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

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EXECUTIVE SUMMARY

A. SOCIAL COSTS OF MOTOR VEHICLE COLLISIONS IN ONTARIO

Motor vehicle collisions generated $18 billion in social costs in Ontario in 2004. Fatalities in those collisions were the largest single contributor to social costs at $11 billion. Also significant were the costs of injuries, at $4 billion and property damage at $2 billion. Other major contributors to the social costs of motor vehicle collisions were: traffic delays; out-of-pocket expenses; hospital/health care; tow trucks; and police, fire and ambulance services.

By collision severity:

- Fatal collisions represent less than 1% of the 231,548 Highway Traffic Act (HTA) reportable collisions in 2004. However, they account for $11 billion or 64% of total social costs. The average social cost of a fatal collision in 2004 was $15.7 million.
- Injury collisions make up 27% of all collisions and 28% or $5 billion of all costs. The average social cost of an injury collision in 2004 was $82 thousand.
- Property Damage Only (PDO) collisions—while the largest collision group at 73% resulted in $1 billion or 8% of social costs. The average social cost of a PDO collision in 2004 was $8 thousand.

Across all collision severities the average social cost of a collision in Ontario in 2004 was $77 thousand. By major consequence of collision the average full (including all allocated) social cost was:

- Fatality — $13.6 million.
- Major injury — $280 thousand.
- Minor injury — $48 thousand.
- Minimal injury — $18 thousand.

Significant from a social cost perspective are sub-categories of collisions in 2004 related to:

- **Drinking and driving**. Collisions where at least one driver had involvement with alcohol not necessarily where alcohol was the cause of the collision represent 18% ($3 billion) of social costs, 24% of fatal collisions but only 3% of all collisions.
- **Pedestrian involvement**. These represent 11% ($2 billion) of social costs, 14% of fatal collisions and 2% of all collisions.

- **Large truck.** Collisions involving larger trucks represent 7% of all collisions, 18% of fatal collisions and 15% ($3 billion) of the social costs.
- **Freeway collisions.** Collisions occurring on 400 series highways represent 14% ($2 billion) of social costs, 12% of fatal, and 11% of all collisions.

B. SOCIAL COSTS OF MOTOR VEHICLE COLLISIONS FOR CANADA AND FOR EACH JURISDICTION

The 613,000 motor vehicle collisions occurring in Canadian jurisdictions in 2004 resulted in social costs of $63 billion. By type of collision, social costs were $39 billion (62%), $20 billion (32%), and $3 billion (5%) for fatal, injury and PDO collisions respectively. Beside Ontario other significant jurisdictions in terms of number and social costs of collisions were:

- Quebec—28% of social costs and 23% of collisions.
- Alberta—15% of social costs and 17% of collisions.
- British Columbia—14% of social costs and 8% of collisions.

C. MODELING THE SOCIAL COSTS OF COLLISION

This project produced a model of the social costs of motor vehicle collisions occurring in Ontario in 2004. The project advances an earlier social cost model (1994) also adding costs components related to traffic delay (extra time, fuel, and pollution).

The model was designed as a flexible tool to facilitate additional analyses including updating for future years. The core Ontario model was applied to sub-sets of collisions in Ontario and to collisions occurring in all Canadian jurisdictions in 2004. Changes to assumptions, values or parameters are easy to perform. The model includes high, low, and medium scenarios for valuing human consequences based on the technically preferred willingness-to-pay valuation methodology. These produce estimates of the human consequences of motor vehicle collisions in Ontario ranging from $7 billion to $22 billion. Also included is a scenario using a discounted future earnings approach that is used in some road safety applications. This method produces an alternative cost of human consequences of $1.5 billion.

We are indebted to the Ministry of Transportation, Transport Canada and the Workplace Safety and Insurance Board that funded the project as well as provided guidance and needed data. We thank other data contributors: the Ministry of Health and Long Term Care; the Insurance Bureau of Canada; the Ontario Provincial Police; the Ontario Fire Marshal; and the Coroner’s Office.

ABBREVIATIONS

CAC	Criteria Air Contaminants
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COMPASS	Advanced Freeway Traffic Management System
DFE	Discounted Future Earnings
EPA	Environmental Protection Agency
ER	Emergency Room
GHG	Greenhouse Gas
GTA	Greater Toronto Area
HC	Hydrocarbon
HTA	Highway Traffic Act
ICD-10	International Classification of Diseases (Version 10)
MTO	Ministry of Transportation
MOH&LTC	Ministry of Health and Long Term Care
NO_x	Oxides of Nitrogen
OPP	Ontario Provincial Police
ORSAR	Ontario Road Safety Annual Report
PCS	Passenger Car Survey
PDO	Property Damage Only
QEW	Queen Elizabeth Way
SOCO	Scenes of Crime Officer
TRAID	Traffic Accident Information Database TRAID
WS&IB	Workplace Safety and Insurance Board
WTP	Willingness to Pay
WTP-M	Willingness to Pay –Medium Scenario
WTP-L	Willingness to Pay –Low Scenario
WTP-H	Willingness to Pay—High Scenario

I INTRODUCTION

This report presents findings from the *Analysis and Estimation of the Social Cost of Motor Vehicle Collisions in Ontario*.[1] The report covers the results of all phases of the study related to data acquisition, modeling, estimation, and validation.

The report is structured as follows:

- Chapter II provides an overview of the social cost model and its results.
- Chapter III provides details on the core Ontario model, data and adjustments.
- Chapter IV presents the social costs of motor vehicle collisions occurring in Ontario in 2004 as estimated by the core Ontario model.
- Chapter V provides an overview of four sub-models of Ontario collisions, their data, adjustments and social costs. These sub-models cover particular sub-sets of Ontario collisions occurring in 2004:
  - Drinking and driving collisions.
  - Pedestrian involved collisions.
  - Large truck collisions.
  - Freeway collisions. (Separate calculations are provided for social costs and costs to government only.)
- Chapter VI gives an overview of the Canadian jurisdictions model. Data, adjustments and social costs are presented for the 13 jurisdictions in Canada and for all of Canada.

Appendices cover:

- Appendix A—Detailed Calculations of the Ontario Model. This appendix identifies how data are used in the core model and all assumptions that are made.
- Appendix B—Changing the Model. Features of the model are described. Examples are presented to test alternative scenarios or to update the model for future collision information. Further it describes how to make changes to the parameters of the model.
- Appendix C—Discounted Future Earnings. Details on the methods to estimate this alternative value for human consequences are provided.

1 This study was commissioned by the Ontario Ministry of Transportation, Transport Canada and the Workplace Safety and Insurance Board. A Steering Committee of representatives from these organizations was instrumental to the success of the study.

- Appendix D—Value of Human Consequences of Collisions by Jurisdiction based on Alternative Assumptions. In this section we provide the value of human consequences for each jurisdiction using the alternative methods and scenarios.
- Appendix E—References. References used by the study are identified.

II SOCIAL COST FINDINGS AND MODEL OVERVIEW

A. INTRODUCTION

This chapter presents key findings on the social costs of motor vehicle collisions and an overview of the Social Cost Model that produced them. More detail on the model's component parts and social cost findings can be found in separate chapters devoted to the models of the social costs of motor vehicle collisions for: Ontario; sub-sets of collisions in Ontario; Canadian jurisdictions; and individuals covered by the WS&IB as well as in Appendices.

For ease of presentation, this chapter provides social cost estimates for all models based on the willingness to pay (WTP) approach and medium scenario for estimating the value of human consequences of motor vehicle collisions. The willingness to pay methodology applies a constant value to human consequences regardless of the gender, age, employment status, or category (driver, passenger, or pedestrian) of individual. The medium scenario calculates average values for human consequences based on previous WTP estimates and on recent (higher) estimates that eliminate biases in the earlier values based on WTP. Estimates based on other valuation methods and scenarios are presented in later chapters and appendices.

B. SOCIAL COSTS OF MOTOR VEHICLE COLLISIONS

1. Ontario—all collisions

Motor vehicle collisions in Ontario in 2004 have a social cost of $17.9 billion. Although fatal collisions accounted for less than 1% of the 231,548 Highway Traffic Act (HTA) reportable collisions, they represented $11.5 billion or 64% of total social costs estimated in 2004. Injury collisions make up 27% of all collisions and 27% or $5.0 billion of all costs. Property Damage Only (PDO) collision—while the largest collision group at 73% resulted in $1.3 billion or 8% of social costs.

Among total social costs the most significant cost components were:

- Fatalities — $11.1 billion (62%).
- Injuries — $3.9 billion (22%).
- Property damage — $1.8 billion (10%).
- Traffic delays — $0.5 billion (3%).
- Out-of-pocket expenses — $0.2 billion (1%).

The average social cost of a collision by collision severity was: Fatal—$15.7 million; Injury—$82 thousand; and PDO—$8 thousand. The average collision had a social cost of $77 thousand in 2004.

2. Ontario—collisions by specific sub-groups

Exhibit II-1 presents the number of collisions by collision severity and the social costs for four sub-groups of collisions occurring in Ontario in 2004. The percentages indicate the sub-groups share by collision severity and social costs among all collisions in Ontario in 2004.

Exhibit II-1 Incidence and Social Costs by Sub-Group of Ontario Collision—2004

	Collision Severity				Social
	Fatal	Injury	PDO	TOTAL	Cost
	(#)	(#)	(#)	(#)	($ 000,000)
Number of collisions and social costs					
Drinking and driving	174	3368	3854	7396	$3,135.8
Pedestrian	106	4316	133	4555	$1,877.9
Large truck	133	3700	12466	16299	$2,712.4
Freeway	86	7572	18382	26041	$2,448.7
Per cent of collisions and social costs relative to Ontario					
	(%)	(%)	(%)	(%)	(%)
Drinking and driving	24	5	2	3	18
Pedestrian	14	7	0	2	11
Large truck	18	6	7	7	15
Freeway	12	12	11	11	14

By sub-group of Ontario collisions in 2004:

- Collisions associated with drinking and driving by one or more involved drivers (not necessarily where alcohol was the cause of the collision) represent 3% of all collisions but 24% of fatal collisions. Drinking and driving collisions represent 18% ($3.1 billion) of the social costs of collision in Ontario in 2004.
- Collisions where one or more of those involved were pedestrians represent 2% of all collisions, 14% of fatal collisions and 11% ($1.9 billion) of the social costs of collision in Ontario in 2004.

- Collisions where one or more of the vehicles involved was a large truck[1] represent 7% of all collisions, 18% of fatal collisions and 15% ($2.7 billion) of the social costs of collision in Ontario in 2004.
- Freeway collisions (those occurring on 400 series highways) compared to the other sub-groups of collision are most similar to the typical collision in Ontario. They represent 11% of all, 12% of fatal, 12% of injury, and 11% of PDO collisions. They also represent 14% ($2.4 billion) of the social costs of collision in Ontario in 2004.

Government costs related to freeway collisions were $51 million in 2004. These represent a sub-set of costs (hospital/health care, police, courts, fire, and ambulance) incurred by government.

3. Canadian jurisdictions

Social costs of the 613,000 motor vehicle collisions occurring in Canadian jurisdictions in 2004 were $62.7 billion. By type of collision, social costs were $39.0 billion (62%), $20.3 billion (32%), and $3.4 billion (5%) for fatal, injury and PDO collisions respectively. Social costs and the per cent (in brackets) by jurisdiction were:

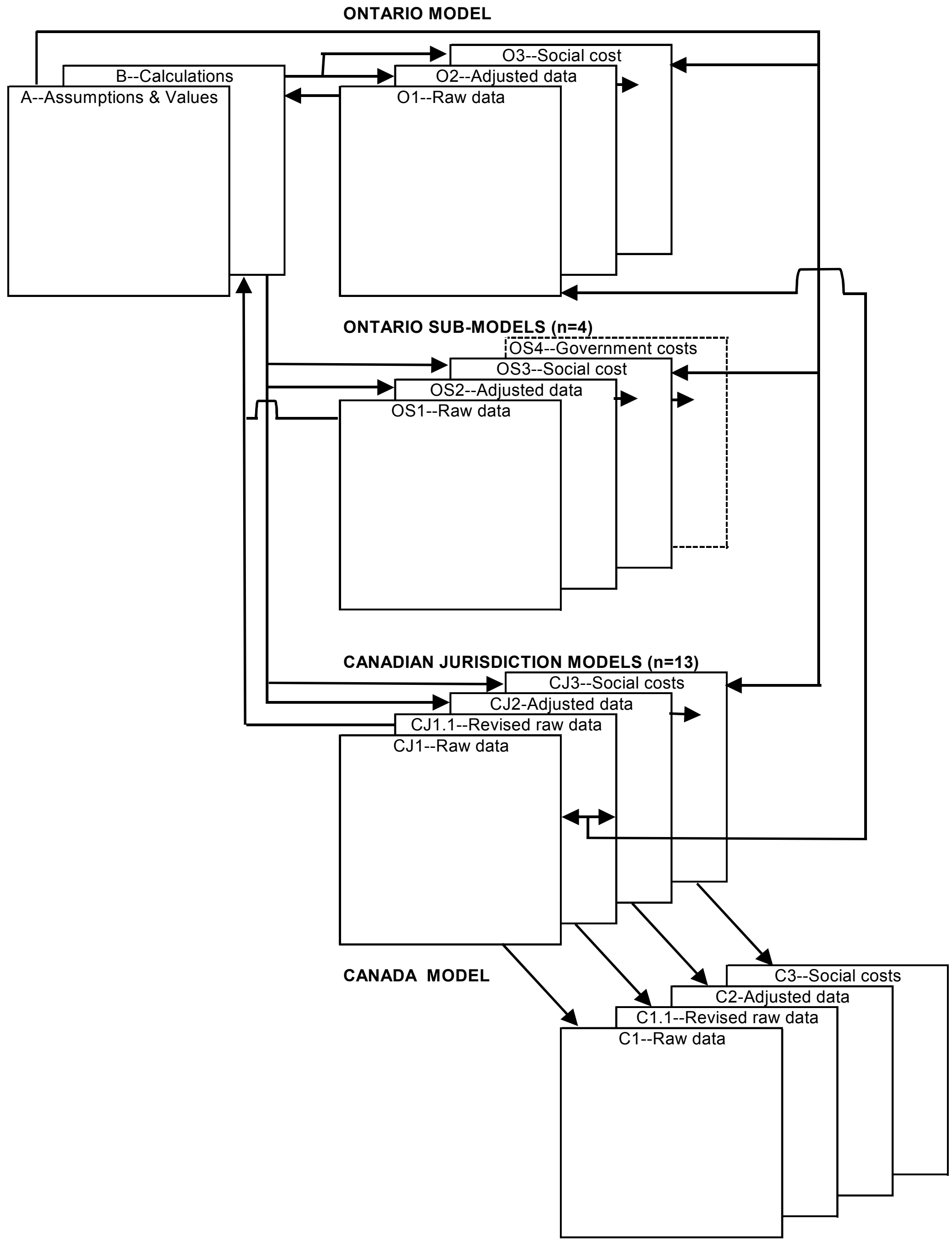
- Newfoundland and Labrador — $0.9 billion (1.4%).
- Prince Edward Island — $0.5 billion (0.8%).
- Nova Scotia — $1.7 billion (2.8%).
- New Brunswick — $1.4 billion (2.3%).
- Quebec — $17.4 billion (27.9%).
- Ontario — $17.9 billion (28.6%).
- Manitoba — $2.2 billion (3.5%).
- Saskatchewan — $2.4 billion (3.9%).
- Alberta — $9.1 billion (14.5%).
- British Columbia — $8.8 billion (14.1%).
- Yukon — $0.1 billion (0.2%).
- Northwest Territories — $0.06 billion (0.1%).
- Nunavut — $0.02 billion (0.0%).

[1] Large truck is defined according to the following selected values under "Vehicle Type" in the MTO Accident Database System (ADS) : 8 truck—open (flatbed); 9 truck—closed (box, van); 10 truck—tank; 11 dump truck; 12 truck—car carrier; 13 truck— tractor; and 98 truck—other (cement mixer, crane, etc.)

C. BASIC STRUCTURE OF THE MODEL

The "model" to estimate the social cost of motor vehicle collisions comprises a series of models and sub-models, each made up of a series of linked spreadsheets. This basic structure is presented in Exhibit II-2. Major linkages between the spreadsheets are identified through arrows—the direction indicating the causal relationship between the spreadsheets.

Exhibit II-2 Structure of the Social Cost Model



Supporting the overall model are two spreadsheets. The first (A—Assumptions & Values) provides social values for the various impacts of collisions. It also allows the analyst control over some model parameters. Parameters include whether the model produces estimates using Willingness to Pay (WTP) or Discounted Future Earnings (DFE); whether a high (WTP—H), low (WTP—L), or medium (WTP—M) estimate is used for WTP[1]; and whether social costs are calculated using values for 2004 or another year.

The second spreadsheet (B—Calculations) provides the calculations needed by the model to adjust for cases of under-reporting and misreporting of collision effects. These provide the mechanism to go from raw data (available from secondary sources) to adjusted data that have been corrected for cases of under-reporting and misreporting observed in data from other secondary sources. The exhibit also provides the set of calculations needed to identify other effects of collisions such as the use of resources by police, fire, and ambulance services.

Two other spreadsheet models not linked to the social cost model are the model used to produce DFE estimates and the model that estimates delay costs. Output from these models is entered as fixed parameters in the social cost model.

1. Ontario model

The Ontario model has three printable spreadsheets:

- **O1—Raw data** will display raw data extracted from the Ontario Road Safety Annual Report (ORSAR) and Accident Database System (ADS) on the effects or characteristics of collisions in Ontario that are Highway Traffic Act (HTA) reportable.
- **O2—Adjusted data** will provide revised collision characteristics based on adjustments for cases of under-reporting and misreporting in the raw data. It also displays other estimated characteristics of motor vehicle collisions (ambulance, fire, tow truck and police services for example) that are valued in other parts of the model.
- **O3—Social costs** provides the total social cost estimated based on the collision characteristics and the values and selected parameters (assumptions) of spreadsheet A—Assumptions and Values.

The core Ontario model enters data (in O1—Raw data) on the characteristics of collisions in Ontario as reported in ORSAR. These are adjusted to reflect cases of under-reporting and misreporting and to add other impacts of the collision, such as use of police

[1] The high and low estimates are based on alternate willingness-to-pay estimates for the value of statistical life available in the literature. The medium estimate averages the other two.

fire and ambulance resources, based on calculations of spreadsheet B—Calculations. Adjusted collision characteristics and estimates of other impacts of the collision are then presented in O2—Adjusted data.

In these two spreadsheets, data are organized by collision severity (fatal, injury, and property damage only (PDO) and total) and by key characteristics such as the number of collisions, fatalities, and injuries by severity, and vehicles damaged by severity. The format for the raw data (spreadsheet O1) and adjusted data (spreadsheet O2) of the model is presented in Exhibit II-3.

Exhibit II-3 Characteristics of Collisions in Total and by Collision Severity—Numbers of Collisions, Fatalities, Injuries and Damaged Vehicles

	Crash Severity			
	Fatal	Injury	PDO	TOTAL
Collisions				
Fatalities				
Injuries:				
Major				
Minor				
Minimal				
Vehicles damaged:				
Demolished				
Severe				
Moderate				
Light				
None				

The adjusted human consequences (fatalities and injuries) and other impacts of spreadsheet O2 are then valued using the assumptions and values of spreadsheet A. Non-human consequences are estimated based on the adjusted data (number of collisions, fatalities, injuries and vehicles damaged) and calculations of spreadsheet B and then valued using the values and assumptions of spreadsheet A.

The social values of these human and non-human consequences are presented in spreadsheet O3—Social costs. The spreadsheet presents separate estimates for human and non-human consequences by collision severity and in total. Social values are based either on individuals' willingness-to-pay or the opportunity cost (value in best alternative use) for resources used. Discounted future earnings estimates represent net losses in income either outside (earnings) or inside (lost household production) the home. The models do not include estimates for "pain and suffering" sometimes included in court awards related to the losses through collisions. Exhibit II-4 illustrates the format of the output of the social cost model.

2. Ontario sub-models

There are four separate sub-models for Ontario, each one formed by sub-sets of HTA reportable collisions:

- **Drinking and driving collisions** defined as collisions associated with alcohol consumption by one or more involved drivers—not necessarily where alcohol was the cause.
- **Collisions involving pedestrians** where one or more of individuals involved was a pedestrian.
- **Large truck collisions** defined as involving one or more vehicles qualifying as large truck.
- **Motor vehicle collisions on freeways** (or 400 series highways).

Each is structured like the Ontario model. However, the raw data of the Ontario model are replaced with a sub-set of collisions (in OS1—Raw data) meeting the particular collision characteristics (the number of collisions, fatalities, injuries by severity, and vehicles damaged by severity by collision severity) of the sub-model presented above.

The same spreadsheet structure (as illustrated in Exhibits II-3 and II-4) is used. The only exception is to include an additional spreadsheet (like Exhibit II-4) reflecting a sub-set of government-only costs (hospital/health care, police, courts, fire and ambulance) related to motor vehicles collisions on freeways.

Exhibit II-4 Costs of Collisions in Total and by Collision Severity—Billions $ (2004)

	Collision Severity			
	Fatal	Injury	PDO	**TOTAL**
Fatalities				
Injuries:				
Major				
Minor				
Minimal				
Total disability				
Partial disability				
HUMAN SUB-TOTAL				
Other costs:				
Property damage				
Hospital/Health care:				
- ER facility				
- Hospital stay facility				
- Medical practitioners				
Police				
Courts				
Fire				
Ambulance				
Tow trucks				
Out of pocket				
Traffic delays:				
- Extra time				
- Extra fuel				
- Extra pollution				
OTHER SUB-TOTAL				
OVERALL TOTAL				

The same adjustment techniques are used to move from raw data to adjusted data based on observations of under-and misreporting. In most cases, calculations in the Ontario model to estimate non-human consequences are applied to the sub-models without change. Some adjustments are made to reflect the unique characteristics of particular models such as more costly tow truck services for large truck collisions and more delay and pollution for collisions on freeways.

3. Canadian jurisdictions model

Raw data on collisions for each of the thirteen Canadian jurisdictions were obtained from Traffic Accident Information Database (TRAID). These data have slightly different formats and coverage by jurisdiction. A first task was to adjust data for each jurisdiction to the format of the Ontario data. When the detail available in the Ontario data was missing (for example an injury severity classification or the distribution of vehicle damage by damage severity) the distribution from Ontario was used to fill in for the missing values. This resulted in data for all jurisdictions being placed in the format of the Ontario data.

As a result, the raw data for a jurisdiction (C1—Raw data) were revised (in C1.1—Revised raw data) to reflect the structure of the data requirements of the Ontario model. Adjustments were made to handle cases of under and misreporting (in C2—Adjusted data) based on the observations made in the more detailed analysis for Ontario. Next the social costs of collisions were estimated based on the characteristics of the collisions in each jurisdiction using parameters established in the Ontario model (in C3—Social costs).

Adjusted collision data from the 13 jurisdictions are aggregated to provide results for Canada as a whole. Social costs for each jurisdiction are also aggregated to produce social costs for all collisions in Canada.

III ONTARIO MODEL

This chapter describes the Ontario model.

A. RAW DATA

Raw data for the Ontario model come from ORSAR. Exhibit III-1 presents the data for 2004.

Exhibit III-1 Raw Data for Ontario Model—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Collisions	718	49,948	180,882	231,548
Fatalities	799			799
Injuries:				
Major	245	3,320		3,565
Minor	330	29,589		29,919
Minimal	189	39,338		39,527
Vehicles damaged:				
Demolished	678	10,023	5,883	16,584
Severe	188	21,021	32,110	53,319
Moderate	147	24,698	99,313	124,158
Light	125	24,486	137,512	162,123
None	45	8,572	19,161	27,778
Unknown	58	5,420	37,511	42,989

In future applications, users will enter ORSAR data for other years to replace the 2004 data. Adjustment factors (developed based on the 2004 data) are applied to other year's data automatically. These adjustments are discussed in the next section.

Note that these ORSAR derived data do not include collisions that are not reported to police. A motor vehicle collision does not need to be reported if:

- No personal injury or fatality occurs.
- Damage to vehicles is less than $1,000.
- No other public or private property is damaged.

- No criminal activity (drinking and driving, stolen vehicle, driving under suspension) is suspected.

The first condition restricts any under-reporting to PDO collisions. As a result, data in ORSAR on the number of PDO collisions and on vehicles involved in PDO collisions are expected to be under-reported in the ORSAR data. We do not have data that would allow us to estimate the number of PDOs not reported to police and subsequently not included in the ORSAR data. Such unreported cases would have a minimal impact on the social cost estimates as they do not, by definition, involve human consequences (fatalities or injuries), or use of resources such as hospital/health care, ambulance, police, courts, and most likely fire departments. (In a later section we use data from the Insurance Bureau of Canada that may indicate the number of vehicles and cost of vehicle damage in unreported collisions.)

B. ADJUSTMENTS TO THE RAW DATA

A number of adjustments are needed to reflect cases of under-reporting and misreporting in the 2004 data. This section presents information on how the model moves from raw data found in ORSAR to adjusted data based on other information. These adjustment factors would be applied automatically if raw data for other years were entered in place of the 2004 ORSAR data. (If updated information used to produce the adjustment factors becomes available the analyst could also replace the information and thereby generate update adjustment factors.)

Diagrams are used to illustrate the adjustments built into the model.

1. Unknown damage to vehicles in collision

Police reports identify the extent of damage to vehicles involved in collisions. However, for 10% of vehicles involved in the collisions reported in 2004, damage is listed as unknown. By collision severity the percentage of unknown among total vehicles damaged is 5% for fatal, 6% for injury and 11% for PDOs.

We have no information that would indicate whether vehicles with unknown damage should be assigned in higher or lower proportion to more sever damage severity categories. For example, vehicles involved in a “hit-and-run” collision and listed as unknown damage may be more likely to have light damage (as the vehicle can be driven away) or severe damage (as the vehicle was involved in a significant collision sufficient to cause the driver to flee the collision scene). As a result, vehicles with unknown damage are assigned based on the known distribution of vehicles by damage severity.

The hypothetical example illustrated below shows the allocation of 10 vehicles with unknown damage to other damage categories based on the proportion of vehicles across other damage categories. The number of vehicles is unchanged by the redistribution. Similar adjustments would be performed automatically if raw data from ORSAR for other years were entered into the model in place of the 2004 data.

Step 1

Allocate unknown vehicle damage to other severity categories based on proportions in each category

Vehicles damaged:	
Demolished	20
Severe	20
Moderate	30
Light	20
None	10
Unknown	10
TOTAL	110

⇨

Vehicles damaged:	
Demolished	20 + 2
Severe	20 + 2
Moderate	30 + 3
Light	20 + 2
None	10 + 1
TOTAL	110

2. Human Consequences

Injury and fatality data reported in ORSAR tend to under report and misreport the extent of human consequences of motor vehicle collisions. This section discusses adjustments made in the raw data to better reflect the impacts on those involved in the collisions.

a) Additional deaths reported by Coroner's Office

ORSAR lists 799 fatalities related to motor vehicle collisions in Ontario in 2004. These data are based on Motor Vehicle Accident Reports (MVAR) filed by police officers. On occasion, a MVAR may not be submitted by police or may be amended but too late for inclusion in the ORSAR. Also the cause of death may be determined only later to be a motor vehicle collision by the Coroner but this information may not be provided to ORSAR or may be provided too late to include in ORSAR.

For 2004, the Coroner reports approximately 900 fatalities due to transportation related crashes, including HTA-reportable and non-reportable collisions, train and subway related incidents using a one-year cut-off instead of the 30-day limit imposed by ORSAR. Of the extra 36 motor vehicle collision fatalities reported by the Coroner, 21 occurred within 30 days and of them 14, could be determined to be HTA reportable based on the weight of evidence. (The status of one case could not be determined.)

As a result, 813 fatalities, or 1.02 times the number identified in ORSAR, are used in the model for 2004. The same factor will be used for subsequent years to reflect fatalities not reported in ORSAR. A later section discusses how these extra fatalities are allocated in the model.

b) Additional injuries reported by hospitals and in a re-analysis of Chipman

Data in ORSAR on the number of injuries and their severity are derived from police reports filled out at the scene of the collision or shortly after the collision. Attending police officers will have information on those who are transported directly to hospital (major and minor injuries) and may have information although potentially not complete on those admitted to hospital (major injuries). They will have information on others who report injuries not requiring transport to hospital (minimal injuries) at the collision scene. Police will follow-up with hospitals to find out the extent of injuries and will amend reports as necessary. However, police will not have information and reports will not record those individuals who subsequently develop symptoms of injury. These injuries may include minimal injuries, requiring no or limited medical intervention, minor injuries, requiring an emergency room visit, or major injuries, involving hospital stays. Since police reports are the basis of ORSAR data, which in turn form the raw data used in our model, these counts of injuries are unlikely to reflect the full extent of injuries resulting from motor vehicle collisions.

To account for under-reporting of injuries we rely on two sources of information. The Ministry of Health and Long-Term Care (MOH&LTC) captures use of medical facilities such as emergency room visits and the characteristics of hospital stays (hospital separations and duration) against codes identifying the reason for the injury. A number of these codes are specific to motor vehicle collisions that would be HTA reportable.[1] The second source of information is the analysis conducted by Mary Chipman[2] of the 1990 Ontario Health Survey. In it she estimates the number of collision-related injuries for Ontario residents in 1990 based on survey data. Adjustments are required to bring the Chipman analysis in line with the definitions of our study particularly to restrict collisions to those that involve a motor vehicle and are HTA reportable.

c) Additional major and minor injuries

We obtained a special run of MOH&LTC data for fiscal years 2003/2004 and 2004/2005. This run considered individuals' use of hospital facilities involving the International Classification of Diseases (ICD-10) motor vehicle traffic accident codes[3]:

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[1] The Tenth Revision of the International Classification of Diseases (ICD-10) is used.

[2] 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, October 5-7, 1992, Portland, Oregon.

[3] We used the same codes as used by ORSAR with the exclusion of V83.4 (Person injured while boarding or alighting from special industrial vehicle), V84.4 (Person injured while boarding or alighting from special agricultural vehicle), V85.4 (Person injured while boarding or alighting from special construction vehicle), and V86.4. Person injured while boarding or alighting from all-terrain or other off-road motor vehicle.

- Pedestrian Injured in Collision/Non Collision Motor Vehicle Traffic Accident.
- Pedal Cyclist Injured in Collision/Non Collision Motor Vehicle Traffic Accident.
- Motorcycle Rider Injured in Collision/Non Collision Motor Traffic Accident.
- Occupant of Three-Wheeled Motor Vehicle Injured in Collision/ Non Collision Motor Vehicle Traffic Accident.
- Occupant of Car Injured in Collision/Non Collision Motor Traffic Accident.
- Occupant of Pick-up Truck or Van Injured in Collision/Non Collision Motor Vehicle Traffic Accident.
- Occupant of Heavy Transport Vehicle Injured in Collision/Non Collision Motor Vehicle Traffic Accident.
- Occupant of Bus Injured in Collision/Non Collision Motor Vehicle Traffic Accident.
- Other land transport accidents.

