travelers that results from transportation collisions and the injuries they cause, and employer productivity losses caused by temporary or permanent worker absence. Quality of life includes the value of pain, suffering, and quality of life loss to victims and their families. It is unclear from the study how the average values shown in the table were computed.

A.12 The External Costs of Traffic Injury: Definition, Estimation, and Possibilities for Internalization (Elvik, 1994)

Report Title: The External Costs of Traffic Injury: Definition, Estimation, and Possibilities for Internalization

Author(s): Elvik (1994)

Jurisdiction: Norway

Brief Overview

The paper estimated collision costs to determine external costs (these are costs that are imposed on others and not borne by the person whose activity generated the costs). The paper compares three types of external costs identified as system, physical injury and traffic volume externalities.

Costs

Table A-10. Cost of Traffic Injury in Norway, 1991 (By Injury)

Injury severity	Type of cost	Distribution of costs by interested party				Total costs
		Road users	Household members	Private third parties	Public sector	
Fatal	Lost quality of life	8,279,000	1,250,000			9,529,000
	Travel time delay			5,000		5,000
	Medical treatment				6,000	6,000
	Lost output	1,651,000	1,656,000		1,275,000	4,582,000
	Property damage	44,000	6,000	8,000		58,000
	Administrative costs	26,000	3,000	3,000	10,000	42,000
	Total costs	10,000,000	2,915,000	16,000	1,291,000	14,222,000
Very severe	Lost quality of life	2,500,000	312,000			2,812,000
	Travel time delay			4,000		4,000
	Medical treatment	40,000	40,000		108,000	188,000
	Lost output	336,000	337,000	144,000	1,357,000	2,174,000
	Property damage	33,000	4,000	7,000		44,000
	Administrative costs	20,000	3,000	3,000	36,000	62,000
	Total costs	2,929,000	696,000	158,000	1,501,000	5,284,000
Severe	Lost quality of life	800,000	100,000			900,000
	Travel time delay			3,000		3,000
	Medical treatment	13,000	12,000		81,000	106,000
	Lost output	55,000	55,000	94,000	455,000	659,000
	Property damage	23,000	3,000	4,000		30,000
	Administrative costs	14,000	2,000	3,000	13,000	32,000
	Total costs	905,000	172,000	104,000	549,000	1,730,000
Slight	Lost quality of life	100,000	12,000			112,000
	Travel time delay			1,000		1,000
	Medical treatment	2,000	2,000		9,000	13,000
	Lost output			5,000	5,000	10,000
	Property damage	16,000	2,000	3,000		21,000
	Administrative costs	11,000	1,000	2,000	3,000	17,000
	Total costs	129,000	17,000	11,000	17,000	174,000
Currency conversion: convert to US Dollars (December 1993) by multiplying each figure by 0.135						

Model Approach: N/A

Parameters used in the Model / How Parameters were Calculated

The estimated costs of lost quality of life are based on an extensive literature survey of willingness-to-pay studies conducted by Elvik (1993). Based on this survey, a value of 10 million Norwegian kroner for a reduction of risk corresponding to one fatal injury was proposed as the best estimate of the willingness-to-pay for reduced risk of fatal injury.

The costs of lost quality of life for the other levels of injury severity were assumed proportional to the number of lost years of living with perfect health entailed by these injuries. These losses were estimated by means of health state indexes describing the quality of life in a certain health state as a number of "quality adjusted life years" (QALYs). The estimates were based on a detailed sample survey of the daily life of traffic injury victims conducted by Haukeland (1991). A severe injury, for example, was estimated to lead to a number of lost years of living with perfect health corresponding to 8% of the loss in case of a fatal injury. Hence, the cost of lost quality of life for a severe injury was estimated to be 800,000 Norwegian kroner, granted the value of 10 million Norwegian kroner for a fatal injury. The value of consumption was deducted from the willingness-to-pay for reduced risk of fatal injury, leading to a "pure" lost-quality-of-life cost of 8,279,000 Norwegian kroner. Corresponding deductions were not made for the other levels of injury severity, since surviving victims continue to consume.

Very little is known about the costs of lost quality of life for members of the household of someone who is killed or injured. Based on the survey of willingness-to-pay studies conducted by Elvik (1993) a tentative estimate of 12.5% of the costs for the injury victim was adopted. For a fatal injury, this means that the costs of lost quality of life for household members are 1,250,000 Norwegian kroner.