We pooled the data for the two fiscal years using weights reflecting each fiscal year's share among incidents for calendar year 2004.

Hospital separations data from MOH&LTC were used to identify major injuries (those admitted to hospital). From the gross number of hospital separations, we subtract those who die in hospital (fatalities) or who were re-admitted for the same injury. This yields 5,293 unique persons who were injured in motor vehicle collisions, admitted to hospital and survived. This definition is most in keeping with the major injury category of ORSAR.

The number of emergency room visits not requiring a hospital stay is also estimated using MOH&LTC data. From the total number of visits to an Emergency Room (ER) we select only those going to ER for an unplanned visit for a new clinical condition. From this number we subtract those who:

- Leave without being seen, treated, or having completed treatment (included in minimal injuries).
- Are admitted (major injury).
- Die on or after arrival (fatalities).
- Transfer to another care facility (possible duplicate in data).

According to the MOT&LTC data a total of 60,726 individuals visit an emergency room and are released after care (comparable to minor injuries) as a result of motor vehicle collisions in 2004.

Exhibit III-2 identifies the revised numbers of major injuries (hospital admittances) and minor injuries (treated in emergency room only) based on the better information available through MOH&LTC. It also identifies factors derived from the ORSAR and revised (MOH&LTC) numbers that are used by the model to adjust ORSAR-derived numbers for major and minor injuries for 2004 and subsequent years.

Exhibit III-2 Revised Data and Adjustment Factors for Injuries in 2004

MOH&LTC 2004	Chipman-* based Estimate 2004	Factors** for 2004 and later years
(#)	(#)	
5,293		1.48
60,726		2.03
	58,822	1.49

* See discussion on the calculation of minimal injuries in the following text.

** Factors for major and minor injuries are derived from MOH&LTC data, and for minimal injuries from a re-analysis of the Chipman analysis of the Ontario Health Survey.

d) Additional minimal injuries

The number of minimal injuries cannot be verified or adjusted using MOH&LTC data, as these injuries do not involve a hospital stay or an emergency room visit. Instead we use an analysis by Mary Chipman[1] of the 1990 Ontario Health Survey. No more recent study exists to help estimate the number of minimal injuries. However, given the age of the study one of the adjustments we make is to reflect the changed mix of injuries from motor vehicle collision in 2004 compared to 1990.

We make a number of adjustments in the Chipman analysis to fit the needs of the social cost model. In brief these adjustments:

- Adjust the proportion of injuries to pedestrians and cyclist to reflect the mix in motor vehicle collisions. The 1990 Ontario Health Survey used a broader definition of traffic collision that did not need to involve a motor vehicle.
- Reduce the number of emergency room visits by 10% to estimate minor injuries. This reflects the proportion that becomes major injuries (hospital stays). Using estimates from the 1990 Ontario Health Survey of emergency room and hospital room use without adjustment would lead to double-counting otherwise.
- Calculate minimal injuries as a residual by subtracting major and minor injuries from total injuries.
- Adjust for the changing mix of injury severities between 1990 and 2004 motor vehicle collisions.

[1] 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, October 5-7, 1992, Portland, Oregon.

Based on this analysis, we estimate 58,822 minimal injuries that are HTA reportable. Using this number we derive the factor (1.49) used for 2004 and later years to adjust ORSAR data to reflect the number of minimal injuries attributable to HTA reportable motor vehicle collisions. The 2004 number and adjustment factor are identified in Exhibit III-2.

e) Allocation of additional fatalities and injuries among collision severities

This section presents information on how the additional fatalities and injuries are allocated among motor vehicle collisions. Based on this allocation some of the extra fatalities occur in injury only collisions and some of the extra injuries occur in PDO collisions. The section next presents how collisions are re-allocated among collision severity categories to maintain the intended coverage of these categories.

Additional fatalities identified through the analysis and resulting from a HTA reportable motor vehicle collision are assumed to occur among those identified by police as having been admitted to hospital (major injuries). We reduce the number of major injuries found in ORSAR to reflect the number of extra deaths identified through the Coroner's Office. Major injuries recorded in ORSAR occur in both fatal and injury collisions. We distribute the number of major injuries transferred to fatalities according to the share of major injuries in these collision severity categories.

This is illustrated in the hypothetical example below. Major injuries are distributed such that 10% are in fatal and 90% are in injury collisions. With 10 extra fatalities to distribute, 1 is assigned to fatal collisions and 9 to injury collisions. As a result of the distribution of the additional fatalities, major injuries reduce by 1 in fatal collisions and by 9 in injury collisions.

Step 2

Allocate additional fatalities based on proportion of major injuries

	Collision Severity: Fatal	Collision Severity: Injury		
ORSAR data			Additional	
Fatalilties	50		Fatalilties	10
Major injuries	10	90		
Fatalilties	50 + 1	9		
Major injuries	10 - 1	90 - 9		
Fatalilties	51	9		
Major injuries	9	81		

The additional injuries (over ORSAR estimates) identified through the MOH&LTC data and the Chipman re-analysis are allocated among collisions severity categories based on the proportion (adjusted to allocate vehicles with unknown damage) of demolished vehicles. This is illustrated in the hypothetical example below where 10%, 50% and 40% of the additional injuries are allocated to fatal, injury and PDO collisions to reflect the proportion of demolished vehicles in these collision severity groups. We believe injuries are highly correlated to vehicle damage and have therefore chosen this allocation mechanism for additional injuries.

Step 3

Allocate additional injuries based on proportion of demolished vehicles

	Collision Severity		
	Fatal	Injury	PDO
Injuries:			
Major	50	100	
Minor	70	150	
Minimal	60	125	
Additional injuries:			
Major	100		
Minor	200		
Minimal	50		
Vehicles damaged:			
Demolished	10	50	40

	Fatal	Injury	PDO
Injuries:			
Major	50 + 10	100 + 50	0 + 40
Minor	70 + 20	150 + 100	0 + 80
Minimal	60 + 5	125 + 25	0 + 20

	Fatal	Injury	PDO
Injuries:			
Major	60	150	40
Minor	90	250	80
Minimal	65	150	20

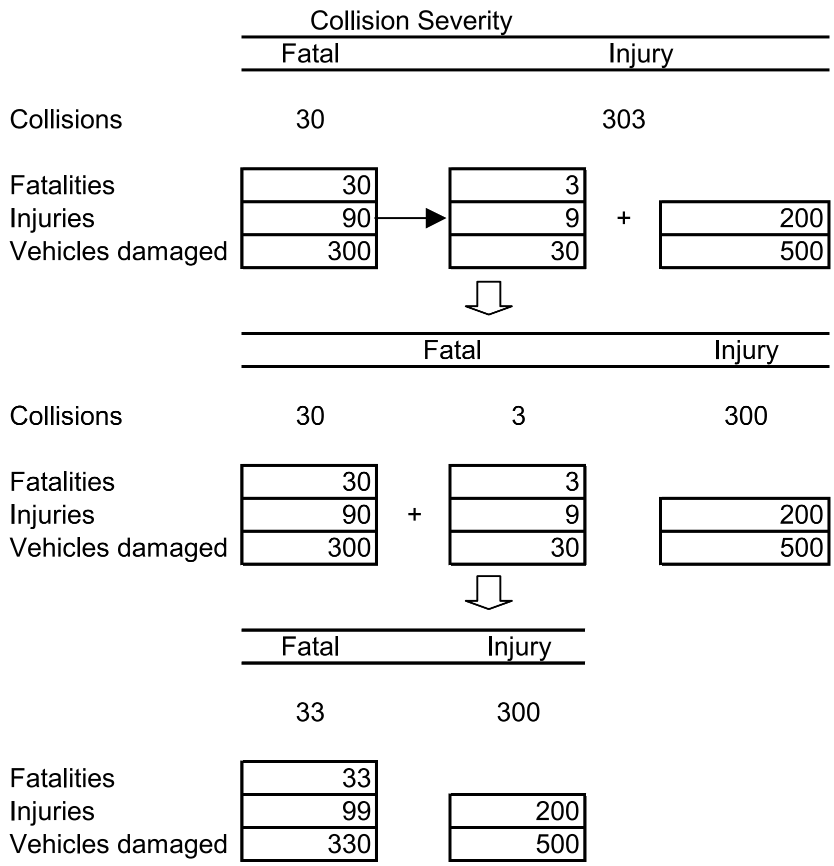
We use the characteristics of fatal collisions[1] to move an appropriate number of collisions with the same characteristics from the injury collision severity group to the fatal severity group. This is illustrated in the hypothetical example provided below.

In this example, the average fatal collision has the following characteristics–1 fatality, 3 injuries and 10 vehicles involved. There are 3 fatalities assigned to injury collisions after the adjustments noted earlier. Assuming the collisions, involving the 3 fatalities, but listed as injury collisions are like other fatal collisions, allows us to identify 3 collisions, with 3 fatalities, 9 injuries and 30 vehicles involved among injury collisions. Transferring these collisions from injury to fatal collisions would increase fatal collisions

[1] Each fatal collision includes 1.11 fatality, 0.44 major injury, 2.16 minor injury, 1.33 minimal injury and involves the following vehicles by damage level: 0.99 demolished, 0.27 severe, 0.21 moderate, 0.18 light and 0.07 none.

by 3 (from 30 to 33 collisions) and reduce injury collisions by 3 from (303 to 300). The characteristics of the collision would also be transferred resulting in the increase of 3 fatalities, 9 injuries and 30 involved vehicles to fatal collisions and the corresponding reduction of these characteristics from the injury collisions.

Step 4
Transfer of injury collisions involving fatalities to fatal collisions based on characteristics of fatal collisions



Similarly the model uses the characteristics of injury collisions to determine the number and characteristics of collisions to transfer from the revised PDO category to the injury collision category. However, the correct number of collisions to transfer will vary depending on which severity category of injury is selected to base the transfer. As a result, the decision on the maximum number of collisions needed to transfer all injuries is model determined based on the characteristics of the data. The model transfers injuries in the proportion they occur in these collisions up to the maximum number by severity category initially allocated to PDOs. It also transfers the expected number of vehicles damaged based on this number of collisions. This is illustrated in the next hypothetical example.

In this example the average injury collision involves 1 injury and 3 vehicles. Given 10 injuries allocated to PDOs, the model would identify that 10 collisions needed to be transferred involving all 10 injuries and 30 vehicles. (The hypothetical example does not illustrate that the decision on how many collisions to transfer is based on the number needed to transfer all injuries of each injury severity.) The 10 collisions are transferred to injury collisions increasing the total from 100 to 110. Similarly, PDO collisions are reduced by 10 from 260 to 250. Characteristics of the collisions are also transferred with offsetting increases for injury collisions and decreases for PDO collisions in the number of injuries and vehicles involved.

Step 5
Transfer of PDO collisions involving injuries to injury collisions
based on characteristics of injury collisions

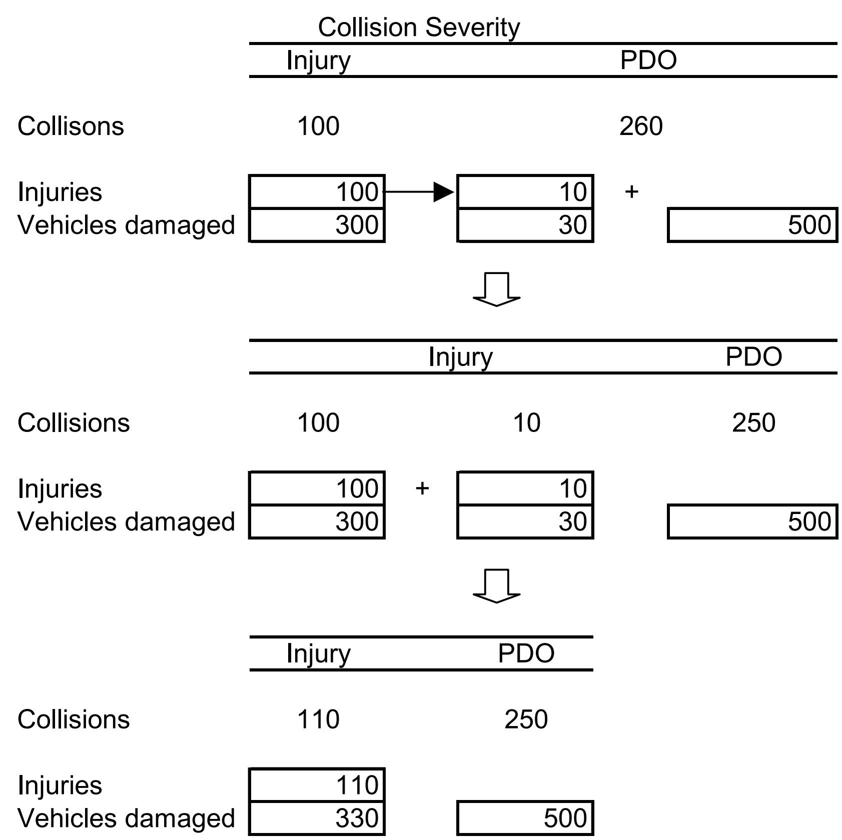


Exhibit III-3 (a section from spreadsheet O2 in the model) illustrates the results of these transfers among collision severity categories to adjust for fatalities occurring in injury collisions and injuries occurring in PDOs. The result of these transfers is to increase the number of fatal collisions by 12 (with a corresponding reduction in injury collisions) and to increase the number of injury collisions by 11,878 (with a corresponding reduction in PDO collisions). The total number of collisions is not affected nor is the number of vehicles involved. However there is a redistribution of collisions and motor vehicles damaged by collision severity, as well as an increase in fatalities and injuries to reflect the better data available from the Coroner's Office (fatalities), MOH&LTC (major and minor injuries) and Chipman re-analysis (minimal injuries).

Exhibit III-3 Adjusted Data for Ontario Model—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Collisions	730	61,814	169,004	231,548
Fatalities	813			813
Injuries:				
Major	317	4,961		5,279
Minor	1,574	59,152		60,726
Minimal	968	57,855		58,822
Vehicles damaged:				
Demolished	723	13,150	4,107	17,980
Severe	200	27,605	30,903	58,708
Moderate	157	32,436	105,753	138,345
Light	133	32,158	148,879	181,170
None	48	11,258	19,443	30,748

In 2004 and subsequent years these transfers are conducted automatically based on decision rules influenced by the data.

C. OTHER CHARACTERISTICS OF INJURED INDIVIDUALS

This section identifies further characteristics of those injured in motor vehicle collisions.

1. Number of total and partial permanent disabilities

Some injuries will result in total or partial permanent disabilities. The likelihood of such disabilities varies by injury severity as identified in the Databook on Nonfatal Injury: Incidence, Costs and Consequences (Ted Miller, et. al.).

Using these probabilities we estimate the number of total and partial permanent disabilities by severity of injury and collision severity. Results for 2004 indicated 140 total and 1,828 partial disabilities occur.

2. Number of activity-days and work-days lost

We estimate the days of lost activity from motor vehicle collisions from data from the Passenger Car Survey (PCS) of Transport Canada. The data are for the period 1984 to 1989 inclusive for all of Canada and measure days of work lost including those days lost by persons engaged in household work. The PSC was discontinued in the early 1990s. Data discussed in this section were originally used in our 1994 study. More detail on the survey methods can be found in this earlier report.

Our estimates of average days lost differ depending on whether the analysis is for our DFE or WTP analysis. This is as a result of the underlying rationale of the DFE (based on work-days lost) and WTP (based on activity-days) approaches.

Based on motor vehicle collisions in 2004 the model estimates 1.28 million activity-days and 600 thousand work-days lost through injury.

D. OTHER RESOURCES EXPENDED DUE TO COLLISIONS

This section identifies the expenditure of resources related to motor vehicle collisions.

1. Medical Care

Resources are expended related to the care and treatment of those killed and injured in motor vehicle collisions. Each category of care is discussed in this section.

a) Transport of those injured

Ambulance use data are available from MOH&LTC. Based on data for 2003/2004 and 2004/2005 we estimate 35,397 ground, 450 air, and 47 water ambulance trips for 2004 based on a proportionate weighting of the data for the two fiscal years. These aggregate data allow reasonable allocation across injury severity categories with the following assumptions:

- Each fatality and major injury is transported.

- Ambulance trips involving a combination of methods (a small minority in the data) are assumed to all involve ground transport and to involve air or water ambulances as well in proportion to individual air and water ambulance use in the data.
- Air and water ambulance are allocated according to the proportionate share of fatalities and major injuries. All remaining fatalities and major injuries transported by ambulance to hospital are assigned a ground ambulance trip.
- Fatalities not transported to hospital are assumed transported by the Coroner.
- Ground ambulance trips not allocated in the above are assigned to individuals with minor injuries. This includes those transported a second time to another facility (day surgery, clinic, or another emergency department).

b) ER visits

Many of those involved in motor vehicle collisions are treated in hospital. When services are complete (for example in the case of a minimal injury, or an individual who is admitted to hospital through an ER) an ER visit is recorded. When services are less than complete (for example if an individual leaves before treatment in the ER) the visit is weighted to reflect the degree of ER service completed. Incomplete ER services are weighted from 0.1 for an individual who is registered but not seen to 0.7 for someone who receives some treatment but leaves before the treatment is complete. All incomplete ER visits are assigned to the minimal injury category because the individual received less than the required treatment to be classified as a minor injury. Fatalities pronounced dead on arrival at hospital are assigned an ER visit weight of 0.25.

Using these weights we calculate a total of 71,203 ER visits, and allocate them among fatalities, major and minor injuries and to minimal injuries as noted.

c) Hospital stay

The number of days of stay as a patient is recorded for those admitted to hospital. A hospital stay is recorded for major injuries and fatalities. It is assumed that individuals who become fatalities after admittance to hospital are not released from hospital prior to their death.

As a result, we assign 47,914 patient-days for those admitted and released from hospital to the major injury category and 1939 patient-days to those admitted to but subsequently dieing in hospital.

2. Other Medical Professional Use

The analysis by Chipman, and with the adjustments noted in an earlier section, identifies the following number of visits per injured surviving individual: primary MD—

2.99; specialist—1.11; nurse—0.64, physiotherapist—3.05, chiropractor—1.82; other[1]—0.92. The Chipman re-analysis does not present visits by severity of injury. If we assumed an equal number of visits across individuals with different injury severities, total visits would be divided according to the proportions by injury severity in the Chipman analysis—7% major, 45% minor, and 48% minimal. Instead we assume that the injury severity categories account for 35%, 45%, and 20% of visits for major, minor, and minimal injuries respectively based on a weighting of the number and severity of injuries within severity categories. The resulting distribution by injury and collision severity in our model is provided in Exhibit III-4.

Exhibit III-4 Health Care Professionals use by Injury and Collision Severity—Number of Visits (2004)

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Primary MD:				
- Major	4,723	73,804		78,527
- Minor	4,666	175,365		180,031
- Minimal	1,214	72,573		73,787
Specialist:				
- Major	1,761	27,526		29,287
- Minor	1,740	65,404		67,144
- Minimal	453	27,067		27,519
Nurse:				
- Major	1,014	15,842		16,856
- Minor	1,002	37,642		38,643
- Minimal	261	15,578		15,838
Physiotherapist:				
- Major	4,820	75,322		80,142
- Minor	4,762	178,973		183,735
- Minimal	1,239	74,066		75,305
Chiropractor:				
- Major	2,878	44,974		47,852
- Minor	2,843	106,863		109,706
- Minimal	740	44,224		44,964
Other (*):				
- Major	1,448	22,628		24,076
- Minor	1,431	53,766		55,197
- Minimal	372	22,251		22,623

* Other is a category that is the sum of visits to dentists, optometrists, pharmacists psychologists, social workers and other health professional not identified.

[1] Other is a category that is the sum of visits to dentists, optometrists, pharmacists, psychologists, social workers and other health professional not identified.

3. Police response

The Ontario Provincial Police (OPP) provided hours expended by all staff, by all levels, related to motor vehicle collisions they attended in 2004. Data are available related to the following groupings of activities: initial collision; assistance provided to the initial officer on the scene; court; follow-up; reporting; administration; SOCO[1] and collision-related activities not otherwise specified).

In 2004, the OPP investigated 73,683 motor vehicle collisions and expended 325,641 staff-hours for these investigations. Although fatal, injury and PDO collisions represent 1%, 19% and 80% respectively of the collisions investigated by the OPP this is unlikely to represent the distribution of hours spent by police officers across these collision severities. Instead we have assigned 15%, 45%, and 40% of OPP staff time respectively by collision severity. This assumed allocation reflects both the degree of difficulty per collision and volume of collisions by collision severity. On average this distribution suggests 107, 10 and 2 hours are spent per fatal, injury and PDO collision respectively. These become the factors used in 2004 and later years to assign hours by police staff to all collisions including those not investigated by the OPP.

Collisions handled by the OPP represent 64% of fatal, 29% of injury and 33% of PDO collisions in Ontario. We used the proportion of collisions handled by OPP officers and the allocated amounts by collision severity (approximately 49,000, 147,000 and 130,000 hours for fatal, injury and PDO collisions respectively) to extrapolate OPP police officer time to all collisions and police forces. This method may under-estimate police involvement; if for example, more than one police force (OPP and a municipal police force) attended a collision. The model allocates 990,000 hours of police time using the unadjusted collision severities (i.e. from police reports) to reflect information available to the police when deciding how much time to allocate to collisions.

4. Fire department response

We obtained data from The Office of the Fire Marshal related to responses by fire departments in 2004. Fire departments responded to 33,082 motor vehicle “accidents” and 2,618 vehicle extrications, not included in the previous number. In addition there were 116 and 14 responses attributed to a vehicle “accident” and listed as fires with loss and without loss respectively.

Although detail on the location of the fire response is not available from the data, most of these “accidents” are likely HTA reportable collisions. As a result, we assign 35,830 responses by fire departments to motor vehicle collisions. We assume that fire departments will respond to all fatal collisions with the remainder of calls going to injury collisions.

[1] Scenes of Crime Officer—officers who ensure any evidentiary material at the "crime scene" is secured and properly documented.

5. Tow trucks

Tow truck services are required when either or both the vehicle cannot be driven safely or no licensed individual is able to drive the vehicle from the collision scene. Data from Transport Canada's former Passenger Car Survey (PCS, data used by the study are from 1984 to 1989) indicate that 89% of the vehicles involved in fatal collisions were towed and 57% of those involved in injury collisions required the services of a tow truck. We assume that 40% of vehicles involved in PDO collisions (not included in the survey coverage) were towed. Thus, the number of vehicles in each type of collision that were towed is derived by applying these proportions to the total number of vehicles involved in collisions including those that were not damaged (in keeping with the survey coverage). As a check on the correct proportion to use, the per cent of vehicles that are demolished or have severe or moderate damage is 86%, 63% and 46% for fatal, injury and PDO collisions respectively. The percentages identified from the PCS and by extrapolation approximate these percentages based on vehicle damage with slightly higher percentages for fatal collisions and lower percentages as collision severity declines. This is in keeping with our expectations that more vehicles will be towed for reasons other than vehicle damage as collision severity increases. Our costing methodology deducts estimated costs for tow truck services from insurance payments calculated elsewhere. As a result any error in our estimate of tow truck costs will be countered by an off-setting error in the value of remaining items paid for through insurance claims.

E. VALUATION OF HUMAN CONSEQUENCES

1. Willingness to Pay (WTP) Estimates

The willingness to pay approach to estimating the value of human consequences is rooted in the observation that individuals make choices each day that balance risks of injury and death against monetary considerations. Whether they decide among vehicles with different safety and price characteristics or among jobs with different work-place accident and pay characteristics they explicitly or implicitly make trade-offs that must balance these factors. By extension, society balances the benefits of risk reduction against the costs to achieve the lower risk when it decides to invest in passing lanes, road divider barriers, and better curve banking that offer the potential to reduce collisions and fatalities.

A number of Canadian studies have been able to use rich labour market data (remuneration and risk variables) to estimate the value of human consequences. The most recent research results on risks and the value of measures to reduce these risks indicates that the benefits of reducing these risks are much higher than had previously been estimated. Most of these earlier studies were unable to correct for known biases in these data, producing as a result, artificially low values of a life saved and injury avoided.

The most recent Canadian estimates of the value of statistical life (Dr. Morley Gunderson and Douglas Hyatt in the Canadian Journal of Economics, Volume 34. No. 2, "Workplace Risks and Wages: Canadian Evidence from Alternative Models", May 2001) correct for income effects (those with higher income are more likely to avoid risky occupations) and tolerance for risk (that make some workers demand a smaller risk premium). Their evidence indicates that the benefits of reducing workplace risks are much higher than earlier estimates. Leigh (2001) has provided related results for the United States.[1] More specifically, the Gunderson and Hyatt estimates suggest 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. Note that these data are expressed in 1988 Canadian dollars.

These results have not been challenged in the economics literature. However, because they are at the high end of what was the previously accepted range of values for human consequences we treat them as one of a number of possible values that can be selected by the analyst in the model.

Our approach to social values based on WTP involves the following:

- Update the Meng-Smith results that were the basis of the earlier TNS(Abt)-TIRF results reported to you in the 1994 study. This will be our "lower bound" estimate based on WTP.

- Review and update the Canadian results of Gunderson and Hyatt based on improved estimation techniques related to risk preferences and selection of individuals into different occupational risks. These estimates are larger than earlier results and have not been the source of any challenge or criticism in the literature. These results will provide an "upper bound" WTP estimate of the core fatality and injury parameters.

- The mean value of the upper and lower bound estimates provides the central estimating result used in our analysis. We provide sensitivity analyses using lower and upper bound estimates of these parameters.

Based on these methods the core parameters for the human consequences (death, activity day, partial and total disability) associated with motor vehicle collisions are provided in Exhibit III-5.

[1] Leigh, J. Paul, James Cone and Robert Harrison (2001) "Costs of Occupational Injuries and Illnesses in California" *Preventive Medicine*, v. 32, no. 5, pp. 393-406.

Exhibit III-5 Core WTP 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

Note: Variables above are constructed as described in the text.

In Exhibit III-5, the lower bound estimates consist of the updated values estimated by Vodden *et al.* (1994). These values, estimated using data from Statistics Canada's 1987 Labour Market Activity Survey, have been updated to 2004. The dependent variable in these regression model estimates is the wage rate so that we have inflated the 1987 value of $4.7 million to $7.8 million using Statistics Canada data on wage rates (*The Labour Market* cat. No: 71-222-XWE). 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 as described in Viscusi and Aldy (2003). The lower bound for the activity day variable and the severe injury variable are calculated in the same way.

The upper bound estimates are based on the models estimated by Gunderson and Hyatt (2001). 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 under-estimates 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 value of a statistical life estimated by Gunderson and Hyatt is $12.75 million, expressed in 1988 dollars. Converting this to 2004 dollars using the wage index described above gives the value of $19.7 million shown in Exhibit III-5. The Gunderson and Hyatt models do not compute the activity day and severe injury variables that we plan to use in our modeling. Their overall results indicate that their correction factors would cause the values to increase by a factor of 5. As a result, we use this factor to calculate the upper bounds for these variables in Exhibit III-5. The final column of Exhibit III-5 calculates the mean of the upper and lower bound estimates.

2. Discounted Future Earnings (DFE) Estimates

The discounted future earnings approach measures losses in productive activity in the workplace and in household activity for those affected by motor vehicle collisions. Losses through three main types of human consequences are measured: fatalities, permanent disabilities (total and partial), and temporary disabilities and injuries. More detail on the DFE approach may be found in Appendix C. Estimates are summarized in Exhibit III-6.

Exhibit III-6 DFE 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.

F. VALUATION OF NON-HUMAN CONSEQUENCES

1. Hospital/health care facilities cost

Data from MOH&LTC record emergency room visits, and days in hospital for those injured as a result of motor vehicle collisions. A series of studies following a methodology established by the Health Services Restructuring Committee have been conducted of costs in Ontario hospitals. The average across 17 such studies[1] for a patient day is $216.29 and per emergency room visit $84.33 respectively, both in 2000 $. 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.

[1] Ministry of Health and Long-Term Care, Operational Review of Hôpital régional de Sudbury Regional Hospital, November 1, 2002.

We combine this value for the non-staff costs with estimates available on the incremental use of medical staff for those injured in motor vehicle collisions (Chipman re-analysis) to provide a more complete estimate of the cost of medical services in the following section.

2. Health care professional cost

The incremental use of health care professionals was estimated through the re-analysis of Chipman as described earlier. These provide broader descriptions of health care professionals' categories than provided in the "OHIP fee schedules" for doctors and other health care professionals found in the Schedule of Benefits for Physician Services and related changes. As a result, we assign the following approximate values related to the health care categories in the Chipman analysis:

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

We use these values and the estimated incremental use of health care professionals by injury severity (from before) for those injured in motor vehicle collisions. Note that the survey data that are the base of the Chipman analysis reports on surviving individuals. It cannot be used to estimate health care professional costs associated to fatalities of motor vehicle collision. However, approximately one-quarter of fatalities occurs in emergency rooms and a further one-quarter occurs after admittance to hospital. For those admitted to hospital before dieing the average hospital stay is similar to those with major injuries. We assign the estimated health care professional cost for minor injuries and major injuries ($920 and $4600 respectively) to approximate the cost for these two groups of fatalities respectively.

3. Police costs

The Ontario Provincial Police (OPP) charge-back municipalities for the cost of police services they provide. They shared the model they use 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).

We apply these fully-loaded costs to the mix of OPP staff hours identified in the earlier section to identify a fully-loaded average cost per police hour of activity expended related to motor vehicle collisions. This fully loaded weighted average is $82.73 (2006$) or $78 in 2004. We assume that other police forces operating in Ontario will have a similar cost structure. We apply this weighted average fully-loaded hourly amount to police activity expended. Potentially this average exceeds the marginal cost of an extra police hour devoted to a motor vehicle collision. However, any difference is viewed as being small.

4. 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 we estimate a cost for court proceedings related to motor vehicle collisions. This method assumes that court proceedings related to motor vehicle collisions are as likely as for other police activities.

5. 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 results in an average total cost per response of $2,501 (2003$). Converting to 2004 dollars this represents an average response cost of $2,548.

We believe the average cost per response provides a useful estimate of the costs per motor vehicle collision response:

- The high fixed operating costs (most costs such as buildings, vehicles, and staff are unavoidable) and the low variable costs (fuel use) of a response, suggest there is unlikely to be a dramatic difference in average costs by type of response.
- In 2003, almost two-thirds of all fire department calls were for medical aid including resuscitation (40%) or were related to false alarms (23%). Most calls related to motor vehicle collisions are for rescue or extrication (9% of all calls in 2003). These typical responses to motor vehicle collisions are likely to have a similar duration and resource use to the majority of calls noted earlier. This suggests that the average costs across all responses should be similar to the costs for motor vehicle collisions.
- Calls related to property fires/explosions are likely to have a higher duration and resource use than the average response. (However even including motor vehicle fires, property fires represent a small component (5% in 2003) of all responses.

For these reasons we feel the average costs of a response by fire departments provides a useful measure of the costs of a response related to a motor vehicle collision.

6. Ambulance

The Ontario Ministry of Health & Long Term Care provides grants to cover the cost of land ambulance services. Services are provided by approximately 60 certified land based municipal, private hospital and volunteer operators—serving 440 individual municipalities in Ontario. In 2004, there were over 1.6 million requests for land ambulance service resulting in approximately 940,000 transports of more than 1.1 million patients.

Those transported by land ambulance for a medically necessary trip, with a valid Ontario Health Card and not subject to a Special Exemption category, are charged a co-payment of $45 toward the cost of their trip. Each person whose transport is deemed medically unnecessary by the receiving hospital is charged a fixed $240 fee for a land ambulance under the Health Insurance Act, Regulation 552. This later fee is unlikely to reflect the full cost of the land ambulance trip.

Instead of this regulated charge we use the cost of $783 (2005 $) per transported patient estimated based on data provided by the City of Toronto website. (The total budget for Emergency Medical Services in Toronto was approximately $130 million with 166,000 transported patients in 2005. This average will include both fixed overheads and variable components of costs. However, like fire departments most costs are unavoidable and therefore an average allocation across all responses seems warranted.) In 2004 dollars the cost per land-based transport by ambulance is $754. We have assumed a value one-half this amount for transport by the Coroner.

We have no data on the costs for water ambulance service. Given its infrequent use related to motor vehicle collision we have assumed a cost identical to land based ambulance services.

A non-profit corporation accountable to the Ontario government provides air ambulance services in Ontario. Budgets and numbers transported are not available. However, approximate values provided to us suggest an average cost of approximately $5,000 per person transported by air ambulance. Given the small number of air ambulance trips involved we use this figure despite its uncertainty.

7. Tow trucks

Tow truck charges are typically included in insurance claims. As a result we deduct the amount estimated for tow truck costs in this section from the estimate of insurance claims payouts. Any uncertainty in our estimate of tow truck costs is netted out in the calculation of insurance claims costs.

Industry sources suggest that most motor vehicle collisions occur in areas covered by municipal contracts for tow truck services. These contracts are extremely competitive and most are "loss-leaders" for tow truck operators. Instead operators of tow trucks recoup losses on related charges for clean-up, dolly wheels, storage, compound fee, and wait times. A useful rule of thumb is $0.30 to $0.32 per pound of vehicle towed. So an average automobile of 1,500 lbs is $450 to $500 and a large truck is $15,000 to $30,000.

Since large trucks make up only 2% (17,849 of 853,902) of vehicles involved in collision in 2004 and commercial vehicles are more likely to be self insured (not covered by insurance claims, we make the simplifying assumption that most vehicles requiring tows will be automobiles or light trucks with an average tow charge of $500 in 2004.

Based on these costs per tow and the number of tow truck services presented earlier we estimate the social costs of tow truck services in 2004 at $95.6 million.

8. Property damage and other losses generally covered through insurance

Property damage caused by motor vehicle collisions is generally covered through the insurance claims of involved parties. In addition, claims cover a number of other incurred losses due to the collision such as tow trucks, damaged vehicle storage, car rental, or hotel accommodation. We include these losses (other than tow truck services discussed earlier) attributable to the motor vehicle collision in our estimate of property damage and other losses generally paid for through insurance claims. We also include the claims and adjustment expenses incurred by insurance companies and recorded in the data available to us from the Insurance Bureau of Canada (IBC). As a final note on coverage, we do not estimate property damages that would be borne by the "at-fault" driver as the deductible not reimbursed under collision and all perils claims. This deductible not included in the claims payouts is included in out-of-pocket expenses discussed in another section.

Property damage and the other losses discussed earlier are covered under the third party liability, collision and all perils insurance coverage of insured parties[1]. In addition a special insurance fund covers claims against uninsured (or unidentified) automobiles and under-insured drivers. However, claims within some of these categories may also include other items not relevant to our estimate of the social cost of motor vehicle collisions. For example:

- Third party liability includes claims for bodily injury.
- All perils include comprehensive coverage (fire, theft).
- Uninsured automobiles include claims for bodily injury and death.

In addition, some vehicle owners self-insure (do not have coverage for collision damage to their vehicle if they are found to be "at fault"). We include the proportion of commercial vehicles that self-insure based on the proportion without some form of collision coverage beyond mandated third party liability in our analysis. (Loses to private

[1] We include coverage of private passenger vehicles and motorcycles, commercial vehicles, farmers, snow machines, buses, ambulances, interurban trucks, trucks for hire, taxicabs, miscellaneous public automobiles (rental cars), and other types of specialty vehicles.

individuals who self-insure will be captured by out-of-pocket expenses estimated below.) Finally claims related to snow machines may not involve a motor vehicle or be HTA reportable. We estimate property damage in 2004 at $1.8 billion. We allocate this total amount to vehicles damaged in 2004 as follows:

- Demolished -- $20,070.
- Severe -- $10,756.
- Moderate -- $4,565.
- Light -- $996.

We use these values in 2004, and values adjusted for inflation in other years, to allocate property damage to vehicles involved in motor vehicle collisions by damage severity.

9. Out of pocket expense by those involved in motor vehicle collisions

Those involved in motor vehicle collisions may incur out-of-pocket expenses:

- Not covered by insurance, including the insurance deductible of the at fault party and car rental, hotel or other expenses not covered under the policy.
- Not claimed under insurance, possibly as a result of a low dollar value of total claim.
- Not insured, for example in the case of an uninsured driver.

Based on data from the 1993 General Social Survey of Statistics Canada, 52.1% of individuals 15 years of age or older (based on coverage of the survey) involved in motor vehicle collisions on roadways in Ontario incurred out-of-pocket expenses that were not reimbursed by another party. In 1993, the average out-of-pocket expense was $719 ($882 in 2004$).

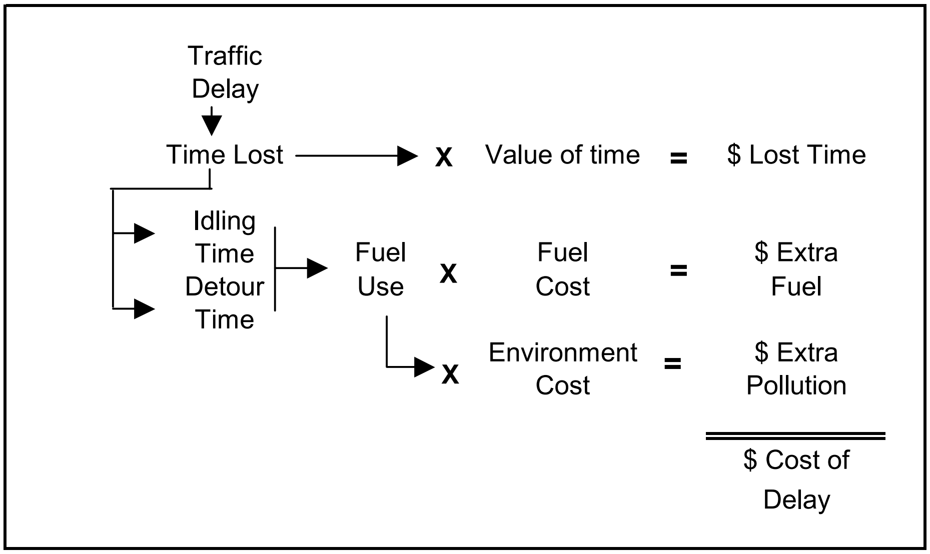
Based on data found in ORSAR for 2004 we estimate 1.3 survivors of collisions 16 years of age and older (a proxy to those 15 and over) per vehicle involved in injury and fatality collisions. We apply this factor to all vehicles involved in collisions and estimate a total out-of-pocket cost for them of $206 million in 2004.

10. Social Costs of Traffic Delays

In this section of the report we estimate traffic delays cause by motor vehicle collisions and the resulting impact on:

- Time losses.
- Fuel use.
- Extra pollution

These three separate components of costs are calculated as described in the following chart.



a) Traffic Delays

COMPASS is an Advanced Freeway Traffic Management System developed by the Ontario Ministry of Transportation (MTO) to respond to traffic congestion problems, primarily on Ontario's divided highways. COMPASS helps increase roadway efficiency and roadway safety by:

- Allowing for the prompt detection and removal of freeway incidents and vehicle breakdowns.
- Providing accurate and timely freeway incident and delay information to motorists.
- Effectively managing peak rush hour traffic flow through a variety of traffic control devices.

In this project, we have used data from the Toronto **COMPASS** system on delays as a critical data input. We have used **COMPASS** data from the MTO Toronto system (there are two other **COMPASS** systems in Burlington and Ottawa) covering the major Highway 401 from Highway 410 to Brock Road. These data are then extrapolated to the entire Province on the basis of population data that we assume are related to traffic volumes.

For 2004, the major Toronto **COMPASS** major incidents were reviewed. This was a total of 246 cases. A major incident is defined as involving a fatality or lifethreatening injury, police investigation, significant damage to MTO property, a full highway closure lasting more than 30 minutes, significant spill or ramp closure or any unusual circumstance (ex. school bus, truck losing tire).

A sample of these cases was then selected for detailed analysis of each individual case. The sample consisted of all recorded Toronto **COMPASS** incidents recorded in the first month of each quarter, effectively capturing seasonal variations within the year. This provided 70 cases that were entered into a spreadsheet showing date, time, location of the incident and roads and/or lanes affected, as described in the **COMPASS** incident reports

These data, in spreadsheet form, were sent to MTO to review and to provide traffic volume data (24 hour traffic distribution data) at the specific location of each of these incidents for that road at the specified time during which the stoppages and delays occurred. We integrated these data with the **COMPASS** incident report data to estimate delay and congestion times (in person hours) for each of the incidents. That is, all 70 incidents were analyzed individually to determine hours of delay and then combined with the 24-hour traffic distribution data to estimate numbers of person subject to the delay and from that, the total person hours of delay for each incident.

Based on the data described above, three delay measures were derived:

- The sampled Toronto **COMPASS** area based on our sampled data.
- "All Toronto **COMPASS**" data calculated using the ratio of 246 to 70 cases to extrapolate sampled data to an overall total for Toronto.
- All of Ontario as described below.

To move to all of Ontario is a more difficult challenge. The Toronto **COMPASS** system includes the 400 series highways around Toronto (400 to Langstaf Rd., 401, and 403 to Highway 10 in Mississauga, Highway 401 information coverage, as shown by **COMPASS** reports, extends from Highway 410 to Brock Rd. The Toronto **COMPASS** coverage does not include the QEW. While the existing **COMPASS** system covers some of the most heavily traveled sections, the major exclusions in our sample, in terms of the highest traffic volumes in Ontario, appear to be the QEW, Highway 404, DVP, Gardiner, Highway 400 north of the **COMPASS** boundary and Highway 401 east and west of **COMPASS system**.

Recent Ontario Finance data show that the GTA accounts for 46% of the Ontario population. Linear extrapolation is not appropriate since traffic volumes (potential delays) are much higher in the GTA. Collision delays are assumed to be 50% more likely in the GTA so that the population share of 46% is inflated to 69% (46%*1.5). The inverse of this is the factor of 1.45 that is used to produce the overall time delay estimate for Ontario. This population extrapolation method is used because there is no consistent database of collisions and delays for the entire province.

b) Lost time

The wage rate that we use to value time spent in traffic delays resulting from motor vehicle collisions is derived from Statistics Canada data on average wage rates (Statistics Canada-*The Labour Market* Cat. No.: 71-222-XWE). This value for 2004 is just under $18 per hour. There is an extensive literature including Small (1992) and Brownstone *et al*. (2002) that discusses what fraction of this wage should be used for traffic delays. Small argues that based on his review of an extensive literature in this area that the fraction should be 50%. The use of a fractional value reflects the fact that all persons delayed are not necessarily employed and that many passengers will be children. Brownstone *et al.* argue that revealed preference methods of determining willingness to pay show that commuters place quite a high value on time, possibly higher than the market wage. Substantial voluntary payment for reduced congestion on Ontario's Highway 407 provides a related example of this willingness to pay.

It seems clear that different types of individuals will place different values on time spent in congested traffic. However, it appears highly unlikely that data would be available to support a more detailed analysis of how willingness to pay to avoid delays might vary across different types of drivers and passengers. As a result, our approach draws on the mainstream literature. In this literature, the lower bound would be a value of 50% of the 2004 market wage ($9). The upper bound from Transport Canada's *Urban Congestion in Canada* (2006-Table 1) gives a value of $32.25 per hour for Ontario in 2004. In our calculations below, we use $20.60 per hour, the average of these two values as an average value for all road users. Note that no distinction is made between passenger cars and large commercial vehicles with respect to value of time, and the reason behind it.

c) Additional fuel use

Incremental fuel costs result from delays (slower speeds), stopping (frequent with lane closures) and detour distances. The COMPASS data provide the duration of lane and road closures and the traffic volumes at the time of the incident. From this, we have estimated idle times and detour/slower driving. The congestion cost model uses a stop time of two hours (or the duration of closure whichever is smaller) and a slow driving/detour time of one hour (or the duration of closure whichever is smaller).

From the U.S. Department of Transportation, we used an estimate of 2.25 litres of gasoline for each hour spent idling. For detours and delays, we used an average fuel efficiency amount of 11.25 litres per 100 km. Based on this fuel efficiency, each hour of detour and delay, in addition to time stopped, consumes 5.5 litres of fuel. Fuel costs of 76.6 cents per litre (from Ontario Ministry of Energy historical price data) are used in the model for 2004. Other values can be substituted in the model.

d) Additional Pollution

A further social cost of traffic delays caused by collisions is the pollution associated with extra burning of fossil fuels during the delay. It is widely recognized that traffic congestion generally, and specifically from collisions, contributes to increased levels of exposure to vehicle emission-related pollutants. Vehicle drivers and passengers will feel the negative impacts during traffic delays. The non-driving public may also experience degradation in the air quality in the area of the collision. Generally, the costs will be larger in urban areas where roadways are contiguous to large numbers of residences and persons. There is evidence in the literature that for passengers, pollution levels inside stopped and idling vehicles, in a group of stopped vehicles, may be from two to eight times higher than when moving at the speed limit. Any policy-related measures to reduce collision-related congestion will reduce the health risks to vehicle occupants and will also reduce general population risk in urban areas.

The extensive literature on air pollution shows that the benefits of risk reduction related to reduced air quality are substantial. These benefits relate primarily to emissions of air pollutants such as hydrocarbons (HC), CO, NO_x, as well as emissions of greenhouse gases (GHGs). In this project, we have estimated incremental emissions related to motor vehicle collisions in Ontario and then valued these additional emissions using widely cited estimates from the environmental policy literature.

The most widely cited report on air quality and valuing benefits is provided by the U.S Environmental Protection Agency (EPA, 1999) estimating the benefits of the *U.S. Clean Air Act* in preventing premature deaths and illness due to reduced air quality.

For greenhouse gas (GHG) emissions, Pearce (2005) and Tol (2005) provide estimates of the benefits of emission reductions designed to be used in a cost-benefit context (that is, to estimate social cost). Their estimates are in the range of C$2.70 to C$17.50 per tonne of CO_2 emitted. In this project, we have used an average of these numbers of C$10 per tonne of CO_2 as the value for this parameter. This literature and the environmental economics literature more generally indicate that these values are likely to be higher in the future.

The air pollution literature contains many benefit estimates associated with reductions in Criteria Air Contaminants (CACs). In the case of GHG emissions including automobiles, this literature suggests that damages related to health effects account for a large fraction of the total value of what are referred to as ancillary benefits (that is benefits associated with GHG reductions that go beyond climate change). In this project, we have used a value of just over C$8 per tonne of CO_2 as the value for the ancillary benefits (air quality) parameter. The source for this estimate is a study for Resources for the Future, a leading environmental research institution, by Burtraw and Toman (1998). This means that the benefits of reducing incremental motor vehicle emissions associated with traffic incidents consist of C$10 per tonne of CO_2 plus an additional $8 per tonne of CO_2 to reflect air quality (CAC) benefits (as opposed to CO_2 climate change benefits). This latter value reflects the damage costs related to CAC emissions per tonne of CO_2.

Note that the CAC damage estimate of $8 per tonne, from the work of Resources for the Future, is $8 per tonne of CO_2, not $8 per tonne of the major (non-diesel) motor vehicle pollutants (HC, CO and NO_x). Average emissions (pounds per mile), according to EPA data are as follows:

- CO_2 -- 0.916 pounds.
- HC -- 0.0033 pounds.
- CO -- 0.033 pounds.
- NO_x -- 0.005 pounds.

As these numbers clearly indicate, emissions of the CAC pollutants are much smaller per mile than for CO_2. Put somewhat differently, one tonne of CO_2 emissions will be accompanied by approximately eight pounds of HC emissions (0.0033/0.916*2205). Alternatively 2407 vehicle miles implies one tonne of CO_2 and eight pounds of HC.

Somewhat different estimates are provided in Transport Canada's *Urban Congestion in Canada* (2006-Table 4). These numbers imply an upper bound of $20 per tonne of CO_2 and $102 per tonne of CO_2 for CAC emissions. Our calculations use an average of these numbers and the Resources for the Future estimate of $18 for a total of $70 per tonne of CO_2 and its associated CAC emissions.

In summary, the core elements of the congestion cost model are as follows:

VARIABLE	DATA
LOST TIME	
W-wage or value of time	\$20.60 per hour-average of upper and lower bound estimates.
Occupants	1.5 per vehicle (includes all types of vehicles)[1]
Vehicles affected (traffic volume)	24-hour traffic distribution data. Volumes were adjusted to reflect varying degrees of road closure from full to partial as described in COMPASS incident reports.
ADDITIONAL FUEL USE	
Additional fuel use	2.25 litres per idling hour plus 5.5 litres per hour for additional driving time.
Fuel price	\$0.766 per litre —Ontario price in 2004.
ADDITIONAL EMISSIONS	
CO_2 emissions	245 kg per 100 kilometers—double when idling.
[CO_2+CAC]\$	\$70 per CO_2 tonne- average of upper and lower bound estimates.

To clarify how these data are used, consider a typical incident. In this example, assume that a segment of Highway 401 is closed for three hours and that this means that each affected vehicle is stopped for two hours followed by one hour of detour/delayed travel.

- **Time Cost**: As noted, the congestion cost model uses a stop time of two hours (or the duration of closure whichever is smaller) and a slow driving/detour time of one hour (or the duration of closure whichever is smaller). Further assume that "normal" traffic volume is 2,000 vehicles per hour. This implies a total of 6,000 affected vehicles, 1.5 persons per vehicle and three hours of delay. Person hours

[1] We used an average vehicle occupancy factor of 1.5. Some studies in the GTA suggest the average auto occupancy is between 1.10 and 1.20 depending on location and time of the day, and has a decreasing trend over time. However, to account for some other vehicle categories such as transit buses, school buses, and some commercial vehicle categories we decided to use the factor of 1. 5. The analyst has control over this assumption in the model.

of delay time would be 6,000*1.5*3 or 27,000 hours. Each hour is valued at $20.60 for a cost of $556,200.

- **Fuel Cost**: In this incident, we have two hours of stop time during which we assume that heating/ air conditioning means that the vehicles idle for two hours followed by one hour of additional driving time. This means that each of 6,000 vehicles uses 2.25 litres per idling hour plus 5.5 litres per hour for additional driving time. For two hours stopped and one hour of delayed driving, this is 4.5 idling litres and 5.5 driving for a total of 10 litres times 6,000 vehicles. The total of 60,000 litres is valued at $0.766 per litre (the 2004 price) for a total of $45,960.

- **Emission Costs**: Emissions are calculated from idling time and incremental driving time for the 6,000 vehicles. Idling emissions are 6,000*490*2 hours, where 490 is 245 kg doubled and extra driving emissions are 6,000*245*1 hour. Total emissions are 7,350 tonnes and each tonne is costed at $70. Total emission costs are $514,500.

- **Total Costs**: This is the sum of the three costs above for a total of $1,116,660. This describes how costs are calculated for each COMPASS-reported incident from the Toronto data.

e) Cost Estimates due to Traffic Delays

The individual cost estimates related to extra time, extra fuel and additional pollution for each incident in the COMPASS sample were extrapolated to All Toronto COMPASS (a proxy for Toronto) and to all of Ontario using the factors described earlier. These costs due to traffic delays are identified in Exhibit III-7. For Ontario, for 2004, traffic delays due to collisions are estimated to be $251 million due to extra time, $21 million due to extra fuel and $230 million due to additional pollution.

Exhibit III-7 Estimated Congestion Costs due to Collisions (2004 $ millions)

	Extra time	Extra fuel	Additional pollution	Total Costs
COMPASS Sample	$49.1	$4.1	$45.2	$98.5
All Toronto COMPASS	$172.9	$14.5	$158.8	$346.1
Ontario	$250.7	$21.0	$230.2	$501.9

We have no data to guide our allocation of traffic delay cost across collision severity. We assume that on average injury collisions involve 10 times the delay of PDOs and fatal collisions involve 100 times the delay of injury collisions (1000 times the delay for PDOs). Given the disproportionate share of PDO collisions this allocation results in 48%, 41% and 11% of traffic delay cost being applied to fatal, injury and PDO collisions respectively.

This section of our report provides an estimate of traffic delay costs based on a sample of data relating to motor vehicle collisions on specified roadways in the Toronto area. These data are then extrapolated to the entire Province, on the basis of population data assumed to be related to traffic volumes. This research is preliminary in the sense that there is not a well-established research literature in this area to establish an analysis framework and there is no consistent overall data for Ontario on which to base estimates. In this context, our approach has been to build a framework for developing the best possible estimate using the available data. Related work has been carried out by MTO in its publication *The Cost of Congestion in the GTA* and by Transport Canada in their publication *Urban Congestion in Canada*. However, both of these studies focus on recurring congestion issues rather than collision-based stoppages and delays. Recurring congestion is generally defined as inadequate capacity of the road system to handle traffic volumes as opposed to what are usually collision-based incidents in our analysis.

IV SOCIAL COST OF MOTOR VEHICLE COLLISIONS IN ONTARIO

A. INTRODUCTION

This chapter presents the social cost of motor vehicle collisions in Ontario for 2004 based on the costs and allocation methods discussed in the previous chapter.

B. SOCIAL COSTS

Exhibit IV-1 presents our estimate of the social costs of motor vehicles collisions using the willingness to pay (WTP) method for valuing human consequences and the medium scenario for this value. The social costs are presented in millions of dollars in the base year 2004.

Social costs estimated based on collision identified in ORSAR for 2004 (See Exhibit III-1), adjustments to reflect under-reporting and misreporting in the data (See Section III B and Exhibit III-3), estimates of other characteristics of injured persons (See Section III C), estimates of resource use as a result of collision (See Section III D), and values for human consequences (See Section III E) and non-human consequences (See Section III F).

Using the medium WTP estimates and the analysis and parameters previously described, the social cost of motor vehicle collisions for 2004 is $17.9 billion. Total social cost by collision severity is: Fatal—$11.5 billion; Injury—$5.0 billion; and PDO—$1.3 billion. The average social cost by collision severity is: Fatal—$15.7 million; Injury—$82 thousand; and PDO—$8 thousand. The average collision had a social cost of $77 thousand in 2004.

Human consequence of the collision represents the largest component of costs at $15 billion (84%) with fatalities comprising $11 billion of this sub-total (62% of all social costs).

Other consequences are significant at $2.9 billion (16%). Major contributors to social costs among non-human consequences are property damage and other losses normally paid through insurance at $1.8 million (6%), traffic delay costs at $502 million (2.8%), out-of-pocket expenses which will include property damages that are not reimbursed through insurance at $206 million (1.2%), hospital/health care costs at $123 million (0.7%), tow truck services at $96 million (0.5%), fire department response at $91 million (0.5%), and police services at $85 million (0.5%).

Exhibit IV-1 Social cost of motor vehicle collisions in Ontario in 2004 based on willingness to pay medium estimate (2004 million $)

Social costs of collisions in: **2004**
Using values ($000,000) for: **2004**
Valuation using: **Medium estimate using Willingness to Pay**

	Collision Severity			
	Fatal	Injury	PDO	**TOTAL**
Fatalities	11,056.8			**11,056.8**
Injuries:				
Major	41.0	641.1		**682.1**
Minor	40.8	1,535.0		**1,575.8**
Minimal	1.3	80.1		**81.4**
Total disability	9.2	192.1		**201.3**
Partial disability	51.3	1,266.8		**1,318.0**
HUMAN SUB-TOTAL	**11,200.5**	**3,715.1**		**14,915.6**
Other costs:				
Property damage	17.5	740.9	1,045.8	**1,804.2**
Hospital/Health care:				
- ER facility	0.2	6.5	0.0	**6.8**
- Hospital stay facility	1.2	11.0		**12.1**
- Medical practitioners	4.3	99.7		**104.0**
Police	6.1	49.9	29.3	**85.3**
Courts	0.9	7.3	4.3	**12.6**
Fire	1.9	89.4		**91.3**
Ambulance	1.6	27.6		**29.1**
Tow trucks	0.6	33.2	61.8	**95.6**
Out of pocket	0.6	56.3	149.3	**206.2**
Traffic delays:				
- Extra time	120.6	102.2	27.9	**250.7**
- Extra fuel	10.1	8.6	2.3	**21.0**
- Extra pollution	110.7	93.8	25.6	**230.2**
OTHER SUB-TOTAL	**276.3**	**1,326.4**	**1,346.4**	**2,949.1**
OVERALL TOTAL	**11,476.8**	**5,041.4**	**1,346.4**	**17,864.6**
AVERAGE ($000)	**15,728**	**81.6**	**8.0**	**77.2**

Exhibit IV-2 provides an alternative allocation of costs (for the willingness to pay medium estimate) across the major consequence of collision. In the exhibit, costs directly related to human consequences (value of life and injury avoided, hospital and health care and ambulance costs) and all other costs (allocated based on the number of fatalities; major, minor and minimal injuries, and PDOs) are identified.

Exhibit IV-2 Allocation of costs by major collision consequence—total (2004 million $) and average (2004 thousand $) for Willingness to Pay Medium Estimate (WTP-M)

	Human Consequences					Total
	Fatalities	Major	Minor	Minimal	PDO	
Human consequences	11056.8	1373.8	2132.0	352.9		14915.6
Hospital/Health Care						
- ER facility	0.0	0.4	6.3	0.0		6.8
- Hospital stay facility	0.5	11.7				12.1
- Medical practitioners	1.0	24.3	55.8	22.9		104.0
Ambulance	0.6	5.9	22.6			29.1
Total directly attributable to individuals	11058.9	1416.2	2216.6	375.8		15067.6
All other attibutable costs	9.4	60.9	701.1	679.2	1346.4	2797.1
Total ($ million)	11068.3	1477.1	2917.8	1055.0	1346.4	17864.6
Average ($ thousand)*	13614.2	279.8	48.0	17.9	8.0	77.2

* Average per fatal, injury by severity, PDO and collision respectively

Using the willingness to pay medium scenario, average costs (including direct and other allocated costs) per fatality are $13.6 million and per major, minor, and minimal injury are $280 thousand, $48 thousand, and $18 thousand respectively. Average costs per PDO are $8 thousand. The average cost of a collision in Ontario in 2004 is $77 thousand.

C. SOCIAL COSTS BASED ON ALTERNATE VALUES FOR HUMAN CONSEQUENCES

The model allows flexibility in terms of the selection of the method used to value human consequences. Exhibit IV-3 shows the result of alternative valuation methods for human consequences. Using the discounted future earnings approach the value placed on human consequences is $1.5 billion. A willingness to pay approach to valuing human consequences would produce a range from $7.4 billion to $22.4 billion.

Based on these alternative valuation methods for human consequences the social costs of motor vehicle collisions in Ontario for 2004 are $4.2 billion using a DFE approach and from $10.0 billion to $25.1 billion using a WTP approach.

Exhibit IV-3 Values for Human Consequences based on alternative valuation methods (2004 million $)

Discounted Future Earnings				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	894.3			894.3
Injuries:				
Major	2.4	38.2		40.7
Minor	1.8	67.2		69.0
Minimal	0.0	2.1		2.1
Total disability	7.0	146.5		153.6
Partial disability	13.4	332.1		345.6
HUMAN SUB-TOTAL	**919.0**	**586.2**		**1,505.2**

Low estimate using Willingness to Pay				
	Collision Severity			
	Fatal	Injury	PDO	**TOTAL**
Fatalities	6,097.5			**6,097.5**
Injuries:				
Major	13.7	213.8		**227.5**
Minor	13.6	512.0		**525.6**
Minimal	0.4	26.7		**27.2**
Total disability	3.1	64.0		**67.1**
Partial disability	17.1	422.2		**439.3**
HUMAN SUB-TOTAL	**6,145.4**	**1,238.8**		**7,384.2**

High estimate using Willingness to Pay				
	Collision Severity			
	Fatal	Injury	PDO	**TOTAL**
Fatalities	16,016.1			**16,016.1**
Injuries:				
Major	68.4	1,069.2		**1,137.6**
Minor	68.1	2,559.8		**2,627.9**
Minimal	2.2	133.5		**135.8**
Total disability	15.3	320.2		**335.6**
Partial disability	85.5	2,111.3		**2,196.7**
HUMAN SUB-TOTAL	**16,255.7**	**6,194.0**		**22,449.6**

D. COMPARISON OF SOCIAL COSTS ESTIMATES FOR 2004 AND 1990

Estimates of the social cost of motor vehicle collisions in Ontario for 2004 use a similar methodology to that employed by the estimates for 1990. We compare the results of the two studies in this section.

The comparison we make uses the willingness to pay approach and low estimate scenario (this results in the same modelling approach to the value of human consequences in the two studies) and excludes cost items for court costs and traffic delays not estimated in the earlier study. This comparison allows us to focus on relative changes in the cost items between the two estimates.

The distribution of total costs by comparable cost component is noted in Exhibit IV-4.

Exhibit IV-4 Comparison of Social Cost Estimates for 2004 and 1990

	Social costs in:	
	2004	1990
Fatalities	62.1%	68.1%
Injuries	13.1%	13.5%
Property damage	18.4%	14.7%
Hospital/Health care	1.3%	1.4%
Police	0.9%	0.4%
Fire	0.9%	0.1%
Ambulance	0.3%	0.1%
Tow trucks	1.0%	0.2%
Out-of-pocket	2.1%	1.6%

A review by cost components suggests:

- The value of fatalities and injuries both declined in the overall estimates of social cost from 1990 to 2004. In terms of total social cost, fatalities declined from 68% to 62% and injuries declined from 13.5% to 13.1% of the estimated values. In the same period fatalities per collision declined by 33% while injuries declined by 11%. (Please note that this comparison uses the low cost WTP estimates. A more complete discussion of the current model's use of higher values for human consequences is presented below.)
- Property damage and out-of-pocket costs have increased in value between 1990 and 2004. We feel this may reflect the higher relative value of vehicles in the later period.