The distribution of costs between interested parties was estimated by relying on a number of sources. The costs of travel-time delays caused by traffic collisions are imposed on other road users, who, in this case, take on the role of private third parties.

Most of the costs of medical treatment are paid by the public sector in Norway. The proportion of these costs paid by injury victims (road users) and their family members was estimated from a sample survey of injury victims (Haukeland 1991). The sample survey did not identify which household member-the injured person or someone else-paid for medical treatment. Based on the fact that exactly 50% of the population belongs to the work force, a 50-50 distribution between injury victims and other household members was assumed.

As far as lost output is concerned, the public sector accounts for at least 50% of the costs of lost output from paid work in terms of lost tax payments. For most very severe and

severe injuries, the public sector gets additional social security payments. The number of injuries that lead to additional social security payments was estimated from a study made by Hagen (1993). It can be argued that the public sector saves the future payment of retirement benefits if someone dies prematurely, but this saving has not been estimated. The costs of lost output include a valuation of household work. The costs of lost household work were assumed to be distributed evenly (50-50) between injury victims and other members of the household. Most of the costs of property damage are covered by insurance. About 15% of the vehicle fleet belongs to businesses, rather than to private individuals. Hence, 15% of the costs of property damage were assumed to be paid by private third parties through their purchases from businesses owning motor vehicles. Of the remaining 85%, about 75% are assumed to be paid by road users (vehicle owners) and 10% by household members. These figures reflect the fact that it is not always the owner of a vehicle who drives it in case of a collision. About 91% of the administrative costs are costs of insurance administration. These costs were assumed to be distributed the same way as the costs of property damage. The rest of the administrative costs (social security administration, police costs, and court costs) are paid by the public sector.

GLOSSARY

Abbreviated Injury Scale (AIS)	Developed by for the Association for the Advancement of Automotive medicine, this scale is used to describe the severity of injuries according to six categories: minor, moderate, serious, severe, critical, and un-survivable.
Classification of Collision Severity	Refers to methods of classifying the resulting injuries and damage caused by collisions. The classification method *by collision* has 3 levels: fatal, injury and property damage only. The classification method *by victim* [injury] has 4 levels: fatal, major injury, minor injury, property damage only.
Direct costs	Sometimes called ***internal*** costs. These are the largely tangible and clearly understood costs that can be directly linked to the collision, including property damage costs, emergency services, medical expenses, legal costs, travel delay costs and the costs associated with lost time from the workplace. Often, the data required to accurately determine the direct costs of collisions are readily available. Types of direct costs: property damage, emergency response, health services, loss of short term productivity, travel delay and pollution.
Disability Adjusted Life Year (DALY)	Used in studies evaluating health outcomes, this method involves calculating the life expectancy factoring the burden that can be associated with an injury.
Health Years Equivalent (HYE)	Refers to the hypothetical number of years spent in good health, and can be used in calculation of indirect costs after an injury.

Human Capital costs	These are indirect costs that estimate the future net production that is lost to society as a result of an injury related collision. A value for future net production is calculated by subtracting the injured victim's future net consumption from their future net production. This calculated value represents a measure of the 'value' of that person to society.
Indirect costs	Sometimes called ***external*** costs. Represent the damages and losses that are NOT necessarily assumed by the individual who is involved in the incident, but are costs that are taken on by persons close to the individual (e.g., family members) and by the society as a whole. Types of indirect costs: loss of [long term] productivity, pain and suffering, lost quality of life, value of statistical life.
Quality of Life	Lost quality of life as a result of an injury or disability is an important component of determining the indirect cost of collisions. The cost is of interest to the healthcare sector when making decisions about allocation of resources based on economic evaluations.
Quality Adjusted Life Year (QALY)	Used in studies evaluating health outcomes and health status, this method combines life expectancy and the quality of life in perfect health, as one unit measure.
Value of Statistical Life (VoSL)	A commonly used method used to calculate the indirect cost of collisions. This is the value associated with an unexpected death due to a collision.
Willingness-To-Pay costs (WTP)	These are indirect costs that a society would be "willing to pay" to prevent or reduce the risks associated with the occurrence of collisions, particularly collisions that involve injury and death. These values are obtained by conducting research with a representative sample of people, comparable to the population being studied.