- Hospital/health care as a proportion of total costs declined from 1.4% to 1.3% between 1990 and 2004. As noted earlier injuries have declined by 11% over this period. As well injuries requiring a hospital stay decline most (down 44% as a proportion of all injuries). As a result there has been a shift in the severity of injuries away from the most costly injuries as may be reflected in our estimate.
- Police, fire, and ambulance costs have increased in the current estimate. This may be due to better data related to the use of these services and estimates of the costs per use in the current model. Also costs related to fire departments which show the largest gains from 0.1% to 0.9% between 1990 and 2004 likely reflect a much greater use of fire services in motor vehicle collisions in the second period.
- The proportion of costs devoted to tow trucks has increased from 0.2% to 1.0% likely due to changes in the industry identified in the current study.

Inclusion of the previously unmeasured cost of traffic delays and court proceedings increases the social costs estimated in 2004. However, the biggest change between the model results for 2004 compared to 1990 is the adoption of higher values for human consequences using the medium scenario willingness to pay estimate. This follows a general trend toward the assignment of higher values to human consequences in the relevant literature (See Trawen et al. (2002), "International Comparison of Costs of a Fatal Casualty of Road Accidents in 1990 and 1999", *Accident Analysis and Prevention*, v. 34). We also include a high estimate that overcomes previous deficiencies in the willingness to pay approach that tended to depress the values assigned to human consequences. Although the existence of this bias is widely recognized, the Gunderson and Hyatt study is the first and to our knowledge only study to adjust for it. We include their estimate as our high scenario related to the social value of human consequences. Given the absence of further discussion in the economics literature related to this study, we use the more conservative medium scenario as the base for our estimates. (In reporting of the results of other models we use the medium scenario willingness to pay approach although the analyst has the option to use any of the methods to valuing human consequences.)

E. COMPARISON OF 2004 ESTIMATE WITH ESTIMATES AVAILABLE THROUGH SMARTRISK

SMARTRISK is a Canadian non-profit organization dedicated to preventing injuries and saving lives. The organization provides information related to everyday risks to allow people to make more informed choices related to the activities they engage in.

We estimate the cost of health care (including hospital and medical professional care) related to motor vehicle collisions at $122.9 million in 2004. A comparable estimate of the direct cost (including hospital care, physician services, prescription drugs and home modifications or vocational rehabilitation) of Ontario motor vehicle collisions is available from a study by SMARTRISK.[1] Their estimate of $125 million in 1996 when adjusted for inflation and number of persons injured or killed in Ontario motor vehicle collisions between 1996 and 2004 would range between $122 to $127 million respectively. This number is almost identical to our estimate of the costs of health care.[2]

SMARTRISK also produces an estimate of the indirect costs of motor vehicle collisions. Their methodology is based on the DFE approach. Their estimate of $442 million in 1996 when adjusted for inflation and the number of persons injured or killed in Ontario motor vehicle collisions would range between $429 to $477 million respectively. The estimate in this study based on the DFE approach is $1.5 billion.[3]

There are two differences between the SMARTRISK estimates and those produced by this study. First, SMARTRISK does not cover the full range of social costs investigated by this study but instead covers only the direct and indirect cost of injury and death. Second, the values assigned to human consequences (indirect costs) are lower for SMARTRISK. The implicit value for a life lost in motor vehicle collision is $300,000 in the SMARTRISK study for 1996. This is one-third of the value of life estimated for this study using the comparable DFE approach. Estimates using the WTP approach, which would be favoured by most social cost practitioners, are higher again.

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[1] The Economic Burden of Unintentional Injury in Ontario, SMARTRISK, 1999.

[2] SMARTRISK re-estimated costs for motor vehicle collisions in 1999 (The Economic Burden of Unintentional Injury in Ontario, SMARTRISK, 2006). In that study they estimated direct (health care) costs of motor vehicle collisions at $373 million almost three times the estimate of three years earlier, despite a reduction in the number of fatalities and injuries and no change in methods. We have not considered these data in our comparison.

[3] Again the 2006 SMARTRISK analysis re-estimates the indirect (human) costs of motor vehicle collisions at $628 million. Correcting for inflation and differences in the number of injuries and fatalities the estimate would be $615 million to $652 million respectively.

V ONTARIO SUB-MODELS AND THEIR SOCIAL COSTS

This chapter describes the modeling and estimation of social costs of motor vehicle collisions in four Ontario sub-models:

- **Drinking and driving collisions** defined as collisions associated with alcohol consumption by one or more involved drivers—not necessarily where alcohol was the cause.
- **Collisions involving pedestrians** where one or more of those involved was a pedestrian.
- **Large truck[1] collisions** defined as involving one or more vehicles qualifying as large truck.
- **Motor vehicle collisions on freeways** (or 400 series highways).

A. RAW DATA AND REVISIONS

Raw data for each model were extracted from ORSAR (2004). These data for the four sub-models are presented in Exhibit V-1.

Similar to the Ontario model, vehicles with unknown damage were assigned to other vehicle damage categories based on the proportions of vehicles in these known damage severity categories.

In the core Ontario model extra fatalities and injuries were first allocated among collision severities based on the number of demolished vehicles. Then fatalities among injury collisions and injuries among PDOs were transferred to either fatal crashes or injury crashes respectively along with the corresponding number of collisions and their characteristics.

In the Ontario sub-models extra fatalities and injuries were calculated and correctly assigned by collision severity based on the overall results observed in Ontario. To determine how many collisions and vehicles to transfer from injury collisions to fatal collisions and from PDOs to injury collisions the model calculates the number of extra fatalities and injuries that would have occurred in injury and PDO collisions. This calculation was based on the proportion of demolished vehicles in these collision types.

[1] Large truck is defined according to the following selected values under Vehicle types in the MTO data set: 8 truck- open (flatbed); 9 truck- closed (box, van); 10 truck- tank; 11 dump truck; 12 truck- car carrier; 13 truck- tractor; and 98 truck- other (cement mixer, crane, etc.)

Exhibit V-1 Raw data on the Characteristic of Motor Vehicle Collision in each Ontario Sub-model

Drinking and Driving

	Collision Severity			
	Fatal	Injury	PDO	Total
Crashes	171	2490	4735	7396
Fatalities	192			192
Injuries:				
Major	64	418		482
Minor	54	1799		1853
Minimal	22	1551		1573
Vehicles damaged:				
Demolished	174	1130	602	1906
Severe	26	1156	1544	2726
Moderate	23	827	2335	3185
Light	21	600	2354	2975
None	5	164	306	475
Unknown	11	205	445	661

Pedestrian Involved

	Collision Severity			
	Fatal	Injury	PDO	Total
Crashes	104	4318	133	4555
Fatalities	106			106
Injuries:				
Major	3	473		476
Minor	7	2328		2335
Minimal	7	1886		1893
Vehicles damaged:				
Demolished	8	44	0	52
Severe	16	107	2	125
Moderate	40	292	9	341
Light	41	1149	38	1228
None	22	2532	79	2633
Unknown	15	511	24	550

Exhibit V-1 Raw data on the Characteristic of Motor Vehicle Collision in each Ontario Sub-model (cont'd)

Large Trucks

		Collision Severity			
		Fatal	Injury	PDO	Total
Crashes		131	2722	13446	16299
Fatalities		154			154
Injuries:					
	Major	29	312		341
	Minor	59	1733		1792
	Minimal	43	1774		1817
Vehicles damaged:					
	Demolished	153	983	513	1649
	Severe	46	1210	2330	3586
	Moderate	40	1258	6056	7354
	Light	35	1569	9826	11430
	None	13	589	5077	5679
	Unknown	7	304	2181	2492

Freeway

		Collision Severity			
		Fatal	Injury	PDO	Total
Crashes		85	5258	20698	26041
Fatalities		103			103
Injuries:					
	Major	47	362		409
	Minor	62	3198		3260
	Minimal	37	4221		4258
Vehicles damaged:					
	Demolished	98	1418	1016	2532
	Severe	25	2575	4708	7308
	Moderate	28	2756	11307	14091
	Light	14	2412	13779	16205
	None	7	600	2676	3283
	Unknown	1	523	3109	3633

Next adjustments were made to transfer the number of collisions and the vehicles involved in them to injury and PDO collisions. The characteristics of a fatal collision were used to transfer a sufficient number of collisions that would have involved extra fatalities from injury to fatal collisions. Note that only the number of collisions and their associated vehicles by damage severity were transferred since the model had already correctly allocated the extra fatalities and injuries among collision severity categories.

The characteristics of an injury-only collision were used to transfer an appropriate number of collisions and their associated vehicles by damage severity from PDOs to injury collisions. A maximum number of collisions was calculated based on which injury severity category would be the hardest to achieve given the number of injuries allocated and the proportion of injuries by severity category in the average injury collision. The number of vehicles by damage severity category was estimated for this maximum number of collisions. This number of vehicles, subject to the maximum vehicles available by damage category, was transferred from PDOs to injury collisions. Recall that the model had already allocated the correct number of injuries to injury collisions based on the Ontario overall result.

The redistribution of collisions moves injury collisions that would involve fatalities to fatal collisions and PDO collisions that would involve injuries to injury collisions while maintaining the total number of collisions. As a result the number of fatal and injury collisions increases while PDOs declined. The model also keeps the number of vehicles and the proportion by damage severity constant. However these are redistributed among collision severity categories. The results of these adjustments are shown in Exhibit V-2.

Note that the model for pedestrian involved collisions transferred injury to fatal collisions but no PDOs to injury collisions. Because there were no demolished vehicles in PDO collisions, no extra injuries were assigned to PDOs by the model and consequently no collisions and their associated vehicles were transferred to injury collisions.

Data from ORSAR identify 133 PDOs involving a pedestrian and as appropriate to the definition of a PDO, none involved an injury either to the pedestrian or vehicle occupants. After adjustment the model continues to retain the 133 PDOs involving a pedestrian but with no injuries.

B. SOCIAL COST OF MOTOR VEHICLE COLLISIONS RELATED TO ONTARIO SUB-MODELS

Social costs related to each cost category of the Ontario core model are also applied to Ontario sub-models. The same flexibility exists over cost parameters as provided in the Ontario model. The analyst selects the valuation method for human consequences, values assigned to human consequences, and year in which values are presented. Social costs presented in this section used the willingness to pay—medium scenario.

Exhibit V-2 Revised/Adjusted Data on the Characteristic of Motor Vehicle Collision in each Ontario Sub-model

Drinking and Driving

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		174	3368	3854	7396
Fatalities		195			195
Injuries:					
	Major	83	625		708
	Minor	258	3596		3854
	Minimal	113	2281		2394
Vehicles damaged:					
	Demolished	184	1608	219	2011
	Severe	28	1647	1210	2884
	Moderate	24	1178	2173	3375
	Light	22	855	2277	3154
	None	5	234	264	503

Pedestrian Involved

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		106	4316	133	4555
Fatalities		108			108
Injuries:					
	Major	4	707		711
	Minor	33	4654		4687
	Minimal	36	2774		2810
Vehicles damaged:					
	Demolished	9	49	0	58
	Severe	18	120	2	141
	Moderate	45	328	11	384
	Light	46	1291	45	1382
	None	25	2846	94	2964

Exhibit V-2 Revised/Adjusted Data on the Characteristic of Motor Vehicle Collision in each Ontario Sub-model (cont'd)

Large Trucks

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		133	3700	12466	16299
Fatalities		157			157
Injuries:					
	Major	38	466		504
	Minor	281	3464		3746
	Minimal	220	2609		2829
Vehicles damaged:					
	Demolished	159	1442	152	1753
	Severe	48	1777	2041	3866
	Moderate	41	1848	6089	7978
	Light	36	2305	10075	12416
	None	13	865	5298	6176

Freeway

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		86	7572	18382	26041
Fatalities		105			105
Injuries:					
	Major	61	541		602
	Minor	296	6393		6689
	Minimal	189	6208		6397
Vehicles damaged:					
	Demolished	99	2604	0	2703
	Severe	25	5236	2622	7883
	Moderate	28	5604	9656	15289
	Light	14	4905	12695	17614
	None	7	1220	2337	3564

In addition, the analyst has control over specific cost parameters that are felt to differ significantly between the Ontario model and particular sub-model. The specific parameters and the values assigned in the calculations presented in this report are given in Exhibit V-3.

Exhibit V-3 Variable Cost Parameters in the Ontario Sub-Models and their Assigned Values used in this Report

Cost Component	Sub-model		
	Drinking and Driving	Large Trucks	Freeway
Police	2	1.5	2
Courts	2		
Fire		2	
Tow trucks		3	
Delay		3	5

Note that parameters are multiples of the standard costing used in the Ontario model. For example, police costs related to motor vehicle collisions involving drinking and driving are expected to be two times the average police costs for a motor vehicle collision in Ontario. In the large truck sub-model the cost of a tow service is assumed to increase three fold from $500 to $1500 on average. This reflects the higher proportion of large truck tow services required in the large truck sub-model. Although the cost of a large truck tow is estimated to be 30 to 50 times the average cost of a car or light truck tow, we believe that most tow services will continue to be for smaller vehicles in the large truck sub-model. No specific cost parameters are identified for the pedestrian involved collisions since all parameters are expected to be similar to those presented in the Ontario model.

1. Drinking and driving collisions

The 7,396 drinking and driving collisions in Ontario in 2004 resulted in social costs estimated at $3.1 billion. The social costs of human consequences makes up almost $3.0 billion (95%) of this total. Exhibit V-4 presents these social costs. The average drinking and driving collision has a social cost of $424 thousand.

Exhibit V-4 Social Costs of Drinking and Driving Collisions in Ontario (2004 million $)

Social costs of collisions in: **2004**
Using values ($000,000) for: **2004**
Valuation using: **Medium estimate using Willingness to Pay**

Drinking and Driving				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	2657.0			2657.0
Injuries:				
Major	10.7	80.7		91.4
Minor	6.7	93.3		100.0
Minimal	0.2	3.2		3.3
Total disability	2.2	18.7		20.9
Partial disability	11.5	106.6		118.2
HUMAN SUB-TOTAL	**2,688.3**	**302.5**		**2,990.8**
Other costs:				
Property damage	4.1	56.2	29.6	89.9
Hospital/Health care:				
- ER facility	0.0	0.4	0.0	0.5
- Hospital stay facility	0.3	1.4		1.7
- Medical practitioners	0.9	7.1		8.0
Police	2.9	5.4	1.3	9.7
Courts	0.9	1.6	0.4	2.9
Fire	0.4	4.9		5.3
Ambulance	0.3	2.0		2.4
Tow trucks	0.1	1.6	1.2	2.9
Out of pocket	0.1	2.7	3.0	5.8
Traffic delays:				
- Extra time	3.9	3.3	0.9	8.0
- Extra fuel	0.3	0.3	0.1	0.7
- Extra pollution	3.5	3.0	0.8	7.4
OTHER SUB-TOTAL	**17.9**	**89.8**	**37.3**	**145.0**
OVERALL TOTAL	**2,706.1**	**392.3**	**37.3**	**3,135.8**

2. Pedestrian involved collisions

Pedestrians were involved in 4555 collisions in Ontario in 2004. These produced social costs estimated at $1.9 billion. The social costs of human consequences make up almost $1.8 billion (98%) of this total. Exhibit V-5 presents these social costs. The average pedestrian involved collision has a social cost of $412 thousand.

3. Large truck collisions

Large trucks were involved in 16,299 collisions in 2004. Social costs for these collisions are estimated at $2.7 billion. The social costs of human consequences make up almost $2.4 billion (89%) of this total. Exhibit V-6 presents these social costs. The average large truck collision has a social cost of $166 thousand.

4. Freeway collisions

There were 26,041 collisions on freeways in Ontario in 2004. Social costs for these collisions are estimated at $2.4 billion. The social costs of human consequences make up almost $1.9 billion (76%) of this total. Exhibit V-7 presents these social costs. The average freeway collision has a social cost of $130 thousand.

C. GOVERNMENT COST OF MOTOR VEHICLE COLLISIONS RELATED TO FREEWAYS

The sub-set of costs borne by the government related to freeway collisions is noted in Exhibit V-8. These costs are estimated at $51 million in 2004 or approximately $2,000 per freeway collision. Police account for $20 million (39%) of costs followed by hospital/health care at $13.7 million (27%) and fire services at $11.2 million (22%) of total government costs.

Exhibit V-5 Social Costs of Pedestrian Involved Collisions in Ontario (2004 million $)

Social costs of collisions in: **2004**
Using values ($000,000) for: **2004**
Valuation using: **Medium estimate using Willingness to Pay**

Pedestrian Involved				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	1466.9			1466.9
Injuries:				
Major	0.5	91.3		91.8
Minor	0.9	120.8		121.6
Minimal	0.0	3.8		3.9
Total disability	0.1	21.7		21.9
Partial disability	0.8	126.3		127.1
HUMAN SUB-TOTAL	**1,469.3**	**364.0**		**1,833.3**
Other costs:				
Property damage	0.6	5.1	0.1	5.8
Hospital/Health care:				
- ER facility	0.0	0.5	0.0	0.5
- Hospital stay facility	0.1	1.6		1.6
- Medical practitioners	0.2	8.6		8.8
Police	0.9	3.5	0.0	4.4
Courts	0.1	0.5	0.0	0.6
Fire	0.3	6.2		6.5
Ambulance	0.1	2.5		2.6
Tow trucks	0.1	1.3	0.0	1.4
Out of pocket	0.1	2.2	0.1	2.4
Traffic delays:				
- Extra time	2.4	2.0	0.5	4.9
- Extra fuel	0.2	0.2	0.0	0.4
- Extra pollution	2.2	1.8	0.5	4.5
OTHER SUB-TOTAL	**7.2**	**36.1**	**1.3**	**44.6**
OVERALL TOTAL	**1,476.4**	**400.1**	**1.3**	**1,877.9**

Exhibit V-6 Social Costs of Large Truck Collisions in Ontario (2004 million $)

Social costs of collisions in: **2004**
Using values ($000,000) for: **2004**
Valuation using: **Medium estimate using Willingness to Pay**

Large Trucks				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	2131.1			2131.1
Injuries:				
Major	4.9	60.2		65.1
Minor	7.3	89.9		97.2
Minimal	0.3	3.6		3.9
Total disability	1.2	15.0		16.2
Partial disability	7.3	89.8		97.1
HUMAN SUB-TOTAL	**2,152.1**	**258.6**		**2,410.7**
Other costs:				
Property damage	3.9	58.8	62.8	125.5
Hospital/Health care:				
- ER facility	0.0	0.4	0.0	0.4
- Hospital stay facility	0.2	1.0		1.2
- Medical practitioners	0.7	6.3		7.1
Police	1.7	4.5	3.2	9.4
Courts	0.2	0.7	0.5	1.4
Fire	0.7	10.7		11.4
Ambulance	0.3	1.8		2.1
Tow trucks	0.4	7.0	14.2	21.6
Out of pocket	0.1	4.0	11.4	15.5
Traffic delays:				
- Extra time	25.5	21.6	5.9	52.9
- Extra fuel	2.1	1.8	0.5	4.4
- Extra pollution	23.4	19.8	5.4	48.6
OTHER SUB-TOTAL	**59.2**	**138.4**	**104.0**	**301.7**
OVERALL TOTAL	**2,211.3**	**397.1**	**104.0**	**2,712.4**

Exhibit V-7 Social Costs of Freeway Collisions in Ontario (2004 million $)

Social costs of collisions in: **2004**
Using values ($000,000) for: **2004**
Valuation using: **Medium estimate using Willingness to Pay**

Freeway				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	1425.3			1425.3
Injuries:				
Major	7.9	69.9		77.8
Minor	7.7	165.9		173.6
Minimal	0.3	8.6		8.9
Total disability	1.8	20.9		22.6
Partial disability	9.8	137.2		147.0
HUMAN SUB-TOTAL	**1,452.7**	**402.5**		**1,855.2**
Other costs:				
Property damage	2.4	139.0	84.9	226.4
Hospital/Health care:				
- ER facility	0.0	0.7	0.0	0.7
- Hospital stay facility	0.2	1.2		1.4
- Medical practitioners	0.8	10.8		11.5
Police	1.5	12.2	6.4	20.0
Courts	0.2	1.8	0.9	2.9
Fire	0.2	11.0		11.2
Ambulance	0.3	3.0		3.2
Tow trucks	0.1	5.6	5.5	11.1
Out of pocket	0.1	9.5	13.2	22.7
Traffic delays:				
- Extra time	67.8	57.4	15.7	141.0
- Extra fuel	5.7	4.8	1.3	11.8
- Extra pollution	62.3	52.8	14.4	129.4
OTHER SUB-TOTAL	**141.5**	**309.7**	**142.3**	**593.5**
OVERALL TOTAL	**1,594.2**	**712.2**	**142.3**	**2,448.7**

Exhibit V-8 Government Costs of Freeway Collisions in Ontario (2004 million $)

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Hospital/Health care:				
- ER facility	0.04	0.70	0.00	0.75
- Hospital stay facility	0.20	1.19		1.39
- Medical practitioners	0.76	10.78		11.53
Police	1.45	12.22	6.37	20.04
Courts	0.21	1.80	0.94	2.95
Fire	0.22	10.95		11.17
Ambulance	0.26	2.99		3.24
Total government cost	3.14	40.63	7.31	51.08

VI CANADIAN JURISDICTIONS MODEL AND SOCIAL COSTS

This chapter describes the modeling and estimation of social costs of motor vehicle collisions in all Canadian jurisdictions and for Canada in total.

A. RAW DATA AND REVISIONS

Raw data on motor vehicle collisions in 2004 for each jurisdiction were obtained from the Traffic Accident Information Database (TRAID) of Transport Canada. Exhibit VI-1 presents the data for 2004.

Some of these data are not recorded in a manner consistent with the data used by the Ontario model. As a result we revised the data to reflect the format of the Ontario data as follows:

- For Newfoundland and Labrador we estimated minimal injuries based on data for other injury categories for Newfoundland and proportions for Ontario across injury categories.
- For Prince Edward Island, Manitoba, Saskatchewan, Nunavut, Northwest Territories and Yukon, vehicles listed as “Towed Away” were assigned to the “Severe” damage category.
- For Newfoundland and Labrador, Nova Scotia, New Brunswick, Quebec, and Alberta, we distributed missing vehicle damage by collision severity based on proportions for Ontario.
- For Quebec and Alberta we estimated missing minimal and minor injury categories based on data for other injury categories and proportions from Ontario.
- For unknown injury severity categories for Manitoba, Nunavut, Northwest Territories and Yukon we redistributed the number of unknown based on proportions for available categories.

Results of the revisions in the raw data for each jurisdiction are presented in Exhibit VI-2.

Exhibit VI-1 Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Newfoundland and Labrador

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		28	1838	4326	6192
Fatalities		37			37
Injuries:					
	Major	12	167		179
	Minor	19	2473		2492
	Minimal	0	0		0
Vehicles damaged:					
	Demolished				0
	Severe				0
	Moderate				0
	Light				0
	None				0
	Unknown	45	3343	7523	10911

Prince Edward Island

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		25	582	1056	1663
Fatalities		30			30
Injuries:					
	Major	10	75		85
	Minor	12	521		533
	Minimal	2	319		321
Vehicles damaged:					
	Towed Away	9	373	416	798
	Demolished	28	221	97	346
	Severe	0	0	0	0
	Moderate	3	176	504	683
	Light	2	185	673	860
	None	1	37	107	145
	Unknown	0	5	42	47

Exhibit VI-1 (cont'd) Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Nova Scotia

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		76	3673	8568	12317
Fatalities		90			90
Injuries:					
	Major	35	276		311
	Minor	43	2747		2790
	Minimal	12	2005		2017
Vehicles damaged:					
	Demolished				0
	Severe				0
	Moderate				0
	Light				0
	None				0
	Unknown	119	6256	15430	21805

New Brunswick

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		61	2920	6090	9071
Fatalities		71			71
Injuries:					
	Major	26	355		381
	Minor	29	2651		2680
	Minimal	6	1090		1096
	Extent Unknown	0	69		69
Vehicles damaged:					
	Demolished				0
	Severe				0
	Moderate				0
	Light				0
	None				0
	Unknown	95	4801	9910	14806

Exhibit VI-1 (cont'd) Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Quebec

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	577	39794	102509	142880
Fatalities	647			647
Injuries:				
Major	210	5828		6038
Minor	361	49489		49850
Minimal	0	0		0
Vehicles damaged:				
Demolished				0
Severe				0
Moderate				0
Light				0
None				0
Unknown	1010	70494	184278	255782

Ontario

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	718	49948	180882	231548
Fatalities	799			799
Injuries:				
Major	245	3320		3565
Minor	330	29589		29919
Minimal	189	39338		39527
Vehicles damaged:				
Demolished	678	10023	5883	16584
Severe	188	21021	32110	53319
Moderate	147	24698	99313	124158
Light	125	24486	137512	162123
None	45	8572	19161	27778
Unknown	58	5420	37511	42989

Exhibit VI-1 (cont'd) Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Manitoba

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	90	6865	24469	31424
Fatalities	99			99
Injuries:				
Major	48	441		489
Minor	39	3731		3770
Minimal	7	4356		4363
Extent Unknown	3	694		697
Vehicles damaged:				
Towed Away	5	1352	2021	3378
Demolished	84	1451	1316	2851
Severe	0	0	0	0
Moderate	15	1969	5471	7455
Light	14	4268	20147	24429
None	6	709	1722	2437
Unknown	0	0	12	12

Saskatchewan

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	105	5249	17718	23072
Fatalities	126			126
Injuries:				
Major	26	494		520
Minor	33	1935		1968
Minimal	46	1863		1909
Vehicles damaged:				
Towed Away	29	1883	2954	4866
Demolished	91	981	575	1647
Severe	0	0	0	0
Moderate	9	1395	3245	4649
Light	20	2361	4466	6847
None	3	514	565	1082
Unknown	7	1757	15881	17645

Exhibit VI-1 (cont'd) Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Alberta

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	317	16289	87704	104310
Fatalities	387			387
Injuries:				
Major	199	3086		3285
Minor	0	0		0
Minimal	166	20798		20964
Vehicles damaged:				
Demolished	309	4231	2842	7382
Severe				0
Moderate				0
Light				0
None				0
Unknown	190	24975	139773	164938

British Columbia

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	398	20300	28780	49478
Fatalities	430			430
Injuries:				
Major	127	2016		2143
Minor	170	15531		15701
Minimal	70	11222		11292
Vehicles damaged:				
Demolished	343	4236	1723	6302
Severe	111	9563	8304	17978
Moderate	86	9220	16937	26243
Light	57	7490	14996	22543
None	22	2439	2324	4785
Unknown	14	2919	5204	8137

Exhibit VI-1 (cont'd) Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Nunavut

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		1	35	71	107
Fatalities		1			1
Injuries:					
	Major	0	10		10
	Minor	0	29		29
	Minimal	0	24		24
	Unknown	0	3		3
Vehicles damaged:					
	Towed Away	0	13	11	24
	Demolished	0	1	2	3
	Severe	0	0	0	0
	Moderate	0	14	38	52
	Light	0	12	53	65
	None	0	13	16	29
	Unknown	0	5	7	12

Northwest Territories

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		3	112	547	662
Fatalities		3			3
Injuries:					
	Major	0	13		13
	Minor	5	45		50
	Minimal	0	58		58
	Extent Unknown	1	28		29
Vehicles damaged:					
	Towed Away	1	37	85	123
	Demolished	3	13	4	20
	Severe	0	0	0	0
	Moderate	1	55	431	487
	Light	1	24	188	213
	None	0	21	122	143
	Unknown	1	21	160	182

Exhibit VI-1 (cont'd) Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Yukon

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	5	148	445	598
Fatalities	5			5
Injuries:				
Major	2	23		25
Minor	1	120		121
Minimal	0	56		56
Extent Unknown	0	11		11
Vehicles damaged:				
Towed Away	2	38	40	80
Demolished	6	26	16	48
Severe	0	0	0	0
Moderate	1	30	120	151
Light	1	78	342	421
None	0	14	47	61
Unknown	0	18	187	205

Exhibit VI-2 Revised Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Newfoundland and Labrador		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		28	1838	4326	6192
Fatalities		37			37
Injuries:					
	Major	12	167		179
	Minor	19	2473		2492
	Minimal	10	3156		3166
Vehicles damaged:					
	Demolished	26	377	151	554
	Severe	7	791	822	1620
	Moderate	6	930	2541	3477
	Light	5	922	3519	4446
	None	2	323	490	815

Prince Edward Island		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		25	582	1056	1663
Fatalities		30			30
Injuries:					
	Major	10	75		85
	Minor	12	521		533
	Minimal	2	319		321
Vehicles damaged*:					
	Demolished	28	222	99	349
	Severe	9	375	426	810
	Moderate	3	177	516	696
	Light	2	186	689	877
	None	1	37	110	148

* Towed away assigned to missing severe category

Exhibit VI-2 (cont'd) Revised Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Nova Scotia

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	76	3673	8568	12317
Fatalities	90			90
Injuries:				
Major	35	276		311
Minor	43	2747		2790
Minimal	12	2005		2017
Vehicles damaged:				
Demolished	68	706	309	1083
Severe	19	1481	1685	3185
Moderate	15	1740	5213	6967
Light	13	1725	7218	8955
None	5	604	1006	1614

New Brunswick

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	61	2920	6090	9071
Fatalities	71			71
Injuries*:				
Major	26	361		387
Minor	29	2696		2725
Minimal	6	1108		1114
Vehicles damaged:				
Demolished	52	511	176	738
Severe	14	1071	960	2045
Moderate	11	1258	2969	4239
Light	10	1248	4111	5368
None	3	437	573	1013

* Extent unknown distributed based on known injuries

Exhibit VI-2 (cont'd) Revised Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Quebec

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		577	39794	102509	142880
Fatalities		647			647
Injuries:					
	Major	210	5828		6038
	Minor	361	49489		49850
	Minimal	188	66124		66311
Vehicles damaged:					
	Demolished	579	7957	3688	12223
	Severe	161	16688	20128	36976
	Moderate	126	19607	62253	81985
	Light	107	19438	86198	105743
	None	38	6805	12011	18854

Ontario

		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		718	49948	180882	231548
Fatalities		799			799
Injuries:					
	Major	245	3320		3565
	Minor	330	29589		29919
	Minimal	189	39338		39527
Vehicles damaged:					
	Demolished	711	10635	6634	17980
	Severe	197	22304	36207	58708
	Moderate	154	26205	111985	138345
	Light	131	25981	155058	181170
	None	47	9095	21606	30748

Exhibit VI-2 (cont'd) Revised Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Manitoba

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	90	6865	24469	31424
Fatalities	99			99
Injuries:*				
Major	50	477		526
Minor	40	4035		4075
Minimal	7	4710		4718
Vehicles damaged:**				
Demolished	84	1451	1317	2852
Severe	5	1352	2022	3379
Moderate	15	1969	5473	7457
Light	14	4268	20155	24437
None	6	709	1723	2438

* Extent unknown distributed based on known injuries

** Towed away replaced by severe

Saskatchewan

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	105	5249	17718	23072
Fatalities	126			126
Injuries:				
Major	26	494		520
Minor	33	1935		1968
Minimal	46	1863		1909
Vehicles damaged:**				
Demolished	95	1223	1349	2666
Severe	30	2347	6928	9305
Moderate	9	1739	7610	9358
Light	21	2942	10474	13437
None	3	641	1325	1969

** Towed away replaced by severe

Exhibit VI-2 (cont'd) Revised Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Alberta

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	317	16289	87704	104310
Fatalities	387			387
Injuries:*				
Major	199	3086		3285
Minor	278	16567		16844
Minimal	166	20798		20964
Vehicles damaged:				
Demolished	309	4231	2842	7382
Severe	71	6235	13784	20090
Moderate	55	7326	42632	50013
Light	47	7263	59030	66340
None	17	2543	8225	10785

* Missing minor injuries replaced using proportions for Ontario

** Mising categories other than demolished based on Ontario

British Columbia

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	398	20300	28780	49478
Fatalities	430			430
Injuries:				
Major	127	2016		2143
Minor	170	15531		15701
Minimal	70	11222		11292
Vehicles damaged:				
Demolished	351	4611	1925	6888
Severe	114	10410	9280	19804
Moderate	88	10037	18927	29052
Light	58	8154	16758	24970
None	22	2655	2597	5275

Exhibit VI-2 (cont'd) Revised Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Nunavut

	Collision Severity			
	Fatal**	Injury	PDO	TOTAL
Crashes*	1	35	71	107
Fatalities	1			1
Injuries:***				
Major	0.3	10.5		10.8
Minor	0.9	30.4		31.2
Minimal	0.7	25.1		25.9
Vehicles damaged:****				
Demolished	0.0	1	2	3
Severe	0.4	14	12	24
Moderate	0.4	15	40	56
Light	0.4	13	56	70
None	0.4	14	17	32

* One fatal collision by definition

*** Extent unknown distributed based on known injuries

** Characteristics of fatal collsion based on injury collisions

**** Towed away replaced by severe

Northwest Territories

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	3	112	547	662
Fatalities	3			3
Injuries:*				
Major	0	16		16
Minor	6	56		62
Minimal	0	72		72
Vehicles damaged:**				
Demolished	4	15	7	26
Severe	1	42	102	146
Moderate	1	61	485	547
Light	1	30	263	294
None	0	23	132	155

* Extent unknown distributed based on known injuries

** Towed away replaced by severe

Exhibit VI-2 (cont'd) Revised Raw Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Yukon

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	5	148	445	598
Fatalities	5			5
Injuries:				
Major	2	24		26
Minor	1	127		128
Minimal	0	59		59
Vehicles damaged:**				
Demolished	6	29	21	56
Severe	2	42	53	97
Moderate	1	33	160	194
Light	1	86	455	542
None	0	15	63	78

* Extent unknown distributed based on known injuries

** Towed away replaced by severe

Next fatal and injury data for each jurisdiction were adjusted to reflect differences between the number and allocation of fatalities and injuries between the revised and adjusted data and the raw data for Ontario. As a result, the number of fatalities and injuries increased and their distribution across collision severity categories changed based on the observations in Ontario. This allowed us to reflect observations of misreporting and under-reporting in the Ontario data and the final distribution of human consequences among collision severities.

The number of collisions and involved vehicles was adjusted across collision severity in keeping with the methods used in the Ontario sub-models. For example, injury collisions were transferred to fatal collisions based on the number of extra fatalities that would have been allocated to injury collisions based on the proportion of demolished vehicles. The characteristics of fatal collisions and the number of fatalities estimated for injury collisions were used to transfer an appropriate number of collisions and their vehicle characteristics. The net result is that the number of fatal and injury collisions and vehicles involved in them increased and the number of PDOs and vehicles involved in them decreased.

The results of the adjustments are noted in Exhibit VI-3.

Exhibit VI-3 Adjusted Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Newfoundland and Labrador

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	28	2095	4069	6192
Fatalities	38			38
Injuries:				
Major	16	250		265
Minor	91	4,944		5,034
Minimal	52	4,641		4,693
Vehicles damaged:				
Demolished	26	430	98	554
Severe	7	902	711	1620
Moderate	6	1060	2411	3477
Light	5	1051	3390	4446
None	2	368	445	815

Prince Edward Island

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	25	671	966	1663
Fatalities	31			31
Injuries:				
Major	13	112		125
Minor	57	1,042		1,099
Minimal	10	469		479
Vehicles damaged*:				
Demolished	28	256	65	349
Severe	9	433	368	810
Moderate	3	204	488	696
Light	2	215	660	877
None	1	43	104	148

* Towed away assigned to missing severe category

Exhibit VI-3 (cont'd) Adjusted Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Nova Scotia

	Fatal	Injury	PDO	TOTAL
	Collision Severity			
Crashes	77	4226	8014	12317
Fatalities	92			92
Injuries:				
Major	45	412		458
Minor	205	5,492		5,697
Minimal	61	2,949		3,010
Vehicles damaged:				
Demolished	69	812	202	1083
Severe	19	1704	1462	3185
Moderate	15	2002	4950	6967
Light	13	1985	6957	8955
None	5	695	915	1614

New Brunswick

	Fatal	Injury	PDO	TOTAL
	Collision Severity			
Crashes	62	3281	5728	9071
Fatalities	72			72
Injuries*:				
Major	34	539		573
Minor	138	5,389		5,527
Minimal	31	1,630		1,661
Vehicles damaged:				
Demolished	53	573	113	738
Severe	15	1204	827	2045
Moderate	11	1414	2813	4239
Light	10	1402	3956	5368
None	3	491	519	1013

Exhibit VI-3 (cont'd) Adjusted Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Quebec

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	586	45950	96344	142880
Fatalities	658			658
Injuries:				
Major	272	8,709		8,981
Minor	1,722	98,934		100,656
Minimal	961	97,248		98,209
Vehicles damaged:				
Demolished	588	9180	2455	12223
Severe	163	19270	17542	36976
Moderate	128	22642	59216	81985
Light	108	22448	83187	105743
None	39	7859	10957	18854

Ontario

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	730	59534	171284	231548
Fatalities	813			813
Injuries:				
Major	317	4,961		5,279
Minor	1,574	59,152		60,726
Minimal	968	57,855		58,822
Vehicles damaged:				
Demolished	723	12667	4590	17980
Severe	200	26587	31921	58708
Moderate	157	31238	106950	138345
Light	133	30971	150066	181170
None	48	10842	19858	30748

Exhibit VI-3 (cont'd) Adjusted Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Manitoba

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	91	8507	22825	31424
Fatalities	101			101
Injuries:*				
Major	64	713		777
Minor	192	8,066		8,258
Minimal	37	6,928		6,965
Vehicles damaged:**				
Demolished	85	1797	969	2852
Severe	5	1676	1698	3379
Moderate	15	2440	5002	7457
Light	14	5290	19133	24437
None	6	879	1553	2438

* Extent unknown distributed based on known injuries

** Towed away replaced by severe

Saskatchewan

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	107	6659	16306	23072
Fatalities	128			128
Injuries:				
Major	34	738		772
Minor	157	3,868		4,026
Minimal	236	2,740		2,975
Vehicles damaged:**				
Demolished	97	1550	1020	2666
Severe	31	2978	6297	9305
Moderate	10	2206	7143	9358
Light	21	3734	9682	13437
None	3	813	1153	1969

** Towed away replaced by severe

Exhibit VI-3 (cont'd) Adjusted Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Alberta

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	322	19616	84372	104310
Fatalities	394			394
Injuries:*				
Major	258	4,611		4,869
Minor	1,324	33,119		34,442
Minimal	850	30,588		31,438
Vehicles damaged:				
Demolished	314	5091	1976	7382
Severe	72	7510	12508	20090
Moderate	56	8824	41133	50013
Light	48	8748	57544	66340
None	17	3063	7705	10785

* Missing minor injuries replaced using proportions for Ontario

** Mising categories other than demolished based on Ontario

British Columbia

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	404	23247	25827	49478
Fatalities	438			438
Injuries:				
Major	165	3,012		3177
Minor	811	31,048		31859
Minimal	358	16,504		16863
Vehicles damaged:				
Demolished	356	5276	1255	6888
Severe	115	11923	7765	19804
Moderate	89	11496	17467	29052
Light	59	9339	15572	24970
None	23	3041	2211	5275

Exhibit VI-3 (cont'd) Adjusted Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Nunavut

	Collision Severity			
	Fatal**	Injury	PDO	TOTAL
Crashes*	1	48	58	107
* One fatal collision by definition				
Fatalities	1			1
Injuries:***				
Major	0	16		16
Minor	4	61		65
Minimal	4	37		41
*** Extent unknown distributed based on known injuries				
Vehicles damaged:****				
Demolished	0	1	2	3
Severe	0	19	6	26
Moderate	0	21	35	56
Light	0	18	51	70
None	0	19	12	32

** Characteristics of fatal collsion based on injury collisions

**** Towed away replaced by severe

Northwest Territories

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	3	134	525	662
Fatalities	3			3
Injuries:*				
Major	0	24		24
Minor	29	112		140
Minimal	0	106		106
* Extent unknown distributed based on known injuries				
Vehicles damaged:**				
Demolished	4	18	4	26
Severe	1	50	94	146
Moderate	1	73	473	547
Light	1	36	257	294
None	0	27	128	155

** Towed away replaced by severe

Exhibit VI-3 (cont'd) Adjusted Data for Canadian Jurisdictions—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Yukon	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Crashes	5	177	416	598
Fatalities	5			5
Injuries:				
Major	3	36		39
Minor	5	253		258
Minimal	0	87		87
Vehicles damaged:**				
Demolished	6	34	16	56
Severe	2	50	45	97
Moderate	1	39	153	194
Light	1	102	438	542
None	0	18	60	78

** Towed away replaced by severe

A review of Exhibit III-3 from the Ontario model and Exhibit VI-3 from the Canadian jurisdictions model for Ontario indicates that the two produce identical estimates of fatalities and injuries and hold constant the total number of collisions and vehicles involved. Although identical in terms of the number and vehicle characteristics for fatal collisions the jurisdictions model identifies 4% less injury collisions and 1% more PDOs with corresponding differences in the number of vehicles involved than the more detailed Ontario model. This reflects the less involved adjustment procedures to transfer injury and PDO collisions to fatal and injury collisions respectively for all jurisdictions compared to Ontario core model.

Exhibits VII-4 and VII-5 provide an aggregation of the revised data (reflecting changes to address missing data and re-allocation of data across severity categories) and adjusted data (correcting for under reported or mis-reported data) respectively across jurisdictions).

Exhibit V-4 Revised Data for Canada on Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Canada		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		2,404	147,753	463,165	613,322
Fatalities		2,773			2,773
Injuries:					
	Major	1,220	24,134		25,354
	Minor	6,308	251,478		257,786
	Minimal	3,568	221,781		225,350
Vehicles damaged:					
	Demolished	2,324	31,740	18,551	52,615
	Severe	656	64,147	97,315	162,117
	Moderate	479	70,866	262,943	334,288
	Light	416	70,929	354,303	425,648
	None	142	23,832	49,480	73,454

Exhibit V-5 Adjusted Data for Canada on Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

Canada		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Crashes		2,443	174,144	436,735	613,322
Fatalities		2,773			2,773
Injuries:					
	Major	1,220	24,134		25,354
	Minor	6,308	251,478		257,786
	Minimal	3,568	221,781		225,350
Vehicles damaged:					
	Demolished	2,350	37,686	12,764	52,800
	Severe	641	74,304	81,246	156,191
	Moderate	492	83,659	248,235	332,387
	Light	416	85,337	350,894	436,648
	None	148	28,157	45,618	73,923

The Canadian totals show over 613,000 collisions in 2004 involving over 1 million vehicles. Although the number of collisions and number of vehicles involved do not change the distribution by collision severity does. For example PDOs decline by 6% while fatal and injury collisions increase by 2% and 18% respectively. The number of fatalities is increased by 5% to 2,773, the number of major (to 25,354) and minimal (to 225,350) injuries increase by slightly less than 50% while minor injuries (to 257,786) increase by slightly more than 100%. All percentage increases for fatalities and injuries are in keeping with the Ontario core model.

B. SOCIAL COST

Exhibit VI-6 presents detail on the social costs by jurisdiction based on the data by jurisdiction from the Traffic Accident Information Database (Exhibit VI-1), the revisions and adjustments to the data as discussed in earlier sections (See Exhibits VII-2 and 3), and the social cost methodology of the model. Note that the detailed cost estimates by jurisdiction assume the cost structures observed in Ontario. If differences exist in the consequences by jurisdiction (proportion of calls by fire departments to collisions for example) or nature of the markets impacted by collisions (for example tow truck services are more or less competitive) there will be differences in the nature and distribution of costs from those observed in Ontario. As a result readers should expect less certainty in the cost estimates for jurisdictions other than Ontario. Also note that the Canadian jurisdictions model uses a slightly simplified approach to handling transfers among collision types to reflect extra fatalities and injuries occurring in injury and PDO collisions. This simplified approach results in less than a 0.03% difference in total social costs between the less precise estimates for Ontario in Exhibit VI-6 compared to results for the Ontario core model in Exhibit IV-1. The social cost of PDOs is 2% higher and injury collision is less than 1% lower in the jurisdictions model compared to the Ontario core model.

Exhibit VI-6 Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

Newfoundland and Labrador	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	512.0			512.0
Injuries:				
Major	2.0	32.2		34.3
Minor	2.4	128.3		130.6
Minimal	0.1	6.4		6.5
Total disability	0.5	12.1		12.6
Partial disability	2.6	87.3		89.9
HUMAN SUB-TOTAL	**519.6**	**266.4**		**785.9**
Other costs:				
Property damage	0.6	24.2	24.0	48.8
Hospital/Health care:				
- ER facility	0.0	0.5	0.0	0.5
- Hospital stay facility	0.1	0.6		0.6
- Medical practitioners	0.2	7.5		7.7
Police	0.2	1.7	0.7	2.6
Courts	0.0	0.2	0.1	0.4
Fire	0.1	3.0		3.1
Ambulance	0.1	2.1		2.2
Tow trucks	0.0	1.1	1.4	2.5
Out of pocket	0.0	1.8	3.4	5.3
Traffic delays:				
- Extra time	3.2	2.7	0.7	6.7
- Extra fuel	0.3	0.2	0.1	0.6
- Extra pollution	3.0	2.5	0.7	6.2
OTHER SUB-TOTAL	**7.9**	**48.3**	**31.1**	**87.2**
OVERALL TOTAL	**527.4**	**314.6**	**31.1**	**873.2**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

Prince Edward Island				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	415.1			415.1
Injuries:				
Major	1.7	14.5		16.2
Minor	1.5	27.0		28.5
Minimal	0.0	0.6		0.7
Total disability	0.4	3.7		4.1
Partial disability	1.9	22.7		24.6
HUMAN SUB-TOTAL	**420.6**	**68.6**		**489.1**
Other costs:				
Property damage	0.7	10.9	8.1	19.8
Hospital/Health care:				
- ER facility	0.0	0.1	0.0	0.1
- Hospital stay facility	0.0	0.2		0.3
- Medical practitioners	0.2	1.7		1.8
Police	0.2	0.5	0.2	0.9
Courts	0.0	0.1	0.0	0.1
Fire	0.1	1.0		1.0
Ambulance	0.1	0.5		0.6
Tow trucks	0.0	0.3	0.3	0.7
Out of pocket	0.0	0.6	0.8	1.4
Traffic delays:				
- Extra time	0.9	0.7	0.2	1.8
- Extra fuel	0.1	0.1	0.0	0.2
- Extra pollution	0.8	0.7	0.2	1.7
OTHER SUB-TOTAL	**3.0**	**17.4**	**9.9**	**30.3**
OVERALL TOTAL	**423.6**	**86.0**	**9.9**	**519.5**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

Nova Scotia	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	1,245.4			1,245.4
Injuries:				
Major	5.9	53.3		59.2
Minor	5.3	142.5		147.8
Minimal	0.1	4.1		4.2
Total disability	1.3	15.7		16.9
Partial disability	6.8	102.3		109.1
HUMAN SUB-TOTAL	**1,264.8**	**317.8**		**1,582.7**
Other costs:				
Property damage	1.7	45.7	49.3	96.7
Hospital/Health care:				
- ER facility	0.0	0.6	0.0	0.6
- Hospital stay facility	0.2	0.9		1.1
- Medical practitioners	0.5	8.1		8.6
Police	0.6	3.4	1.4	5.4
Courts	0.1	0.5	0.2	0.8
Fire	0.2	6.1		6.3
Ambulance	0.2	2.5		2.7
Tow trucks	0.1	2.1	2.9	5.0
Out of pocket	0.1	3.5	7.0	10.5
Traffic delays:				
- Extra time	6.4	5.4	1.5	13.3
- Extra fuel	0.5	0.5	0.1	1.1
- Extra pollution	5.9	5.0	1.4	12.2
OTHER SUB-TOTAL	**16.5**	**84.3**	**63.8**	**164.5**
OVERALL TOTAL	**1,281.3**	**402.1**	**63.8**	**1,747.2**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

New Brunswick	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	982.5			982.5
Injuries:				
Major	4.4	69.7		74.1
Minor	3.6	139.8		143.4
Minimal	0.0	2.3		2.3
Total disability	0.9	18.0		18.9
Partial disability	4.9	109.6		114.5
HUMAN SUB-TOTAL	**996.3**	**339.4**		**1,335.7**
Other costs:				
Property damage	1.3	32.3	27.9	61.5
Hospital/Health care:				
- ER facility	0.0	0.6	0.0	0.6
- Hospital stay facility	0.1	1.2		1.3
- Medical practitioners	0.4	8.1		8.5
Police	0.5	2.6	1.0	4.2
Courts	0.1	0.4	0.1	0.6
Fire	0.2	4.7		4.9
Ambulance	0.1	2.6		2.8
Tow trucks	0.0	1.4	1.6	3.1
Out of pocket	0.0	2.5	4.0	6.5
Traffic delays:				
- Extra time	4.7	4.0	1.1	9.8
- Extra fuel	0.4	0.3	0.1	0.8
- Extra pollution	4.3	3.7	1.0	9.0
OTHER SUB-TOTAL	**12.2**	**64.5**	**36.9**	**113.6**
OVERALL TOTAL	**1,008.6**	**403.8**	**36.9**	**1,449.3**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

Quebec	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	8,953.4			8,953.4
Injuries:				
Major	35.2	1,125.4		1,160.6
Minor	44.7	2,567.3		2,612.0
Minimal	1.3	134.6		135.9
Total disability	8.3	331.2		339.5
Partial disability	47.6	2,165.0		2,212.6
HUMAN SUB-TOTAL	**9,090.4**	**6,323.5**		**15,414.0**
Other costs:				
Property damage	14.3	517.2	591.1	1,122.6
Hospital/Health care:				
- ER facility	0.2	10.9	0.0	11.2
- Hospital stay facility	1.0	19.2		20.2
- Medical practitioners	4.0	168.8		172.8
Police	4.9	37.1	16.7	58.7
Courts	0.7	5.5	2.5	8.6
Fire	1.5	66.5		68.0
Ambulance	1.4	46.6		48.0
Tow trucks	0.5	23.2	34.7	58.3
Out of pocket	0.5	39.3	83.7	123.5
Traffic delays:				
- Extra time	74.4	63.0	17.2	154.7
- Extra fuel	6.2	5.3	1.4	13.0
- Extra pollution	68.3	57.9	15.8	142.0
OTHER SUB-TOTAL	**178.0**	**1,060.5**	**763.2**	**2,001.7**
OVERALL TOTAL	**9,268.4**	**7,384.0**	**763.2**	**17,415.6**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

Ontario	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	11,056.8			11,056.8
Injuries:				
Major	41.0	641.1		682.1
Minor	40.8	1,535.0		1,575.8
Minimal	1.3	80.1		81.4
Total disability	9.2	192.1		201.3
Partial disability	51.3	1,266.8		1,318.0
HUMAN SUB-TOTAL	**11,200.5**	**3,715.1**		**14,915.6**
Other costs:				
Property damage	17.5	713.6	1,073.1	1,804.2
Hospital/Health care:				
- ER facility	0.2	6.5	0.0	6.8
- Hospital stay facility	1.2	11.0		12.1
- Medical practitioners	4.3	99.7		104.0
Police	6.1	48.0	29.7	83.9
Courts	0.9	7.1	4.4	12.3
Fire	1.9	86.1		88.0
Ambulance	1.6	27.6		29.1
Tow trucks	0.6	32.0	62.7	95.2
Out of pocket	0.6	54.2	151.3	206.2
Traffic delays:				
- Extra time	120.6	102.2	27.9	250.7
- Extra fuel	10.1	8.6	2.3	21.0
- Extra pollution	110.7	93.8	25.6	230.2
OTHER SUB-TOTAL	**276.3**	**1,290.3**	**1,377.1**	**2,943.7**
OVERALL TOTAL	**11,476.8**	**5,005.4**	**1,377.1**	**17,859.3**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

Manitoba	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	1,370.0			1,370.0
Injuries:				
Major	8.3	92.1		100.4
Minor	5.0	209.3		214.3
Minimal	0.1	9.6		9.6
Total disability	1.7	26.6		28.3
Partial disability	8.7	172.6		181.3
HUMAN SUB-TOTAL	**1,393.7**	**510.2**		**1,903.9**
Other costs:				
Property damage	1.9	70.5	79.6	151.9
Hospital/Health care:				
- ER facility	0.0	0.9	0.0	0.9
- Hospital stay facility	0.2	1.6		1.8
- Medical practitioners	0.6	13.4		14.0
Police	0.8	6.9	4.0	11.6
Courts	0.1	1.0	0.6	1.7
Fire	0.2	12.3		12.5
Ambulance	0.2	3.8		4.0
Tow trucks	0.1	3.4	5.7	9.2
Out of pocket	0.1	5.8	13.7	19.6
Traffic delays:				
- Extra time	16.4	13.9	3.8	34.0
- Extra fuel	1.4	1.2	0.3	2.8
- Extra pollution	15.0	12.7	3.5	31.2
OTHER SUB-TOTAL	**36.9**	**147.4**	**111.1**	**295.4**
OVERALL TOTAL	**1,430.6**	**657.6**	**111.1**	**2,199.2**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

Saskatchewan	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	1,743.6			1,743.6
Injuries:				
Major	4.4	95.4		99.7
Minor	4.1	100.4		104.5
Minimal	0.3	3.8		4.1
Total disability	1.0	21.8		22.8
Partial disability	5.9	123.0		128.9
HUMAN SUB-TOTAL	1,759.3	344.4		2,103.7
Other costs:				
Property damage	2.3	76.9	130.4	209.7
Hospital/Health care:				
- ER facility	0.0	0.5	0.0	0.5
- Hospital stay facility	0.1	1.6		1.8
- Medical practitioners	0.6	8.0		8.6
Police	0.9	5.4	2.8	9.1
Courts	0.1	0.8	0.4	1.3
Fire	0.3	9.6		9.9
Ambulance	0.2	2.3		2.5
Tow trucks	0.1	3.2	5.1	8.3
Out of pocket	0.1	5.4	12.2	17.7
Traffic delays:				
- Extra time	12.0	10.2	2.8	25.0
- Extra fuel	1.0	0.9	0.2	2.1
- Extra pollution	11.0	9.3	2.6	22.9
OTHER SUB-TOTAL	**28.8**	**134.1**	**156.5**	**319.4**
OVERALL TOTAL	**1,788.1**	**478.5**	**156.5**	**2,423.1**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

Alberta	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	5,355.4			5,355.4
Injuries:				
Major	33.3	595.9		629.3
Minor	34.3	859.4		893.8
Minimal	1.2	42.3		43.5
Total disability	7.5	149.6		157.2
Partial disability	42.3	899.1		941.4
HUMAN SUB-TOTAL	**5,474.1**	**2,546.5**		**8,020.6**
Other costs:				
Property damage	7.4	231.9	419.3	658.6
Hospital/Health care:				
- ER facility	0.2	3.8	0.0	4.0
- Hospital stay facility	0.8	10.2		11.0
- Medical practitioners	3.2	63.6		66.8
Police	2.7	15.8	14.6	33.2
Courts	0.4	2.3	2.2	4.9
Fire	0.8	28.4		29.2
Ambulance	1.1	17.5		18.6
Tow trucks	0.2	9.5	24.2	33.9
Out of pocket	0.2	16.1	58.4	74.7
Traffic delays:				
- Extra time	54.3	46.0	12.6	112.9
- Extra fuel	4.6	3.9	1.1	9.5
- Extra pollution	49.9	42.3	11.6	103.7
OTHER SUB-TOTAL	**125.8**	**491.2**	**543.8**	**1,160.8**
OVERALL TOTAL	**5,599.9**	**3,037.7**	**543.8**	**9,181.4**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

British Columbia	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	5950.5			5950.5
Injuries:				
Major	21.3	389.3		410.6
Minor	21.0	805.7		826.7
Minimal	0.5	22.8		23.3
Total disability	4.7	104.4		109.1
Partial disability	25.9	650.9		676.8
HUMAN SUB-TOTAL	**6,023.9**	**1,973.2**		**7,997.1**
Other costs:				
Property damage	8.9	295.9	203.9	508.7
Hospital/Health care:				
- ER facility	0.1	3.5	0.0	3.6
- Hospital stay facility	0.6	6.6		7.3
- Medical practitioners	2.2	48.8		51.0
Police	3.4	18.8	4.5	26.6
Courts	0.5	2.8	0.7	3.9
Fire	1.0	33.6		34.7
Ambulance	0.8	14.9		15.8
Tow trucks	0.3	11.7	8.9	20.8
Out of pocket	0.3	19.8	21.4	41.5
Traffic delays:				
- Extra time	25.8	21.8	6.0	53.6
- Extra fuel	2.2	1.8	0.5	4.5
- Extra pollution	23.7	20.0	5.5	49.2
OTHER SUB-TOTAL	**69.7**	**500.2**	**251.3**	**821.2**
OVERALL TOTAL	**6,093.6**	**2,473.3**	**251.3**	**8,818.2**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

Nunavut	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	13.8			13.8
Injuries:				
Major	0.1	2.0		2.1
Minor	0.1	1.6		1.7
Minimal	0.0	0.1		0.1
Total disability	0.0	0.4		0.4
Partial disability	0.1	2.3		2.4
HUMAN SUB-TOTAL	**14.1**	**6.4**		**20.5**
Other costs:				
Property damage	0.0	0.4	0.3	0.7
Hospital/Health care:				
- ER facility	0.0	0.0	0.0	0.0
- Hospital stay facility	0.0	0.0		0.0
- Medical practitioners	0.0	0.1		0.2
Police	0.0	0.0	0.0	0.1
Courts	0.0	0.0	0.0	0.0
Fire	0.0	0.1		0.1
Ambulance	0.0	0.0		0.0
Tow trucks	0.0	0.0	0.0	0.0
Out of pocket	0.0	0.0	0.1	0.1
Traffic delays:				
- Extra time	0.1	0.0	0.0	0.1
- Extra fuel	0.0	0.0	0.0	0.0
- Extra pollution	0.1	0.0	0.0	0.1
OTHER SUB-TOTAL	**0.1**	**0.8**	**0.4**	**1.4**
OVERALL TOTAL	**14.3**	**7.3**	**0.4**	**21.9**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

Northwest Territories	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	41.5			41.5
Injuries:				
Major	0.0	3.1		3.1
Minor	0.7	2.9		3.6
Minimal	0.0	0.1		0.1
Total disability	0.0	0.7		0.7
Partial disability	0.2	4.0		4.2
HUMAN SUB-TOTAL	**42.5**	**10.8**		**53.4**
Other costs:				
Property damage	0.1	1.3	3.5	4.9
Hospital/Health care:				
- ER facility	0.0	0.0	0.0	0.0
- Hospital stay facility	0.0	0.1		0.1
- Medical practitioners	0.0	0.3		0.3
Police	0.0	0.1	0.1	0.2
Courts	0.0	0.0	0.0	0.0
Fire	0.0	0.2		0.2
Ambulance	0.0	0.1		0.1
Tow trucks	0.0	0.1	0.2	0.3
Out of pocket	0.0	0.1	0.5	0.6
Traffic delays:				
- Extra time	0.3	0.3	0.1	0.7
- Extra fuel	0.0	0.0	0.0	0.1
- Extra pollution	0.3	0.3	0.1	0.7
OTHER SUB-TOTAL	**0.9**	**2.7**	**4.4**	**8.0**
OVERALL TOTAL	**43.4**	**13.6**	**4.4**	**61.4**

Exhibit VI-6 (cont-d) Social Costs for Canadian Jurisdictions based on Willingness to Pay—Medium Scenario (2004 $ millions)

Yukon	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	69.2			69.2
Injuries:				
Major	0.3	4.7		5.0
Minor	0.1	6.6		6.7
Minimal	0.0	0.1		0.1
Total disability	0.1	1.1		1.2
Partial disability	0.3	6.4		6.7
HUMAN SUB-TOTAL	**70.0**	**18.8**		**88.9**
Other costs:				
Property damage	0.1	1.5	1.9	3.6
Hospital/Health care:				
- ER facility	0.0	0.0	0.0	0.0
- Hospital stay facility	0.0	0.1		0.1
- Medical practitioners	0.0	0.4		0.5
Police	0.0	0.1	0.1	0.3
Courts	0.0	0.0	0.0	0.0
Fire	0.0	0.3		0.3
Ambulance	0.0	0.1		0.1
Tow trucks	0.0	0.1	0.1	0.2
Out of pocket	0.0	0.1	0.3	0.5
Traffic delays:				
- Extra time	0.3	0.3	0.1	0.6
- Extra fuel	0.0	0.0	0.0	0.1
- Extra pollution	0.3	0.2	0.1	0.6
OTHER SUB-TOTAL	**0.9**	**3.3**	**2.6**	**6.8**
OVERALL TOTAL	**70.9**	**22.2**	**2.6**	**95.7**

Social cost estimates for each jurisdiction were then aggregated to reflect the social costs of motor vehicle collisions in Canada. Results for 2004 using the willingness to pay approach and medium scenario are shown in Exhibit VI-7. The Canadian results indicate a social cost of $63 billion. A total of $55 billion (87%) are related to the human consequences of the collision while $8 billion (13%) are related to other costs of motor vehicle collisions.

Totals for Canada are derived from individual estimates of social costs for each jurisdiction. Exhibit VI-8 presents the distribution of social costs estimated using the willingness to pay—medium scenario by jurisdiction within the Canadian total. The distribution of the Canadian population, gross domestic product, passenger kilometres travelled, and licensed drivers by jurisdiction is also presented for comparison purposes only. Although there are many determinants of motor vehicle collisions, there are some interesting findings through a comparison of these distributions. For example, Ontario represents a smaller share of the total Canadian social costs than its share of all social indicators.

Exhibit VI-9 illustrates changes to the social costs of human consequences for Canada if other social cost methods and assumptions are used. Using the discounted future earnings (DFE) method the cost of human consequences have a value of $5.8 billion for a total social costs including human consequences of $13.7 billion to Canada. The low and high scenarios using willingness to pay (WTP) result in estimates of human consequences of $26.5 billion and $83.0 billion respectively. Based on these estimates the total social cost of motor vehicle collisions in 2004 for Canada are $34.4 billion and $90.9 billion respectively. The social costs of human consequences for Canadian jurisdictions assuming other social cost methods and assumptions are presented in Appendix D.

Exhibit VI-7 Social cost of motor vehicle collisions in Canada in 2004 based on willingness to pay medium estimate (2004 million $)

Social costs of collisions in: **2004**
Using values ($000,000) for: **2004**
Valuation using: **Medium estimate using Willingness to Pay**

Canada				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Fatalities	37,709.4			37,709.4
Injuries:				
Major	157.7	3,118.8		3,276.6
Minor	163.7	6,525.8		6,689.5
Minimal	4.9	306.9		311.9
Total disability	35.5	877.5		913.0
Partial disability	198.6	5,611.9		5,810.6
HUMAN SUB-TOTAL	**38,269.9**	**16,441.1**		**54,711.0**
Other costs:				
Property damage	56.7	2,022.4	2,612.6	25.7
Hospital/Health care:				
- ER facility	0.9	27.9	0.1	28.9
- Hospital stay facility	4.3	53.3		57.6
- Medical practitioners	16.3	428.3		444.6
Police	20.5	140.6	75.7	236.7
Courts	3.0	20.7	11.1	34.8
Fire	6.2	251.9		258.1
Ambulance	5.8	120.7		126.5
Tow trucks	1.8	88.1	147.8	237.7
Out of pocket	2.0	149.3	356.8	508.0
Traffic delays:				
- Extra time	319.5	270.6	74.0	664.1
- Extra fuel	26.8	22.7	6.2	55.6
- Extra pollution	293.3	248.5	67.9	609.8
OTHER SUB-TOTAL	**757.1**	**3,845.0**	**3,352.1**	**7,954.2**
OVERALL TOTAL	**39,026.9**	**20,286.1**	**3,352.1**	**62,665.1**

Exhibit VI-8 Distribution of Social Cost based on Willingness to Pay—Medium Scenario and Various Social Indicators by Canadian Jurisdiction—2004

Jurisdiction	Social cost*		Population**	GDP***	Passenger km****	Licensed drivers*****
	($M)	(%)	(%)	(%)	(%)	(%)
Newfoundland and Labrador	865.6	1.4	1.6	1.5	1.3	1.6
Prince Edward Island	519.5	0.8	0.4	0.3	0.4	0.4
Nova Scotia	1,747.2	2.8	2.9	2.3	3.5	3.0
New Brunswick	1,449.3	2.3	2.4	1.8	2.6	2.4
Quebec	17,415.6	27.9	23.6	20.4	23.1	21.8
Ontario	17,859.3	28.6	38.8	40.1	39.3	39.9
Manitoba	2,199.2	3.5	3.7	3.1	3.4	3.2
Saskatchewan	2,423.1	3.9	3.1	3.1	3.7	3.1
Alberta	9,051.4	14.5	10.0	14.6	10.9	11.0
British Columbia	8,818.2	14.1	13.1	12.2	11.9	13.2
Yukon Territory	95.7	0.2	0.1	0.1	NA	0.1
Northwest Territories	61.4	0.1	0.1	0.3	NA	0.1
Nunavut	21.9	0.0	0.1	0.1	NA	NA
TOTAL	62,527.5	100.0	100.0	100.0	100.0	100.0

* Based on Willlingness to Pay--Medium Scenario
** Statistics Canada, 2004, CANSIM 051-0001
*** Statistics Canada, 2004, CANSIM 384-0002
***Transport Canada, Canadian Vehicle Survey, 2004
****Transport Canada, available data, 2004

Exhibit VI-9 Social Costs of Human Consequence for Canada using Alternative Costing Methods and Assumptions —2004

Canada					
		Collision Severity			
		Fatal	Injury	PDO	TOTAL
Discounted Future Earnings					
Fatalities		3050.0			3050.0
Injuries:					
	Major	9.4	186.0		195.5
	Minor	7.2	285.7		292.8
	Minimal	0.1	8.0		8.1
	Total disability	27.1	669.2		696.3
	Partial disability	52.1	1471.3		1523.4
HUMAN SUB-TOTAL		**3,145.9**	**2,620.3**		**5,766.2**
Willingness to pay--low scenario					
Fatalities		20795.6			20795.6
Injuries:					
	Major	52.6	1040.2		1092.8
	Minor	54.6	2176.5		2231.1
	Minimal	1.6	102.4		104.0
	Total disability	11.8	292.5		304.3
	Partial disability	66.2	1870.6		1936.9
HUMAN SUB-TOTAL		**20,982.5**	**5,482.3**		**26,464.8**
Willingness to pay--high scenario					
Fatalities		54623.1			54623.1
Injuries:					
	Major	263.0	5201.1		5464.1
	Minor	273.0	10882.7		11155.7
	Minimal	8.2	511.9		520.1
	Total disability	59.2	1462.5		1521.7
	Partial disability	331.1	9353.2		9684.3
HUMAN SUB-TOTAL		**55,557.6**	**27,411.4**		**82,969.0**

Appendix A

Detail on Calculations of the Ontario Model

APPENDIX A: DETAIL ON CALCULATIONS OF THE ONTARIO MODEL

This chapter describes the Ontario model.

A. RAW DATA

Raw data for the Ontario model comes from ORSAR. Exhibit A-1 presents the data for 2004 data.

Exhibit A-1 Raw Data for Ontario Model—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Collisions	718	49,948	180,882	231,548
Fatalities	799			799
Injuries:				
Major	245	3,320		3,565
Minor	330	29,589		29,919
Minimal	189	39,338		39,527
Vehicles damaged:				
Demolished	678	10,023	5,883	16,584
Severe	188	21,021	32,110	53,319
Moderate	147	24,698	99,313	124,158
Light	125	24,486	137,512	162,123
None	45	8,572	19,161	27,778
Unknown	58	5,420	37,511	42,989

This raw data is entered into spreadsheet O1 and forms the core data used in all subsequent adjustments. In future applications, users will enter ORSAR data for other years to replace the 2004 data. Adjustment factors (developed based on the 2004 data) are applied to other year's data automatically. These adjustments are discussed in the next section.

Note that these data do not include collisions that are not reported to police. A motor vehicle collision does not need to be reported if:

- No personal injury or fatality occurs.
- Damage to vehicles is less than $1,000.

- No other public or private property is damaged.
- No criminal activity (drinking and driving, stolen vehicle, driving under suspension) is suspected.

The first condition restricts any under-reporting to PDO collisions. As a result, data in ORSAR on the number of PDO collisions and on vehicles involved in PDO collisions is expected to be under-reported in the ORSAR data. We do not have data that would allow us to estimate the number of PDOs not reported to police and subsequently not included in the ORSAR data. Such unreported cases would have a minimal impact on the social cost estimates as they do not by definition involve human consequences (fatalities or injuries), or use of resources such as hospital/health care, ambulance, police, courts, and most likely fire departments. (In Section D. 8 we present data from the Insurance Bureau of Canada which may indicate the number of vehicles and cost of vehicle damage in unreported collisions.)

B. ADJUSTMENTS TO THE RAW DATA

A number of adjustments are needed to reflect cases of under-reporting and misreporting in the 2004 data. This section presents information on how the model moves from raw data found in ORSAR to adjusted data based on other information. These adjustment factors would be applied automatically if raw data for other years were entered in place of the 2004 ORSAR data. (If updated information used to produce the adjustment factors becomes available the analyst could also replace the information and thereby generate update adjustment factors.)

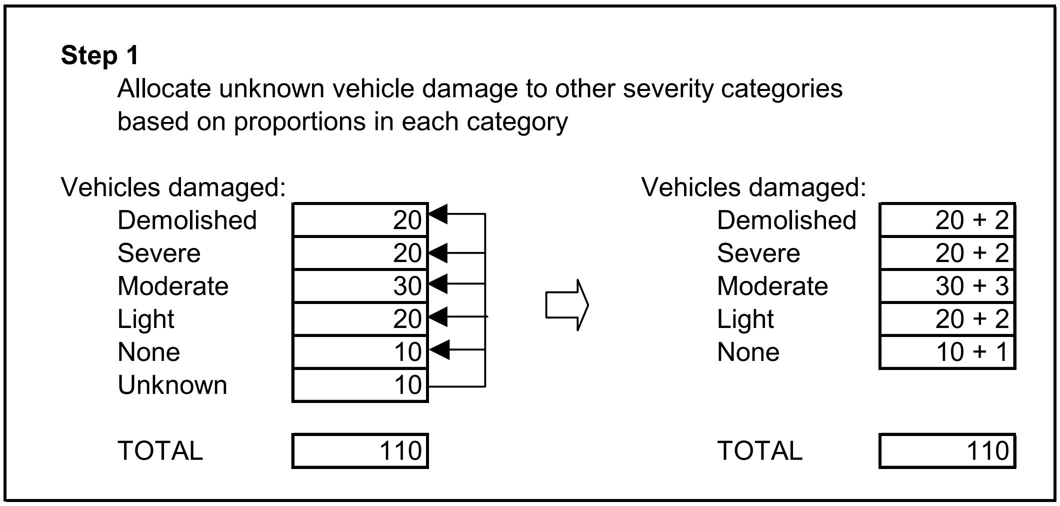
Diagrams are used to illustrate the adjustments built into the model.

1. Unknown damage to vehicles in collision

Police reports identify the extent of damage to vehicles involved in collisions. However, for 10% of vehicles involved in the collisions reported in 2004, damage is listed as unknown. By collision severity the percentage of unknown among total vehicles damaged is 5% for fatal, 6% for injury and 11% for PDOs. The higher proportion of vehicles with unknown damage in PDOs is likely due to self-reporting.

We have no information that would indicate whether vehicles with unknown damage should be assigned in higher or lower proportion to more sever damage severity categories. As a result, vehicles with unknown damage are assigned based on the known distribution of vehicles by damage severity.

The example illustrated below shows the allocation of 10 vehicles with unknown damage to other damage categories based on the proportion of vehicles across other damage categories. The number of vehicles is unchanged by the redistribution. This procedure is conducted for each collision severity separately. For example, the 58 vehicles with unknown vehicle damage involved in fatal collisions in 2004, are redistributed as follows: 33 demolished; 9 severe; 7 moderate; 6 light and 2 none. Similar adjustments would be performed automatically if raw data from ORSAR for other years was entered into the model in place of the 2004 data.



The redistributed vehicles by damage categories for 2004 are presented in Exhibit A-2.

Exhibit A-2 Adjusted Number of Vehicles by Vehicle Damage Category (2004)

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Vehicles damaged:				
Demolished	711	10,635	6,634	17,980
Severe	197	22,304	36,207	58,708
Moderate	154	26,205	111,985	138,345
Light	131	25,981	155,058	181,170
None	47	9,095	21,606	30,748

2. Human Consequences

Injury and fatality data reported in ORSAR tend to under report and misreport the extent of human consequences of motor vehicle collisions. This section discusses adjustments made in the raw data to better reflect the impacts on those involved in the collisions.

a) Additional deaths reported by Coroner's Office

ORSAR lists 799 fatalities related to motor vehicle collisions in Ontario in 2004. These data are based on Motor Vehicle Accident Reports (MVAR) filed by police officers. On occasion, a MVAR may not be submitted by police or may be amended but too late for inclusion in the ORSAR. Also the cause of death may be determined only later to be a motor vehicle collision by the Coroner but this information may not be provided to ORSAR or may be provided too late to include in ORSAR.

For 2004, the Coroner reports approximately 900 fatalities due to transportation related crashes, including HTA-reportable and non-reportable collisions, train and subway related incidents using a one-year cut-off instead of the 30-day limit imposed by ORSAR. Of the extra 36 motor vehicle collision fatalities reported by the Coroner, 21 occurred within 30 days and of them 14, could be determined to be HTA reportable based on the weight of evidence. (The status of one case could not be determined.)

As a result, 813 fatalities, or 1.02 times the number identified in ORSAR, are used in the model for 2004. The same factor will be used for subsequent years to reflect fatalities not reported to ORSAR. A later section discusses how these extra fatalities are allocated in the model.

b) Additional injuries reported by hospitals and in a re-analysis of Chipman

Data in ORSAR on the number of injuries and their severity are derived from police reports filled out at the scene of the collision or shortly after the collision. Attending police officers will have information on those who are transported directly to hospital (major and minor injuries) and may have information although potentially not complete on those admitted to hospital (major injuries). They will have information on others who report injuries not requiring transport to hospital (minimal injuries) at the collision scene. Police will follow-up with hospitals to find out the extent of injuries and will amend reports as necessary. However, police will not have information and reports will not record those individuals who subsequently develop symptoms of injury. These injuries may include minimal injuries, requiring no or limited medical intervention, minor injuries, requiring an emergency room visit, or major injuries, involving hospital stays. Since police reports are the basis of ORSAR data, which in turn form the raw data used in our model, these counts of injuries are unlikely to reflect the full extent of injuries resulting from motor vehicle collisions.

To account for under-reporting of injuries we rely on two sources of information. The Ministry of Health and Long-Term Care (MOH&LTC) captures use of medical facilities such as emergency room visits and the characteristics of hospital stays (hospital separations and duration) against codes identifying the reason for the injury. A number of these codes are specific to motor vehicle collisions that would be HTA reportable.[1] The second source of information is the analysis conducted by Mary Chipman[2] of the 1990 Ontario Health Survey. In it she estimates the number of collision-related injuries for Ontario residents in 1990 based on survey data. Adjustments are required to bring the Chipman analysis in line with the definitions of our study particularly to restrict collisions to those that involve a motor vehicle and are HTA reportable.

c) Additional major and minor injuries

We obtained a special run of MOH&LTC data for fiscal years 2003/2004 and 2004/2005. This run considered individuals' use of hospital facilities involving the International Classification of Diseases (ICD-10) motor vehicle traffic accident codes[3]:

- Pedestrian Injured in Collision/Non Collision Motor Vehicle Traffic Accident.
- Pedal Cyclist Injured in Collision/Non Collision Motor Vehicle Traffic Accident.
- Motorcycle Rider Injured in Collision/Non Collision Motor Traffic Accident.
- Occupant of Three-Wheeled Motor Vehicle Injured in Collision/ Collision Motor Vehicle Traffic Accident.
- Occupant of Car Injured in Collision/Non Collision Motor Traffic Accident.
- Occupant of Pick-up Truck or Van Injured in Collision/Collision Motor Vehicle Traffic Accident.
- Occupant of Heavy Transport Vehicle Injured in Collision/Non Collision Motor Vehicle Traffic Accident.
- Occupant of Bus Injured in Collision/Non Collision Motor Vehicle Traffic Accident.
- Other land transport accidents.

We pooled the data for the two fiscal years using weights reflecting each fiscal year's share among incidents for calendar year 2004.

Hospital separations data from MOH&LTC were used to identify major injuries (those admitted to hospital). From the gross number of hospital separations, we subtract those who die in hospital (fatalities) or who were re-admitted for the same injury. This

[1] The Tenth Revision of the International Classification of Diseases (ICD-10) is used.

[2] 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, October 5-7, 1992, Portland, Oregon.

[3] We used the same codes as used by ORSAR with the exclusion of V83.4 (Person injured while boarding or alighting from special industrial vehicle)**,** V84.4 (Person injured while boarding or alighting from special agricultural vehicle)**,** V85.4 (Person injured while boarding or alighting from special construction vehicle)**,** and V86.4**.** Person injured while boarding or alighting from all-terrain or other off-road motor vehicle

yields 5,293 unique persons who were injured in motor vehicle collisions, admitted to hospital and survived. This definition is most in keeping with the major injury category of ORSAR.

The number of emergency room visits not requiring a hospital stay is also estimated using MOH&LTC data. From the total number of visits to an Emergency Room (ER) we select only those going to ER for an unplanned visit for a new clinical condition. From this number we subtract those who:

- Leave without being seen, treated, or having completed treatment (included in minimal injuries).
- Are admitted (major injury).
- Die on or after arrival (fatalities).
- Transfer to another care facility (possible duplicate in data).

According to the MOT&LTC data a total of 60,726 individuals visit an emergency room and are released after care (comparable to minor injuries) as a result of motor vehicle collisions in 2004.

Exhibit A-3 identifies the revised numbers of major injuries (hospital admittances) and minor injuries (treated in emergency room only) based on the better information available through MOH&LTC. It also identifies factors derived from the ORSAR and revised (MOH&LTC) numbers that are used by the model to adjust ORSAR-derived numbers for major and minor injuries for 2004 and subsequent years.

Exhibit A-3 Adjustment Factors for Major and Minor Injuries

					Data used in Model for 2004		
	ORSAR 1990	Chipman Re-analysis 1990	ORSAR 2004	Chipman Adjusted for Mix 1990 to 2004	MOH&LTC 2004	Chipman-* based Estimate 2004	Factors** for 2004 and later years
	(#)	(#)	(#)	(#)	(#)	(#)	
Major	7,516	17,299	3,565	8,205	5,293		1.48
Minor	38,824	111,608	29,919	86,009	60,726		2.03
Minimal	55,235	117,234	39,527	83,894		58822	1.49

* Factors for major and minor injuries are derived from MOH&LTC data, and for minimal injuries from a re-analysis of the Chipman analysis of the Ontario Health Survey.

d) Additional minimal injuries

The number of minimal injuries cannot be verified or adjusted using MOH&LTC data, as these injuries do not involve a hospital stay or an emergency room visit. Instead we use an analysis by Mary Chipman[1] of the 1990 Ontario Health Survey. No more recent study exists to help estimate the number of minimal injuries. However, given the age of the study one of the adjustments we make is to reflect the changed mix of injuries from motor vehicle collision in 2004 compared to 1990.

We make a number of adjustments in the Chipman analysis to fit the needs of the social cost model. In brief these adjustments:

- Adjust the proportion of injuries to pedestrians and cyclist to reflect the mix in motor vehicle collisions. The 1990 Ontario Health Survey used a broader definition of traffic collision that did not need to involve a motor vehicle.
- Reduce the number of emergency room visits by 10% to estimate minor injuries. This reflects the proportion that becomes major injuries (hospital stays). Using estimates from the 1990 Ontario Health Survey of emergency room and hospital room use without adjustment would lead to double-counting otherwise.
- Calculate minimal injuries as a residual by subtracting major and minor injuries from total injuries.
- Adjust for the changing mix of injury severities between 1990 and 2004 motor vehicle collisions.

The following adjustments were made[2]:

- Reduce injuries to pedestrians and cyclists to reflect the proportions of injuries in motor vehicle collisions recorded in ORSAR for 1990 (vehicle occupants, 90.6%; pedestrians, 5.8%; and cyclists, 3.6%)[3] compared to Chipman (vehicle occupants, 67.7%; pedestrians, 17.4%; and cyclists, 14.9%). The 1990 Ontario Health Survey did not require involvement of a motor vehicle in its definition of a traffic collision. This adjustment brings the Chipman data in line with our definition of a motor vehicle collision.
- Estimate the number of minor injuries by reducing the estimated number of emergency room visits by 90% of the number of hospital admissions. This reflects information obtained in the 1994 Social Cost study for the per cent of hospital admissions that go through the emergency department. (For 2004, the percentage derived from MOH&LTC is 85%.)
- Estimate the number of minimal injuries as the residual left by subtracting major and minor injuries from the number of total injuries estimated in the analysis.

[1] 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, October 5-7, 1992, Portland, Oregon.

[2] More detail on these adjustments can be found in the previous (1994) Social Cost Study.

[3] From the 2004 ORSAR data the proportions are very similar (vehicle occupants, 89.7%; pedestrians, 6.4%; and cyclists, 3.9%).

- Adjust proportions of injuries to reflect the changing mix of injury severities between the 1990 and 2004 ORSAR data. These result in a reduced proportion of major injuries and an increased proportion of minor injuries.
- Adjust downward the number of injuries estimated by the Chipman analysis to reflect those that are HTA reportable. Data from MOH&LTC for HTA reportable major and minor injuries are 64.5% and 70.6% respectively of the estimates from the re-analysis with the above adjustments. For the estimate of the number of minimal injuries (not available from MOH&LTC) we use the average of these two factors (70.1%).

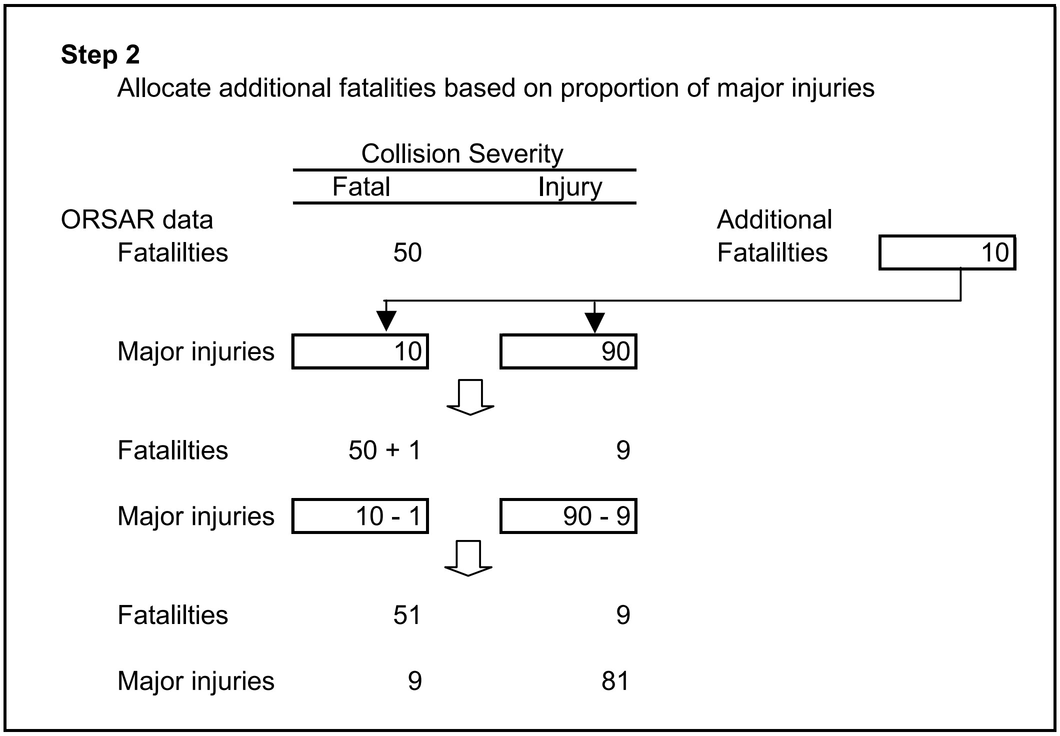
Based on this analysis, we estimate 58,822 minimal injuries that are HTA reportable. Using this number we derive the factor (1.49) used for 2004 and later years to adjust ORSAR data to reflect the number of minimal injuries attributable to HTA reportable motor vehicle collisions. The 2004 number and adjustment factor are identified in Exhibit A-3.

e) Allocation of additional fatalities and injuries among collision severities

This section presents information on how the additional fatalities and injuries are allocated among motor vehicle collisions. Based on this allocation some of the extra fatalities occur in injury only collisions and some of the extra injuries occur in PDO collisions. The section next presents how collisions are re-allocated among collision severity categories to maintain the intended coverage of these categories.

Additional fatalities identified through the analysis and resulting from a HTA reportable motor vehicle collision are assumed to occur among those identified by police as having been admitted to hospital (major injuries). We reduce the number of major injuries found in ORSAR to reflect the number of extra deaths identified through the Coroner's Office. Major injuries recorded in ORSAR occur in both fatal and injury collisions. We distribute the number of major injuries transferred to fatalities according to the share of major injuries in these collision severity categories.

This is illustrated in the hypothetical example below. Major injuries are distributed such that 10% are in fatal and 90% are in injury collisions. With 10 extra fatalities to distribute, 1 is assigned to fatal collisions and 9 to injury collisions. As a result of the distribution of the additional fatalities, major injuries reduce by 1 in fatal collisions and by 9 in injury collisions.



In the model for 2004, 7% of major injuries occur in fatal and 93% in injury collisions. As a result, 7% (1) and 93% (13) of the misclassified major injuries are assigned to fatal and injury collision categories respectively. Other years would use different proportions based on the ORSAR data for that year.

The additional injuries (over ORSAR estimates) identified through the MOH&LTC data and the Chipman re-analysis are allocated among collisions severity categories based on the proportion (adjusted to allocate vehicles with unknown damage) of demolished vehicles. This is illustrated in the hypothetical example below where 10%, 50% and 40% of the additional injuries are allocated to fatal, injury and PDO collisions to reflect the proportion of demolished vehicles in these collision severity groups. We believe injuries are highly correlated to vehicle damage and have therefore chosen this allocation mechanism for additional injuries.

Step 3

Allocate additional injuries based on proportion of demolished vehicles

	Collision Severity		
	Fatal	Injury	PDO
Injuries:			
Major	50	100	
Minor	70	150	
Minimal	60	125	
Additional injuries:			
Major	100		
Minor	200		
Minimal	50		
Vehicles damaged:			
Demolished	10	50	40

	Fatal	Injury	PDO
Injuries:			
Major	50 + 10	100 + 50	0 + 40
Minor	70 + 20	150 + 100	0 + 80
Minimal	60 + 5	125 + 25	0 + 20

	Fatal	Injury	PDO
Injuries:			
Major	60	150	40
Minor	90	250	80
Minimal	65	150	20

Exhibit A-4 provides the allocation of extra injuries based on the distribution of demolished vehicles for 2004. In other years the allocation of additional injuries will be based on the proportion of demolished vehicles by collision severity in the year in question.

Exhibit A-4 Allocation of Additional Injuries among Collision Severity Categories for 2004

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Vehicles damaged:				
Demolished #	711	10,635	6,634	17,980
Demolished %	4%	59%	37%	100%
Allocated Additional Injuries:				
Major	68	1,022	637	1,728
Minor	1,219	18,222	11,366	30,807
Minimal	763	11,413	7,119	19,295

Exhibit A-5 presents the initial allocation of additional injuries and fatalities among collision severity categories. Note that the allocation methods identify fatalities among injury collisions and injuries among PDOs. Next we move collisions between severity categories to restore the original definitions within the model.

Exhibit A-5 Revised Data for Ontario Model reflecting Additional Injuries and Fatalities by Original Collision Severity (2004)

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Collisions	718	49,948	180,882	231,548
Fatalities	800	13		813
Injuries:				
Major	312	4,329	637	5,279
Minor	1,549	47,811	11,366	60,726
Minimal	952	50,751	7,119	58,822
Vehicles damaged (adjusted):				
Demolished	711	10,635	6,634	17,980
Severe	197	22,304	36,207	58,708
Moderate	154	26,205	111,985	138,345
Light	131	25,981	155,058	181,170
None	47	9,095	21,606	30,748

We use the characteristics of fatal collisions[1] to move an appropriate number of collisions with the same characteristics from the injury collision severity group to the fatal severity group. This is illustrated in the hypothetical example provided below.

In this example, the average fatal collision has the following characteristics–1 fatality, 3 injuries and 10 vehicles involved. There are 3 fatalities assigned to injury collisions after the adjustments noted earlier. Assuming the collisions, involving the 3 fatalities, but listed as injury collisions are like other fatal collisions, allows us to identify 3 collisions, with 3 fatalities, 9 injuries and 30 vehicles involved among injury collisions. Transferring these collisions from injury to fatal collisions would increase fatal collisions by 3 (from 30 to 33 collisions) and reduce injury collisions by 3 from (303 to 300). The characteristics of the collision would also be transferred resulting in the increase of 3 fatalities, 9 injuries and 30 involved vehicles to fatal collisions and the corresponding reduction of these characteristics from the injury collisions.

Step 4
Transfer of injury collisions involving fatalities to fatal collisions based on characteristics of fatal collisions

	Collision Severity		
	Fatal	Injury	
Collisions	30	303	
Fatalities	30	3	
Injuries	90	9	+ 200
Vehicles damaged	300	30	500

	Fatal		Injury
Collisions	30	3	300
Fatalities	30	3	
Injuries	90 +	9	200
Vehicles damaged	300	30	500

	Fatal	Injury
	33	300
Fatalities	33	
Injuries	99	200
Vehicles damaged	330	500

[1] Each fatal collision includes 1.11 fatality, 0.44 major injury, 2.16 minor injury, 1.33 minimal injury and involves the following vehicles by damage level: 0.99 demolished, 0.27 severe, 0.21 moderate, 0.18 light

For 2004, the model transfers 12 collisions from injury to fatal collisions. These collisions involve 13 fatalities, 5 major injuries, 25 minor injuries, 16 minimal injuries, and the following number of vehicles by damage severity: 12 demolished, 3 severe, 3 moderate, 2 light and 1 none.

Similarly the model uses the characteristics of injury collisions[1] to determine the number and characteristics of collisions to transfer from the revised PDO category to the injury collision category. However, the correct number of collisions to transfer will vary depending on which severity category of injury is selected to base the transfer. As a result, the decision on the maximum number of collisions needed to transfer all injuries is model determined based on the characteristics of the data. The model transfers injuries in the proportion they occur in these collisions up to the maximum number by severity category initially allocated to PDOs. It also transfers the expected number of vehicles damaged based on this number of collisions. This is illustrated in the next hypothetical example.

In this example the average injury collision involves 1 injury and 3 vehicles. Given 10 injuries allocated to PDOs, the model would identify that 10 collision needed to be transferred involving all 10 injuries and 30 vehicles. (The hypothetical example does not illustrate that the decision on how many collisions to transfer is based on the number needed to transfer all injuries of each injury severity.) The 10 collisions are transferred to injury collisions increasing the total from 100 to 110. Similarly, PDO collisions are reduced by 10 from 260 to 250. Characteristics of the collisions are also transferred with offsetting increases for injury collisions and decreases for PDO collisions in the number of injuries and vehicles involved.

and 0.07 none.

[1] Each injury collision includes 0.09 major injury, 0.96 minor injury, 1.02 minimal injury and the following vehicles by damage level: 0.21 demolished, 0.45 severe, 0.52 moderate, 0.52 light and 0.18 none.

Step 5
Transfer of PDO collisions involving injuries to injury collisions based on characteristics of injury collisions

	Collision Severity			
	Injury			PDO
Collisons	100			260
Injuries	100	→	10	+
Vehicles damaged	300		30	500

⇩

	Injury		PDO
Collisions	100	10	250
Injuries	100 +	10	
Vehicles damaged	300	30	500

⇩

	Injury	PDO
Collisions	110	250
Injuries	110	
Vehicles damaged	330	500

Exhibit A-6 provides an example drawn from the 2004 data to illustrate this procedure to identify the number of collisions to transfer based on the number of injuries by injury severity.

Exhibit A-6 Revisions for 2004 Reflecting the Transfer of PDO Collisions involving Allocated Injuries to Injury Collisions

Characteristic of average injury collision		Number of injuries to transfer from PDO collisions (#)	Like PDO collisions needed to transfer injuries (#)	Transfer if based on maximum collisions needed (#)	Actual transfer from PDO to injury collisions (#)
Collisions	1.00				11878
Injuries:					
Major	0.09	637	7,361	1,028	637
Minor	0.96	11,366	11,878	11,366	11,366
Minimal	1.02	7,119	7,007	12,068	7,119
Vehicles damaged:					
Demolished	0.21				2,527
Severe	0.45				5,304
Moderate	0.52				6,233
Light	0.52				6,179
None	0.18				2,163

Given the characteristics of an average collision involving injury 7,361; 11,878; or 7,007 collisions would need to be transferred depending on whether the transfer decision was based on the 637; 11,366; or 7,119 major, minor, or minimal injuries respectively estimated as occurring in PDO collisions. Because we need to transfer all injuries from the revised PDO category we transfer 11,878 collisions (the number needed to transfer all minor injuries based on the average characteristics of injury collisions), the vehicles by damage severity involved in these collisions, all (11,366) minor injuries and the available major (637) and minimal (7,119) injuries.

Exhibit A-7 (a section from spreadsheet O2 in the model) illustrates the results of these transfers among collision severity categories to adjust for fatalities occurring in injury collisions and injuries occurring in PDOs. The result of these transfers is to increase the number of fatal collisions by 12 (with a corresponding reduction in injury collisions) and to increase the number of injury collisions by 11,878 (with a corresponding reduction in PDO collisions). The total number of collisions is not affected nor is the number of vehicles involved. However there is a redistribution of collisions and motor vehicles damaged by collision severity, as well as an increase in fatalities and injuries to reflect the better data available from the Coroner's Office (fatalities), MOH&LTC (major and minor injuries) and Chipman re-analysis (minimal injuries).

Exhibit A-7 Adjusted Data for Ontario Model—Number of Collisions, Fatalities, Injuries and Damaged Vehicles (2004)

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Collisions	730	61,814	169,004	231,548
Fatalities	813			813
Injuries:				
Major	317	4,961		5,279
Minor	1,574	59,152		60,726
Minimal	968	57,855		58,822
Vehicles damaged:				
Demolished	723	13,150	4,107	17,980
Severe	200	27,605	30,903	58,708
Moderate	157	32,436	105,753	138,345
Light	133	32,158	148,879	181,170
None	48	11,258	19,443	30,748

In 2004 and subsequent years this transfer is conducted automatically based on decision rules influenced by the proportion of injuries and number of injuries needing to be transferred by severity of injury.

C. OTHER CHARACTERISTICS OF INJURED INDIVIDUALS

This section identifies further characteristics of those injured in motor vehicle collisions.

1. Number of total and partial permanent disabilities

Some injuries will result in total or partial permanent disabilities. The likelihood of such disabilities varies by injury severity as identified in the Databook on Nonfatal Injury: Incidence, Costs and Consequences (Ted Miller, et. al.). These probabilities (factors used in 2004 and later years) are identified in Exhibit A-8.

Exhibit A-8 Probabilities of Total and Partial Permanent Disability by Injury Severity

	Incidence of permanent disability	
	Total	Partial
Injuries:		
Major	0.0162	0.1493
Minor	0.0006	0.0115
Minimal	0.0003	0.0058

Source: Databook on Nonfatal Injury: Incidence, Costs and Consequences by Ted R. Miller, Nancy M. Pindus, John B. Douglass, Shelli B. Rossman, May 1995:

Using these probabilities we estimate the number of total and partial permanent disabilities by severity of injury and collision severity. Results for 2004 are provided in Exhibit A-9. Note that the exhibit identifies fractional total disabilities within a year. In the case of 0.3 total disabilities from minimal injuries under the fatal category this should be interpreted as one total disability approximately each three years (1 injury/0.3 injury per year =3.3 years).

2. Number of activity-days and work-days lost

We estimate the days of lost activity from motor vehicle collisions from data from the Passenger Car Survey (PCS) of Transport Canada. The data are for the period 1984 to 1989 inclusive for all of Canada and measure days of work lost including those days lost by persons engaged in household work. The PSC was discontinued in the early 1990s. Data discussed in this section was originally used in our 1994 study. More detail on the survey methods can be found in this earlier report.

Our estimates of average days lost differ depending on whether the analysis is for our DFE or WTP analysis. This is as a result of the underlying rationale of the DFE and WTP approaches.

Exhibit A-9 Total and Partial Permanent Disabilities by Injury Severity—Number of Disabilities (2004)

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Total disabilities:				
Major	5.1	80		86
Minor	0.9	35		36
Minimal	0.3	17		18
ALL	6.4	133		140
Partial disabilities:				
Major	47	741		788
Minor	18	680		698
Minimal	6	336		341
ALL	71	1756		1828

Discounted future earnings place a value on lost productive time. Productive time would include work-time, household duties and in-school time. This is the framework of the Transport Canada data which records a zero for lost time if the individual is not working, not in school, or less than five years old. Also, a zero is recorded if less than a full "work" day is lost through injury. For those not in these "non-worker/student" groups (74.4% in Ontario, based on 1991 Census data (the closest year to the data in question), we assume a recorded zero will imply one-half day of loss if a work-day. We assume that the probability of the day of injury being a work-day is 220/365. For the DFE analysis, we estimate the average number of "work" days lost by injury severity at 0.2 for injuries that are minimal, 6.5 days for injuries that are minor, and 45 days for injuries that are major. Our estimate for major is based on an assumed value for injuries of more than 30 days. These values do not include work-days lost by those who suffer total or partial disabilities as a result of their injuries.

For the WTP analysis, we value activity days and not work days. An individual will place the same value on a day of activity lost through injury whether that day would have been spent working or not working. We therefore reduce the number of zeros recorded in the data set by the proportion of individuals not working, not at school or less than five years old. We assume that the length of days lost would be similar for those in this group and those outside of this group. We therefore reassign zeros for those not working based on the distribution of days lost for those who are working. Further, we adjust days of work lost (recorded in the data) to days of activity lost using the factor (365/220).

As a result we estimate 0.8 days of activity lost on average for those with minimal injuries, 15.0 days of activity lost for those with minor and 74.7 activity days lost for those with major injuries. These values do not include activity days lost for those with total or partial permanent disabilities.

Exhibit A-10 provides estimates of the number of activity-days and work-days lost through motor vehicle collision injuries. Note that activity-days and work-days lost are for non-disabling injuries only since the model calculates the number and social cost related to permanently disabling injuries separately. Based on motor vehicle collisions in 2004 the model estimates 1.28 million activity-days and 600 thousand work-days lost through injury.

Exhibit A-10 Activity and Work-days Lost through Injury Caused by Motor Vehicle Collisions—Days Lost (2004)

Activity-days lost:		Collision Severity			
	Factor (days/injury)	Fatal	Injury	PDO	TOTAL
Major	74.7	19,790	309,257		329,047
Minor	15.0	23,323	876,538		899,861
Minimal	0.8	770	46,001		46,771
ALL		43,882	1,231,796		1,275,678
Work-days lost:					
Major	45.0	11,922	186,299		198,221
Minor	6.5	10,106	379,833		389,940
Minimal	0.2	192	11,500		11,693
ALL		22,220	577,633		599,853

D. OTHER RESOURCES EXPENDED DUE TO COLLISIONS

This section identifies the expenditure of resources related to motor vehicle collisions.

1. Medical Care

Resources are expended related to the care and treatment of those killed and injured in motor vehicle collisions. Exhibit A-11 identifies selected medical care received by those involved in motor vehicle collisions and the factors per injured individual used in the model. Each category of care is discussed in this section.

Exhibit A-11 Selected Medical Care (2004)

	Coroner trips	Transportation: Ground ambulance	Transportation: Air ambulance	Transportation: Water ambulance	ER visit	Hospital days
	(#)	(#)	(#)	(#)	(#)	(patient-days)
All within category:						
Fatalities	422	391	32	3	373	1,939
Major		5,075	417	43	4,642	47,914
Minor		29,930			65,704	
Minimal*					484	
TOTALS	422	35,397	450	47	71,203	49,853
Factors by individual:						
Fatalities	0.519	0.481	0.040	0.004	0.458	2.385
Major		0.962	0.079	0.008	0.879	9.077
Minor		0.493			1.082	
Minimal*					0.008	

* ER visits that are incomplete are assigned to minimal injuries. Incomplete ER visits are weighted to reflect the extent of completeness depending on the extent of services received before the individual left the ER.

a) Transport of those injured

Ambulance use data are available from MOH&LTC. Based on data for 2003/2004 and 2004/2005 we estimate 35,397 ground, 450 air, and 47 water ambulance trips for 2004 based on a proportionate weighting of the data for the two fiscal years. These aggregate data allow reasonable allocation across injury severity categories with the following assumptions:

- Each fatality and major injury is transported.
- Ambulance trips involving a combination of methods (a small minority in the data) are assumed to all involve ground transport and to involve air or water ambulances as well in proportion to individual air and water ambulance use in the data.
- Air and water ambulance are allocated according to the proportionate share of fatalities and major injuries. All remaining fatalities and major injuries transported by ambulance to hospital are assigned a ground ambulance trip.
- Fatalities not transported to hospital are assumed transported by the Coroner.
- Ground ambulance trips not allocated in the above are assigned to individuals with minor injuries. This includes those transported a second time to another facility (day surgery, clinic, or another emergency department).

b) *ER visits*

Many of those involved in motor vehicle collisions are treated in hospital. When services are complete (for example in the case of a minimal injury, or an individual who is admitted to hospital through an ER) an ER visit is recorded. When services are less than complete (for example if an individual leaves before treatment in the ER) the visit is weighted to reflect the degree of ER service completed. Incomplete ER services are weighted from 0.1 for an individual who is registered but not seen to 0.7 for someone who receives some treatment but leaves before the treatment is complete. All incomplete ER visits are assigned to the minimal injury category because the individual received less than the required treatment to be classified as a minor injury. Fatalities pronounced dead on arrival at hospital are assigned an ER visit weight of 0.25.

Using these weights we calculate a total of 71,203 ER visits, and allocate them among fatalities, major and minor injuries and to minimal injuries as noted.

c) *Hospital stay*

The number of days of stay as a patient is recorded for those admitted to hospital. A hospital stay is recorded for major injuries and fatalities. It is assumed that individuals who become fatalities after admittance to hospital are not released from hospital prior to their death.

As a result, we assign 47,914 patient-days for those admitted and released from hospital to the major injury category and 1939 patient-days to those admitted to and died in hospital.

2. Other Medical Professional Use

The analysis by Chipman, and with the adjustments noted in an earlier section, identifies the following number of visits per injured surviving individual: primary MD—2.99; specialist—1.11; nurse—0.64, physiotherapist—3.05, chiropractor—1.82; other[1]—0.92. The Chipman re-analysis does not present visits by severity of injury. If we assumed an equal number of visits across individuals with different injury severities, total visits would be divided according to the proportions by injury severity in the Chipman analysis—7% major, 45% minor, and 48% minimal. Instead we assume that the injury severity categories account for 35% major, 45% minor, and 20% minimal of visits resulting in the average number of visits by severity category noted in Exhibit A-12 with the resulting distribution of injuries in our model as provided in Exhibit A-13.

[1] Other is a category that is the sum of visits to dentists, optometrists, pharmacists psychologists, social workers and other health professional not identified.

Exhibit A-12 Assumed Average Visits to Health Care Professionals by Injury Severity

	Visits due to collisions (Chipman re-analysis)	Average visits per injured individual (Chipman re-analysis)	Allocation to Major Injuries	Allocation to Minor Injuries	Allocation to Minimal Injuries
	(total visits)	(visits/perso	(visits/perso	(visits/perso	(visits/persor
Primary MD	735,291	2.99	14.9	3.0	1.3
Specialist	274,234	1.11	5.5	1.1	0.5
Nurse	157,829	0.64	3.2	0.6	0.3
Physiotherapist	750,417	3.05	15.2	3.0	1.3
Chiropractor	448,067	1.82	9.1	1.8	0.8
Other (1)	225,438	0.92	4.6	0.9	0.4
Allocation Factor			0.35	0.45	0.20
Based on number injured (Chipman re-analysis):			**Major injuries**	**Minor injuries**	**Minimal injuries**
- Total (#)	246,141		17,299	111,608	117,234
- Per cent (%)			0.07	0.45	0.48

3. Police response

The Ontario Provincial Police (OPP) provided hours expended by all staff, by all levels, related to motor vehicle collisions they attended in 2004. Data are available related to the following groupings of activities: initial collision; assistance provided to the initial officer on the scene; court; follow-up; reporting; administration; SOCO[1] and collision-related activities not otherwise specified). In 2004, the OPP, investigated 73,683 motor vehicle collisions and expended 325,641 staff-hours for these investigations. Although fatal, injury and PDO collisions represent 1%, 19% and 80% respectively of the collisions investigated by the OPP this is unlikely to represent the distribution of hours spent by police officers across these collision severities. Instead we have assigned 15%, 45%, and 40% of OPP staff time respectively by collision severity. This assumed allocation reflects both the degree of difficulty per collision and volume of collisions by collision severity. On average this distribution suggests 107, 10 and 2 hours are spent per fatal, injury and PDO collision respectively. These become the factors used in 2004 and later years to assign hours by police staff to collisions. (This assumption affects only the distribution across collision severity and not the amount to distribute. In the 1994 study we used an

[1] Scenes of Crime Officer—officers who ensure any evidentiary material at the "crime scene" is secured and properly documented.

almost identical distribution, this time based on estimates by police of the average amount devoted to each severity type of collision.)

Exhibit A-13 Health Care Professionals use by Injury and Collision Severity—Number of Visits (2004)

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Primary MD:				
- Major	4,723	73,804		78,527
- Minor	4,666	175,365		180,031
- Minimal	1,214	72,573		73,787
Specialist:				
- Major	1,761	27,526		29,287
- Minor	1,740	65,404		67,144
- Minimal	453	27,067		27,519
Nurse:				
- Major	1,014	15,842		16,856
- Minor	1,002	37,642		38,643
- Minimal	261	15,578		15,838
Physiotherapist:				
- Major	4,820	75,322		80,142
- Minor	4,762	178,973		183,735
- Minimal	1,239	74,066		75,305
Chiropractor:				
- Major	2,878	44,974		47,852
- Minor	2,843	106,863		109,706
- Minimal	740	44,224		44,964
Other (*):				
- Major	1,448	22,628		24,076
- Minor	1,431	53,766		55,197
- Minimal	372	22,251		22,623

* Other is a category that is the sum of visits to dentists, optometrists, pharmacists psychologists, social workers and other health professional not identified.

Collisions handled by the OPP represent 64% of fatal, 29% of injury and 33% of PDO collisions in Ontario. We used the proportion of collisions handled by OPP officers and the allocated amounts by collision severity (approximately 49,000, 147,000 and 130,000 hours for fatal, injury and PDO collisions respectively) to extrapolate OPP police officer time to all collisions and police forces. This method may under-estimate police involvement; if for example, more than one police force (OPP and a municipal police force) attended a collision. The result of this analysis of the time spent by police related to collisions is noted in Exhibit A-14. Note that the model allocates police time using the unadjusted collision severities (i.e. from police reports) to reflect information available to the police when deciding how much time to allocate to collisions.

Exhibit A-14 Estimate of Police

		Collision Severity			
	units	Fatal	Injury	PDO	TOTAL
All collisions (police reports)	#	718	49,948	180,882	231,548
OPP collision coverage	#	456	14,242	58,985	73,683
Collisions by severity	%	0.01	0.19	0.80	
Assumed allocation of hours	%	0.15	0.45	0.40	
Distributed OPP total hours	hrs	48,846	146,539	130,257	325,641
Calculated time per collision	hrs/collision	107	10	2	
Coverage by severity	%	0.64	0.29	0.33	
Extapolated hours to all police	hrs	76,911	513,924	399,441	990,277
Factor for future years	hrs/collision	107	10	2	

4. Fire department response

We obtained data from The Office of the Fire Marshal related to responses by fire departments in 2004. Fire departments responded to 33,082 motor vehicle "accidents" and 2,618 vehicle extrications, not included in the previous number. In addition there were 116 and 14 responses attributed to a vehicle "accident" and listed as fires with loss and without loss respectively.

Most of these "accidents" are likely to be HTA reportable collisions. As a result, we assign 35,830 responses by fire departments to motor vehicle collisions. We assume that fire departments will respond to all fatal collisions with the remainder of calls going to injury collisions. Exhibit A-15 shows this allocation and the factors used in the model.

Exhibit A-15 Fire Department Responses for 2004 and Factors for Later Years

	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Collisions	730	61,814	169,004	231,548
Fire department responses	730	35,100		35,830
Factor	1.000	0.568		

5. Tow trucks

Tow truck services are required when either or both the vehicle cannot be driven safely or no licensed individual is able to drive the vehicle from the collision scene. Data from Transport Canada's former Passenger Car Survey (PCS, data used by the study are from 1984 to 1989) indicate that 89% of the vehicles involved in fatal collisions were towed and 57% of those involved in injury collisions required the services of a tow truck. We assume that 40% of vehicles involved in PDO collisions (not included in the survey coverage) were towed. Thus, the number of vehicles in each type of collision that were towed is derived by applying these proportions to the total number of vehicles involved in collisions including those that were not damaged (in keeping with the survey coverage). As a check on the correct proportion to use, the per cent of vehicles that are demolished or have severe or moderate damage is 86%, 63% and 46% for fatal, injury and PDO collisions respectively. The percentages identified from the PCS and by extrapolation approximate these percentages based on vehicle damage with slightly higher percentages for fatal collisions and lower percentages as collision severity declines. This is in keeping with our expectations that more vehicles will be towed for reasons other than vehicle damage as collision severity increases. Our costing methodology deducts estimated costs for tow truck services from insurance payments calculated elsewhere. As a result any error in our estimate of tow truck costs will be countered by an off-setting error in the value of remaining items paid for through insurance claims.

Exhibit A-16 provides the estimated number of vehicles requiring tow truck services in 2004.

Exhibit A-16 Tow truck services

	Collision Severity			
	Fatal	**Injury**	**PDO**	**TOTAL**
Vehicles damaged:				
Demolished	723	13,150	4,107	17,980
Severe	200	27,605	30,903	58,708
Moderate	157	32,436	105,753	138,345
Light	133	32,158	148,879	181,170
None	48	11,258	19,443	30,748
Total	1,261	116,606	309,084	426,951
Per cent requiring tow	89%	57%	40%	
Total requiring a tow	1,122	66,465	123,634	191,221

E. VALUATION OF HUMAN CONSEQUENCES

1. Willingness to Pay (WTP) Estimates

The willingness to pay approach to estimating the value of human consequences is rooted in the observation that individuals make choices each day that balance risks of injury and death against monetary considerations. Whether they decide among vehicles with different safety and price characteristics or among jobs with different work-place accident and pay characteristics they explicitly or implicitly make trade-offs which must balance these factors. By extension, society balances the benefits of risk reduction against the costs to achieve the lower risk when it decides to invest in passing lanes, road divider barriers, and better curve banking that offer the potential to reduce collisions and fatalities.

A number of Canadian studies have been able to use rich labour market data (remuneration and risk variables) to estimate the value of human consequences. The most recent research results on risks and the value of measures to reduce these risks indicates that the benefits of reducing these risks are much higher than had previously been estimated. Most of these earlier studies were unable to correct for known biases in these data, producing as a result, artificially low values of a life saved and injury avoided.

The most recent Canadian estimates of the value of statistical life (Dr. Morley Gunderson and Douglas Hyatt in the Canadian Journal of Economics, Volume 34. No. 2, "Workplace Risks and Wages: Canadian Evidence from Alternative Models", May 2001) correct for income effects (those with higher income are more likely to avoid risky occupations) and tolerance for risk (that make some workers demand a smaller risk premium). Their evidence indicates that the benefits of reducing workplace risks are much higher than earlier estimates. Leigh (2001) has provided related results for the United States.[1] More specifically, the Gunderson and Hyatt estimates suggest 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. Note that these data are expressed in 1988 Canadian dollars.

These results have not been challenged in the economics literature. However, because they are at the high end of what was the previously accepted range of values for human consequences we treat them as one of a number of possible values that can be selected by the analyst in the model.

Our approach to social values based on WTP involves the following:

- Update the Meng-Smith results that were the basis of the earlier TNS(Abt)-TIRF results reported to you in the 1994 study. This will be our "lower bound" estimate based on WTP.

[1] Leigh, J. Paul, James Cone and Robert Harrison (2001) "Costs of Occupational Injuries and Illnesses in California" *Preventive Medicine*, v. 32, no. 5, pp. 393-406.

- Review and update the Canadian results of Gunderson and Hyatt based on improved estimation techniques related to risk preferences and selection of individuals into different occupational risks. These estimates are larger than earlier results and have not been the source of any challenge or criticism in the literature. These results will provide an "upper bound" WTP estimate of the core fatality and injury parameters.

- The mean value of the upper and lower bound estimates provides the central estimating result used in our analysis. We provide sensitivity analyses using lower and upper bound estimates of these parameters.

Based on these methods the core parameters for the human consequences (death, activity day, partial and total disability) associated with motor vehicle collisions are provided in Exhibit A-17. The values for short-term disability by injury severity are derived from the core parameter for activity day value and the estimate of activity days lost in Exhibit A-10.

Exhibit A-17 Core WTP 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

Note: Variables above are constructed as described in the text.

In Exhibit A-17, the lower bound estimates consist of the updated values estimated by Vodden *et al.* (1994). These values, estimated using data from Statistics Canada's 1987 Labour Market Activity Survey, have been updated to 2004. The dependent variable in these regression model estimates is the wage rate so that we have inflated the 1987 value of $4.7 million to $7.8 million using Statistics Canada data on wage rates (*The Labour Market* cat. No: 71-222-XWE). 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 as described in Viscusi and Aldy (2003). The lower bound for the Activity Day variable and the severe injury variable are calculated in the same way.

The upper bound estimates are based on the models estimated by Gunderson and Hyatt (2001). 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 under-estimates 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 value of a statistical life estimated by Gunderson and Hyatt is $12.75 million, expressed in 1988 dollars. Converting this to 2004 dollars using the wage index described above gives the value of $19.7 million shown in Exhibit A-16. The Gunderson and Hyatt models do not compute the Activity Day and Severe Injury variables that we plan to use in our modeling. Their overall results indicate that their correction factors would cause the values to increase by a factor of 5. As a result, we use this factor to calculate the upper bounds for these variables in Exhibit A-17. The final column of Exhibit A-15 calculates the mean of the upper and lower bound estimates.

2. Discounted Future Earnings (DFE) Estimates

The discounted future earnings approach measures losses in productive activity in the workplace and in household activity for those affected by motor vehicle collisions. Losses through three main types of human consequences are measured: fatalities, permanent disabilities (total and partial), and temporary disabilities and injuries. More detail on the DFE approach may be found in Appendix A. Estimates are summarized in Exhibit A-18.

Exhibit A-18 DFE 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.

F. VALUATION OF NON-HUMAN CONSEQUENCES

1. Hospital/health care facilities cost

Data from MOH&LTC record emergency room visits, and days in hospital for those injured as a result of motor vehicle collisions. A series of studies following a methodology established by the Health Services Restructuring Committee have been conducted of costs in Ontario hospitals. The average across 17 such studies[1] for a patient day is $216.29 and per emergency room visit $84.33 respectively, both in 2000 $. 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.

We combine this value for the non-staff costs with estimates available on the incremental use of medical staff for those injured in motor vehicle collisions (Chipman re-analysis) to provide a more complete estimate of the cost of medical services in the following section.

2. Health care professional cost

The incremental use of health care professionals was estimated through the re-analysis of Chipman as described earlier. These provide broader descriptions of health care professionals' categories than provided in the "OHIP fee schedules" for doctors and other health care professionals found in the Schedule of Benefits for Physician Services and related changes. As a result, we assign the following approximate values related to the health care categories in the Chipman analysis:

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

We use these values and the estimated incremental use of health care professionals by injury severity (from before) for those injured in motor vehicle collisions. Note that the survey data that is the base of the Chipman analysis reports on surviving individuals. It cannot be used to estimate health care professional costs associated to fatalities of motor vehicle collision. However, approximately one-quarter of fatalities occurs in emergency rooms and a further one-quarter occurs after admittance to

[1] Ministry of Health and Long-Term Care, Operational Review of Hôpital régional de Sudbury Regional Hospital, November 1, 2002.

hospital. For those admitted to hospital before dieing the average hospital stay is similar to those with major injuries. We assign the estimated health care professional cost for minor injuries and major injuries ($920 and $4600 respectively) to approximate the cost for these two groups of fatalities respectively.

3. Police costs

The Ontario Provincial Police (OPP) charge-back municipalities for the cost of police services they provide. They shared the model they use 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 OPP shared their model for our costing.

We apply these fully-loaded costs to the mix of OPP staff hours identified in the earlier section to identify a fully-loaded average cost per police hour of activity expended related to motor vehicle collisions. This fully loaded weighted average is $82.73 (2006$) or $78 in 2004. We assume that other police forces operating in Ontario will have a similar cost structure. We apply this weighted average fully-loaded hourly amount to police activity expended. Potentially this average exceeds the marginal cost of an extra police hour devoted to a motor vehicle collision. However, any difference is viewed as being small.

4. Court activities

Data from the Canadian Centre for Justice Statistics of Statistics Canada (See Exhibit A-19) 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 we estimate a cost for court proceedings related to motor vehicle collisions. This method assumes that court proceedings related to motor vehicle collisions are as likely as for other police activities.

Exhibit A-19 Ratio of Court to Police Costs

	Police	Courts	Court:Police
1992/93	5717	867	15.2%
1993/94	5790	852	14.7%
1994/95	5784	838	14.5%
1995/96	5809	847	14.6%
1996/97	5856	857	14.6%
Average			14.7%

Source: Juristat, Canadian Centre for Justice Statistics, Statistics Canada, Catalogue no. 85-002-XIE Vol. 19 no 12

5. 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 results in an average total costs per response of $2,501 (2003$). Converting to 2004 dollars this represents an average response cost of $2,548.

We believe the average cost per response provides a useful estimate of the costs per motor vehicle collision response:

- The high fixed operating costs (most costs such as buildings, vehicles, and staff are unavoidable) and the low variable costs (fuel use) of a response, suggest there is unlikely to be a dramatic difference in average costs by type of response.
- In 2003, almost two-thirds of all fire department calls were for medical aid including resuscitation (40%) or were related to false alarms (23%). Most calls related to motor vehicle collisions are for rescue or extrication (9% of all calls in 2003). These typical responses to motor vehicle collisions are likely to have a similar duration and resource use to the majority of calls noted earlier. This suggests that the average costs across all responses should be similar to the costs for motor vehicle collisions.
- Calls related to property fires/explosions are likely to have a higher duration and resource use than the average response. (However even including motor vehicle fires, property fires represent a small component (5% in 2003) of all responses.

For these reasons we feel the average costs of a response by fire departments provides a useful measure of the costs of a response related to a motor vehicle collision.

6. Ambulance

The Ontario Ministry of Health & Long Term Care provides grants to cover the cost of land ambulance services. Services are provided by approximately 60 certified land based municipal, private hospital and volunteer operators—serving 440 individual municipalities in Ontario. In 2004, there were over 1.6 million requests for land ambulance service resulting in approximately 940,000 transports of more than 1.1 million patients.

Those transported by land ambulance for a medically necessary trip, with a valid Ontario Health Card and not subject to a Special Exemption category, are charged a co-payment of $45 toward the cost of their trip. Each person whose transport is deemed medically unnecessary by the receiving hospital is charged a fixed $240 fee for a land ambulance under the Health Insurance Act, Regulation 552. This later fee is unlikely to reflect the full cost of the land ambulance trip.

Instead of this regulated charge we use the cost of $783 (2005 $) per transported patient estimated based on data provided by the City of Toronto website. (The total budget for Emergency Medical Services in Toronto was approximately $130 million with 166,000 transported patients in 2005. This average will include both fixed overheads and variable components of costs. However, like fire departments most costs are unavoidable and therefore an average allocation across all responses seems warranted.) In 2004 dollars the cost per land-based transport by ambulance is $754. We have assumed a value one-half this amount for transport by the Coroner.

We have no data on the costs for water ambulance service. Given its infrequent use related to motor vehicle collision we have assumed a cost identical to land based ambulance services.

A non-profit corporation accountable to the Ontario government provides air ambulance services in Ontario. Budgets and numbers transported are not available. However, approximate values provided to us suggest an average cost of approximately $5,000 per person transported by air ambulance. Given the small number of air ambulance trips involved we use this figure despite its uncertainty.

7. Tow trucks

Tow truck charges are typically included in insurance claims. As a result we deduct the amount estimated for tow truck costs in this section from the estimate of insurance claims payouts. Any uncertainty in our estimate of tow truck costs is netted out in the calculation of insurance claims costs.

Industry sources suggest that most motor vehicle collisions occur in areas covered by municipal contracts for tow truck services. These contracts are extremely competitive and most are “loss-leaders” for tow truck operators. Instead operators of tow trucks recoup losses on related charges for clean-up, dolly wheels, storage, compound fee, and wait times. A useful rule of thumb is $0.30 to $0.32 per pound of vehicle towed. So an average automobile of 1,500 lbs is $450 to $500 and a large truck is $15,000 to $30,000.

Since large trucks make up only 2% (17,849 of 853,902) of vehicles involved in collision in 2004 and commercial vehicles are more likely to be self insured (not covered by insurance claims, we make the simplifying assumption that most vehicles requiring tows will be automobiles or light trucks with an average tow charge of $500 in 2004.

Based on these costs per tow and the number of tow truck services presented earlier we estimate the social costs of tow truck services in 2004 at $95.6 million.

8. Property damage and other losses generally covered through insurance

Property damage caused by motor vehicle collisions is generally covered through the insurance claims of involved parties. In addition, claims cover a number of other incurred losses due to the collision such as tow trucks, damaged vehicle storage, car rental, or hotel accommodation. We include these losses (other than tow truck services discussed earlier) attributable to the motor vehicle collision in our estimate of property damage and other losses generally paid for through insurance claims. We also include the claims and adjustment expenses incurred by insurance companies and recorded in the data available to us from the Insurance Bureau of Canada (IBC). As a final note on coverage, we do not estimate property damages that would be borne by the "at-fault" driver as the deductible not reimbursed under collision and all perils claims. This deductible not included in the claims payouts is included in out-of-pocket expenses discussed in another section.

Property damage and the other losses discussed earlier are covered under the third party liability, collision and all perils insurance coverage of insured parties[1]. In addition a special insurance fund covers claims against uninsured (or unidentified) automobiles and under-insured drivers. However, claims within some of these categories may also include other items not relevant to our estimate of the social cost of motor vehicle collisions. For example:

- Third party liability includes claims for bodily injury.
- All perils include comprehensive coverage (fire, theft).
- Uninsured automobiles include claims for bodily injury and death.

In addition, some vehicle owners self-insure (do not have coverage for collision damage to their vehicle if they are found to be "at fault"). We include the proportion of commercial vehicles that self-insure based on the proportion without some form of collision coverage beyond mandated third party liability in our analysis. (Loses to private

[1] We include coverage of private passenger vehicles and motorcycles, commercial vehicles, farmers, snow machines, buses, ambulances, interurban trucks, trucks for hire, taxicabs, miscellaneous public automobiles (rental cars), and other types of specialty vehicles.

individuals who self-insure will be captured by out-of-pocket expenses estimated below.) Finally claims related to snow machines may not involve a motor vehicle or be HTA reportable. Exhibit A-20 presents the adjustment factors we use in the analysis to move from data supplied to us by the IBC of claims in 2004[1] to estimates of property damage and other losses discussed earlier.

Exhibit A-20 Adjustment factors used to bring Insurance Claims Payouts to appropriate social cost coverage

	Reduction factor		Augmentation
	# of claims (1)	$ of claims (2)	factor (4)
Third party liability	0.9	0.3	
All perils	0.3	0.3	
Uninsured automobile	0.9	0.3	
Snow machine (3)	0.1	0.2	
Collision/all perils for:			
- Commercial automobile			1.27
- Interurban trucks			1.56
- For-hire trucks			3.02
- Taxicabs			5.00
- Public buses			5.19
- School/hotel/camp buses			4.59
- Funeral carriages/hearses			1.66
- Ambulances			1.79
- Miscellaneous			4.48
- Garages/automobile dealers			3.30

Notes:
(1) proportion of claims expected to include property damage
(2) proportion of claim value expected to include property damage
(3) also reflects proportion that are expected to involve a motor vehicle and be HTA reportable
(4) to reflect proportion that self-insure

To interpret Exhibit A-20, reduction factors reduce claims data to reflect the component (either number or dollar value of claims) that is related to our coverage (property damage or related losses) and HTA reportable involving a motor vehicle (in the case of snow machines). The augmentation factors reflect that portion of commercial vehicles that self-insure. This is measured as the number of written policies for third party liability (a regulated requirement) divided by the sum of all perils and collision policies (voluntary). This is used to estimate the degree of property damage and related losses that are covered by the commercial enterprises (self-insurers) instead of through

[1] Not all losses identified in the data were incurred at the time the data were assembled (May 2005). The data include adjustments to reflect expected payouts based on historical data.

insurance. We do not estimate a comparable amount for private individuals since out-of-pocket expenses (calculated in the next section) will include such costs.

The analysis is not able to adjust for property damage caused by motor vehicles owned by a government since governments typically self-insure. These government losses are expected to be small.

For 2004, the analysis identifies $2.3 billion in property damages and other losses typically covered through insurance claims. Removing tow truck services, as discussed earlier the total is $2.2 billion. A total of 483,000 claims (or quasi-claims for those self-insured) are estimated through the analysis. Given the somewhat arbitrariness of our reduction factors in Exhibit A-20 we revised down the property damage estimate to reflect the 396,000 vehicles with vehicle damage classified from light to demolished in 2004. In so doing we estimate property damage in 2004 at $1.8 billion.

We allocate this total amount to vehicles damaged in 2004 as follows:

- Demolished -- $20,070.
- Sever -- $10,756.
- Moderate -- $4,565.
- Light -- $996.

We use these values in 2004, and values adjusted for inflation in other years, to allocate property damage to vehicles involved in motor vehicle collisions by damage severity.

An alternate assumption would be that the additional 86,000 claims reflect damage to vehicles in non-reported collisions. (See Section III. A.) If so these claims likely represent vehicles with light damage involved in PDO collisions. Under this assumption the number of vehicles with light damage would increase by 86,000, the factors used to allocate damage to vehicles would change slightly and the total estimated property damage in 2004 would be $2.3 billion.

9. Out of pocket expense by those involved in motor vehicle collisions

Those involved in motor vehicle collisions may incur out-of-pocket expenses:

- Not covered by insurance, including the insurance deductible of the at fault party and car rental, hotel or other expenses not covered under the policy.
- Not claimed under insurance, possibly as a result of a low dollar value of total claim.
- Not insured, for example in the case of an uninsured driver.

Based on data from the 1993 General Social Survey of Statistics Canada, 52.1% of individuals 15 years of age or older (based on coverage of the survey) involved in motor vehicle collisions on roadways in Ontario incurred out-of-pocket expenses that were not reimbursed by another party. In 1993, the average out-of-pocket expense was $719 ($882 in 2004$).

Based on data found in ORSAR for 2004 we estimate 1.3 survivors of collisions 16 years of age and older (a proxy to those 15 and over) per vehicle involved in injury and fatality collisions. We apply this factor to all vehicles involved in collisions and estimate a total out-of-pocket cost for them of $206 million in 2004.

10. Social Costs of Traffic Delays

In this section of the report we estimate traffic delays cause by motor vehicle collisions and the resulting impact on:

- Time losses.
- Fuel use.
- Extra pollution

a) Introduction

This section of our report provides an estimate of traffic delay costs based on a sample of data relating to motor vehicle collisions on specified roadways in the Toronto area. This research is preliminary in the sense that there is not a well-established research literature in this area to establish an analysis framework and there is no consistent overall data for Ontario on which to base estimates. In this context, our approach has been to build the best possible estimate using what are clearly limited data resources. Related work has been carried out by MTO in its publication *The Cost of Congestion in the GTA* and by Transport Canada in their publication *Urban Congestion in Canada*. However, both of these studies focus on recurring congestion issues rather than collision-based stoppages and delays. Recurring congestion is generally defined as inadequate capacity of the road system to handle traffic volumes as opposed to what are usually collision-based incidents in our analysis.

Estimating the costs of traffic delays resulting from motor vehicle collisions is a challenging task. It requires data on the following:

- Motor vehicle collisions causing delays.
- Number of persons affected. In this report, the number of persons affected is based on MTO data on traffic volumes (24 hour traffic distribution data) for that roadway at the time and date of the incident. That is, for each incident, the COMPASS data were matched with the relevant MTO data on traffic volumes to determine the number of persons affected.

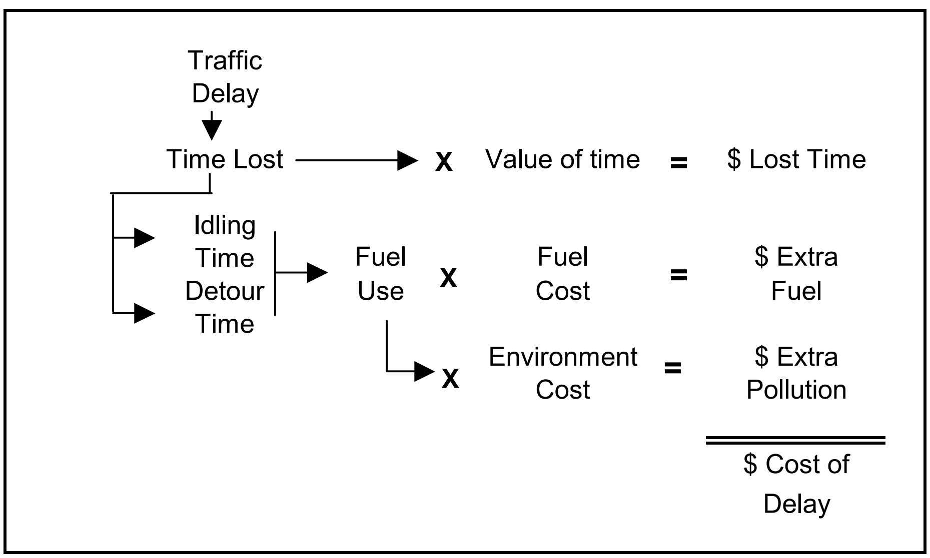
- Duration of and extent of delay. This is from COMPASS incident reports, including information on the extent of closure ranging from partial (single lane) to full roadway closure.
- Additional fuel consumed as a result of the delay. This is based on the duration data and estimates of idling fuel use and detour fuel use.
- Additional motor vehicle emissions resulting from the delay. Data on durations of stop and additional detour driving are combined with emission rates for the major motor vehicle pollutants to estimate total emissions.

More specifically, congestion costs are estimated on the basis of the following equation:

CONGESTION COST* = Delay hours∗W + Additional litres of fuel∗price + Additional tonnes of [CO_2+CAC]∗$ per tonne.

*Where: W represents the value of time based on wage rates and CAC refers to Criteria Air Contaminants.

The following flowchart further explains this calculation.



To carry out this analysis, this component of our report builds on the economics literature dealing with the economics of congestion that we have applied to the analysis of the social cost impact of traffic delays. From this literature including Transport Canada (2006), Dodgson (1997), Perry *et al.* (2006) and from the literature on applied labour economics, we have merged two sets of data. The first set is from the **COMPASS** system and consists of estimates of the time delays on Ontario freeways and major highways associated with motor vehicle collisions.

COMPASS is an Advanced Freeway Traffic Management System developed by the Ontario Ministry of Transportation (MTO) to respond to traffic congestion problems, primarily on Ontario's divided highways. COMPASS helps increase roadway efficiency and roadway safety by:

- Allowing for the prompt detection and removal of freeway incidents and vehicle breakdowns.
- Providing accurate and timely freeway incident and delay information to motorists.
- Effectively managing peak rush hour traffic flow through a variety of traffic control devices.

In this project, we have used data from the **COMPASS** system on delays as a critical data input. We have used **COMPASS** data from the MTO Toronto system (there are two other **COMPASS** systems in Burlington and Ottawa) covering Highway 401 from Highway 410 to Brock Road These data are then extrapolated to the entire Province, on the basis of population data that we assume are related to traffic volumes.

The methodology described in this section provides estimates of delays from motor vehicle collisions, measured in person hours. These delays are then combined with wage data from Statistics Canada for representative members of the population to value these time delay costs. In addition to these time delay costs, we have also estimated the incremental costs associated with the use of more motor vehicle fuel in a congested traffic context and the environmental costs associated with this additional and less efficient fuel use.

b) Lost time

The wage rate that we use to value time spent in traffic delays resulting from motor vehicle collisions is derived from Statistics Canada data on average wage rates (Statistics Canada-*The Labour Market* Cat. No.: 71-222-XWE). This value for 2004 is just under $18 per hour. There is an extensive literature including Small (1992) and Brownstone *et al*. (2002) that discusses what fraction of this wage should be used for traffic delays. Small argues that based on his review of an extensive literature in this area that the fraction should be 50%. The use of a fractional value reflects the fact that all persons delayed are not necessarily employed and that many passengers will be children. Brownstone *et al.* argue that revealed preference methods of determining willingness to pay show that commuters place quite a high value on time, possibly higher than the market wage. Substantial voluntary payment for reduced congestion on Ontario's Highway 407 provides a related example of this willingness to pay.

It seems clear that different types of drivers will place different values on time spent in congested traffic. However, it appears highly unlikely that data would be available to support a more detailed analysis of how willingness to pay to avoid delays might vary across different types of drivers. As a result, our approach draws on the mainstream literature. In this literature, the lower bound would be a value of 50% of the 2004 market wage ($9). The upper bound from Transport Canada's *Urban Congestion in Canada* (2006-Table 1) gives a value of $32.25 per hour for Ontario in 2004. In our calculations below, we use $20.60 per hour, the average of these two values as an average value for all road users.

c) Additional fuel use

Incremental fuel costs result from delays (slower speeds), stopping (frequent with lane closures) and detour distances. The COMPASS data provide the duration of lane and road closures and the traffic volumes at the time of the incident. From this, we have estimated idle times and detour/slower driving. The current congestion cost model uses a stop time of two hours (or the duration of closure whichever is smaller) and a slow driving/detour time of one hour (or the duration of closure whichever is smaller).

From the U.S. Department of Transportation, we used an estimate of 2.25 litres of gasoline for each hour spent idling. For detours and delays, we used an average fuel efficiency amount of 11.25 litres per 100 km. Based on this fuel efficiency, each hour of detour and delay, in addition to time stopped, consumes 5.5 litres of fuel. Fuel costs of 76.6 cents per litre (from Ontario Ministry of Energy historical price data) are used in the model for 2004.

d) Additional Pollution

A further social cost of traffic delays caused by collisions is the pollution associated with extra burning of fossil fuels during the delay. It is widely recognized that traffic congestion generally, and specifically from collision, contributes to increased levels of exposure to vehicle emission-related pollutants. Vehicle drivers and passengers will feel the negative impacts during traffic delays. The non-driving public may also experience a degradation in the air quality in the area of the collision. Generally, the costs will be larger in urban areas where roadways are contiguous to large numbers of residences and persons. There is evidence in the literature that for passengers, pollution levels inside stopped and idling vehicles, in a group of stopped vehicles, may be from two to eight times higher than when moving at the speed limit. Any policy-related measures to reduce collision-related congestion will reduce the health risks to vehicle occupants and will also reduce general population risk in urban areas. The extensive literature on air pollution shows that the benefits of risk reduction related to reduced air quality are substantial. These benefits relate primarily to emissions of air pollutants such as hydrocarbons (HC), CO, NO_x, as well as emissions of greenhouse gases (GHGs). In this project, we have estimated incremental emissions related to motor vehicle collisions in

Ontario and then valued these additional emissions using widely cited estimates from the environmental policy literature.

The most widely cited report on air quality and valuing benefits is provided by the U.S Environmental Protection Agency (EPA, 1999) estimating the benefits of the *U.S. Clean Air Act* in preventing premature deaths and illness due to reduced air quality.

For greenhouse gas (GHG) emissions, Pearce (2005) and Tol (2005) provide estimates of the benefits of emission reductions designed to be used in a cost-benefit context (that is, as we are using the estimates). Their estimates are in the range of C$2.70 to C$17.50 per tonne of CO_2 emitted. In this project, we have used an average of these numbers of C$10 per tonne of CO_2 as the value for this parameter. This literature and the environmental economics literature more generally indicate that these values are likely to be higher in the future.

The air pollution literature contains many benefit estimates associated with reductions in Criteria Air Contaminants (CACs). In the case of GHG emissions including automobiles, this literature suggests that damages related to health effects account for a large fraction of the total value of what are referred to as ancillary benefits (that is benefits associated with GHG reductions that go beyond climate change). In this project, we have used a value of just over C$8 per tonne of CO_2 as the value for the ancillary benefits (air quality) parameter. The source for this estimate is a study for Resources for the Future, a leading environmental research institution, by Burtraw and Toman (1998). This means that the benefits of reducing incremental motor vehicle emissions associated with traffic incidents consist of C$10 per tonne of CO_2 plus an additional $8 per tonne of CO_2 to reflect air quality (CAC) benefits (as opposed to CO_2 climate change benefits). This latter value reflects the damage costs related to CAC emissions per tonne of CO_2.

Note that the CAC damage estimate of $8 per tonne, from the work of Resources for the Future, is $8 per tonne of CO_2, not $8 per tonne of the major (non-diesel) motor vehicle pollutants (HC, CO and NO_x). Average emissions (pounds per mile), according to EPA data are as follows:

- CO_2 -- 0.916 pounds.
- HC -- 0.0033 pounds.
- CO -- 0.033 pounds.
- NO_x -- 0.005 pounds.

As these numbers clearly indicate, emissions of the CAC pollutants are much smaller per mile than for CO2. Put somewhat differently, one tonne of CO2 emissions will be accompanied by approximately eight pounds of HC emissions (0.0033/0.916*2205). Alternatively 2407 vehicle miles implies one tonne of CO2 and eight pounds of HC.

Somewhat different estimates are provided in Transport Canada's *Urban Congestion in Canada* (2006-Table 4). These numbers imply an upper bound of $20 per tonne of CO_2 and $102 per tonne of CO_2 for CAC emissions. Our calculations use an average of these numbers and the Resources for the Future estimate of $18 for a total of $70 per tonne of CO_2 and its associated CAC emissions.

The core elements of the congestion cost model are presented in Exhibit A-21.

Exhibit A-21 Summary of Congestion Cost Data

VARIABLE	DATA
LOST TIME	
W-wage or value of time	$20.60 per hour-average of upper and lower bound estimates.
Occupants	1.5 per vehicle (includes all types of vehicles)[1]
Vehicles affected (traffic volume)	24-hour traffic distribution data. Volumes were adjusted to reflect varying degrees of road closure from full to partial as described in COMPASS incident reports.
ADDITIONAL FUEL USE	
Additional fuel use	2.25 litres per idling hour plus 5.5 litres per hour for additional driving time.
Fuel price	$0.766 per litre —Ontario price in 2004.
ADDITIONAL EMISSIONS	
CO_2 emissions	245 kg per 100 kilometers—double when idling.
[CO_2+CAC]$	$70 per CO_2 tonne- average of upper and lower bound estimates.

To clarify how these data are used, consider a typical incident. In this example, assume that a segment of Highway 401 is closed for three hours and that this means that

[1] We used an average vehicle occupancy factor of 1.5. Some studies in the GTA suggest the average auto occupancy is between 1.10 and 1.20 depending on location and time of the day, and has a decreasing trend over time. However, to account for some other vehicle categories such as transit buses, school buses, and some commercial vehicle categories we decided to use the factor of 1. 5. The analyst has control over this assumption in the model.

each affected vehicle is stopped for two hours followed by one hour of detour/delayed travel.

- **Time Cost**: As noted, the congestion cost model uses a stop time of two hours (or the duration of closure whichever is smaller) and a slow driving/detour time of one hour (or the duration of closure whichever is smaller). Further assume that "normal" traffic volume is 2,000 vehicles per hour. This implies a total of 6,000 affected vehicles, 1.5 persons per vehicle and three hours of delay. Person hours of delay time would be 6,000*1.5*3 or 27,000 hours. Each hour is valued at $20.60 for a cost of $556,200.

- **Fuel Cost**: In this incident, we have two hours of stop time during which we assume that heating/ air conditioning means that the vehicles idle for two hours followed by one hour of additional driving time. This means that each of 6,000 vehicles uses 2.25 litres per idling hour plus 5.5 litres per hour for additional driving time. For two hours stopped and one hour of delayed driving, this is 4.5 idling litres and 5.5 driving for a total of 10 litres times 6,000 vehicles. The total of 60,000 litres is valued at $0.766 per litre (the 2004 price) for a total of $45,960.

- **Emission Costs**: Emissions are calculated from idling time and incremental driving time for the 6,000 vehicles. Idling emissions are 6,000*490*2 hours, where 490 is 245 kg doubled and extra driving emissions are 6,000*245*1 hour. Total emissions are 7,350 tonnes and each tonne is costed at $70. Total emission costs are $514,500.

- **Total Costs**: This is the sum of the three costs above for a total of $1,116,660. This describes how costs are calculated for each COMPASS-reported incident from the Toronto data.

e) Cost Estimates due to Traffic Delays

The core cost parameters are described in the preceding sections for each of the major cost areas. The **COMPASS** system of MTO provided the remaining data. For 2004, the major Toronto **COMPASS** incidents were reviewed. This was a total of 246 cases. A sample of these cases was then selected for detailed analysis of each individual case. The sample consisted of all recorded Toronto **COMPASS** incidents recorded in the first month of each quarter, effectively capturing seasonal variations within the year. This provided 70 cases that were entered into a spreadsheet showing date, time, location of the incident and roads and/or lanes affected, as described in the **COMPASS** incident reports. These data, in spreadsheet form, were sent to MTO to review and to provide traffic volume data (24 hour traffic distribution data) at the specific location of each of these incidents for that road at the specified time during which the stoppages and delays occurred. We integrated these data with the **COMPASS** incident report data to estimate delay and congestion times (in person hours) for each of the incidents. That is, all 70 incidents were analyzed individually to determine hours of delay and then combined with the 24-hour traffic distribution data to estimate numbers of person subject to the delay and from that, the total person hours of delay for each incident.

Based on the data described above, Exhibit A-22 shows estimated costs for each of the three categories and a total congestion cost. These are shown for the sample, for all of the Toronto **COMPASS** area and for Ontario. The " Toronto **COMPASS**" data use a ratio of 246 to 70 cases to develop the overall total for Toronto. To move to all of Ontario is a more difficult challenge. The Toronto **COMPASS** system includes the 400 series highways around Toronto (400 to Langstaff Rd., 401, 403 to Highway 10). . Highway 401 information coverage, as shown by **COMPASS** reports, extends on Highway 401 from Highway 410 to Brock Road. The Toronto **COMPASS** coverage does not include the QEW. While the existing **COMPASS** system covers some of the most heavily traveled sections, the major exclusions in our sample, in terms of the highest traffic volumes in Ontario, appear to be the QEW, Highway 404, DVP, Gardiner, Highway 400 north of the **COMPASS** boundary and Highway 401 east and west of **COMPASS**.

The next step is to extrapolate these data to all of Ontario. This represents a major challenge and would be a major research study on its own. The preliminary Ontario congestion cost estimate that we have developed in this report is derived as follows. Recent Ontario Finance data show that the GTA accounts for 46% of the Ontario population. Linear extrapolation is not appropriate since traffic volumes (potential delays) are much higher in the GTA. Collision delays are assumed to be 50% more likely in the GTA so that the population share of 46% is inflated to 69% (46%*1.5). The inverse of this is the factor of 1.45 that is used to produce the overall Ontario total cost estimate of $501.8 million shown in Exhibit A-22. This population extrapolation method is used because there is no consistent database of collisions and delays for the entire province.

Exhibit A-22 Estimated Congestion Costs due to Collisions: 2004

($ Millions)	Extra time	Extra fuel	Additional pollution	Total Costs
COMPASS Sample	$49.1	$4.1	$45.2	$98.5
All Toronto COMPASS	$172.9	$14.5	$158.8	$346.1
Ontario	$250.7	$21.0	$230.2	$501.9

We have no data to guide our allocation of traffic delay cost across collision severity. We assume that on average injury collisions involve 10 times the delay of PDOs and fatal collisions involve 100 times the delay of injury collisions (1000 times the delay for PDOs). Given the disproportionate share of PDO collisions this allocation results in 48%, 41% and 11% of traffic delay cost being applied to fatal, injury and PDO collisions respectively.

Appendix B

Making Changes to the Models

APPENDIX B: MAKING CHANGES TO THE MODELS

This appendix provides examples of typical applications of the models. These are provided for the Ontario Model, Ontario Sub-Models, and Canadian Jurisdictions Models, and WS&IB models. The first section identifies changes that can be made which will affect all models equally. A final section discusses the possibility for more advanced changes to the models. Cell references are identified using standard notation in Excel spreadsheets. For example A!D15 refers to column D, row 5 in spreadsheet A.

A. CHANGES AFFECTING ALL MODELS

The models are a series of Excel spreadsheets. Data found in spreadsheet A—Assumptions and Values and B—Calculations will affect all models. Those that are most likely to be changed in the normal application of the model are described in this section. (Other changes to the model that go beyond "normal" applications of the model are discussed in the final section of this Appendix.)

1. Year of social value (A!D15)

The year that the analyst would like social values reported in is recorded in A!D15. In the current model this year is set at 2004. Entering a new year between 2000 and 2015, in place of 2004, will result in an automatic recalculation to values in this new year.

The model uses three separate price indices for values related to human consequences (Statistics Canada, The Labour Market, 71-222-XWE), health care costs (Statistics Canada, Consumer Price Index, Health Care Services), and all other cost items (Statistics Canada, Consumer Price Index, All Items). Actual values for these indices are recorded for years 2000 to 2005 and extrapolated values for these series for 2006 to 2015. (Changes to these indices are discussed in the final section of this appendix.)

2. Valuation method, scenario for human consequences (A!D20)

The analyst has control over which valuation method and cost scenario, if the willingness-to-pay method, is used to calculate values for human consequences. This is done by typing in the following short forms in cell A!D20.Doing so returns appropriate values for human consequences based on the valuation method or whether the low, medium or high scenario is used for the willingness-to-pay method.

Enter	For valuation method yielding
DFE	Discounted Future Earnings
WTP-H	High estimate using Willingness to Pay
WTP-L	Low estimate using Willingness to Pay
WTP-M	Medium estimate using Willingness to Pay
OTHER	Analyst-specified values

The “OTHER” command allows the analyst to employ user-specified values for human consequences. The analyst enters “OTHER” in cell A!D20 and a user-specified Value for Social Life (VSL) into cell A!B36. All other values for human consequences are calculated based on the VSL following the willingness-to-pay approach. In the current model a VSL of $5,000,000 (2004 $) is used in the “OTHER” default setting.

3. Better/more recent data for social values

The remainder of Spreadsheet A lists data we gathered related to the social costs of non-human consequences of collisions. If more recent or better data comes available data in Spreadsheet A can be updated.

When such updates are made the analyst should ensure that values are recorded in 2004$ in Spreadsheet A. (Valued parameters to be expressed in 2004 $ are noted by a boxed cell in Spreadsheet A.) This is because the model automatically adjusts all values for the year that social costs are to be reported in (as discussed in Section 1 above) based on values for each valued item reported in the common base of 2004 $. Price indices, noted earlier, will assist in conversion from other base years to 2004 $.

B. CHANGES TO THE ONTARIO MODEL

The current model is base on data on the characteristics of motor vehicle collisions in 2004. These unadjusted data originally obtained from ORSAR are entered into Spreadsheet O1—unadjusted data.

Collision characteristics data can be replaced by similar data for other years. In so doing the model automatically updates all calculations based on the new collision data input into Spreadsheet O1.[1] For example data for 2005 can be input in place of the current model’s 2004 data in Spreadsheet O1.

The analyst should also record the year that the new data represents in cell O1!A2. This will automatically record the year for the collision data in other spreadsheets.

[1] Note that unadjusted and adjusted data for Ontario collisions for 2004 are also recorded in Spreadsheet B—Calculations. Calculations in the model are based on the data that appear in Spreadsheet B and should not be altered.)

C. CHANGES TO THE ONTARIO SUB-MODELS

Four sub-models for Ontario are presented in the current model. Unadjusted data related to collisions meeting the characteristics of the particular sub-model are entered into 4 tables in Spreadsheet OS1—one for each sub-model. Each table is similar in structure to Spreadsheet O1.

Currently the sub-models are based on data on the characteristics of motor vehicle collisions in 2004 meeting the characteristics of the particular sub-models. These unadjusted data originally were obtained from ORSAR. Collision characteristics data can be replaced by similar data for other years—for example 2005. In so doing the model automatically updates all calculations based on the new collision data input into Spreadsheet OS1.

The analyst should also record the year that the new data represents in cell OS1!A2. This will automatically record the year for the collision data in other relevant spreadsheets.

The analyst has control over user-specified parameters in three of the four sub-models. When new values are entered these automatically affect the use of resources according to the factor specified in the sub-model relative to the use of these same resources in the core Ontario model. For example, a default factor of 2 applied to police resources in the drinking and driving sub-model implies that twice as many police services are applied to each collision in the drinking and driving sub-model compared to the Ontario model. The cell reference for these user-specified parameters and their default setting are presented below:

Cost Component	**Sub-model**		
	Drinking and Driving	Large Trucks	Freeway
Police	OSD2!C5—2	OSL2!C5—1.5	OSF2!C5—2
Courts	OSD2!C6—2		
Fire		OSL2!C6—2	
Tow trucks		OSL2!C7—3	
Delay		OSL2!C8—3	OSF2!C6—5

D. CHANGES TO THE CANADIAN JURISDICTIONS MODEL

Unadjusted data on the collisions characteristics for each Canadian jurisdiction is entered into Spreadsheet C1. These data are obtained from TRAID for 2004.

Data on collision characteristics can be replaced by similar data for other years—for example 2005. In so doing the model automatically updates all calculations based on the new collision data input into Spreadsheet C1. When making changes to the data in the model, the analyst should also record the year that the new data represents in cell C1!A2. This will automatically record the year for the collision data in other spreadsheets.

The most likely users of the Canadian Jurisdictions Model will be individual jurisdictions. As a result the model was designed to provide jurisdiction-specific estimates of the social costs of the motor vehicle collisions. These estimates are produced once the user transfers the revised and adjusted data automatically produced by the model from Spreadsheet C1.3 to corresponding cells in Spreadsheet C2. This is done by copying cells from Spreadsheet C1.3 and pasting them (using the Paste Special/Values function in Excel) to Spreadsheet C2. (For Newfoundland and Labrador appropriate cells to copy from Spreadsheet C1.3 are C1.3!A25:C1.3!F43.) The model then automatically calculates the social cost of collisions occurring in the jurisdiction in Spreadsheet C3.

The model can be used to calculate the social cost of motor vehicle collisions occurring in all jurisdictions by copying total collision characteristics automatically calculated for Canada from Spreadsheet C1.3 (correct cells for Canada from Spreadsheet C1.3 are C1.3!A5:C1.3!F23) and pasting them (using the Paste Special/Values function in Excel) to Spreadsheet C2.

The model records the social costs for all jurisdictions and for Canada in Spreadsheet C3T.

E. MORE ADVANCED CHANGES TO THE MODELS

Calculations in the Ontario model are based on factors derived from data collected in the study. These data, the calculations based on them, and the derived factors used in analyses are provided in Spreadsheet B. The analyst has the opportunity to change any of these derived factors either by assuming different factors or by entering new data in place of the data collected during the study. The most likely changes to the model are noted in this section.

1. Price indices

The model uses three separate price indices for values related to human consequences (Statistics Canada, The Labour Market, 71-222-XWE), health care costs (Statistics Canada, Consumer Price Index, Health Care Services), and all other cost items (Statistics Canada, Consumer Price Index, All Items). Actual values for these indices are recorded for years 2000 to 2005 and the model estimates values based on each series for 2006 to 2015.

The analyst could enter actual data for each price index when available and re-estimate values for remaining years in the series. These data are record in B!J6:B!L21.

2. Coroner estimates of deaths

For a number of reasons ORSAR data may not capture all deaths related to collisions. Given the high social value assigned to a fatality in the analysis it would be useful to have an estimate based on more than a single year of data concerning the difference between Coroner and ORSAR data related to the number of fatalities. This factor, found in B!G68, could be revised based on further analysis covering additional years.

3. MOH&LTC data to estimate major and minor injuries

The model pools MOH&LTC data related to hospital stays, emergency room use, by those involved in motor vehicle collisions in two years—2003/2004 and 2004/2005. These are then compared to data available from ORSAR on the number of major and minor injuries. Although there is a high degree of consistency across the two years it may be useful to combine additional years of data and compare them to ORSAR data to better assess the factors used to increase major (those admitted to hospital who do not die) and minor (emergency room visit) injuries. These factors are found in cells B!H147 for major injuries and B!H148 for minor injuries.

4. Fuel prices

Delay cost calculations include the cost of fuel expended. Due to the current variability in the price of fuel the model allows for the adjustment of fuel costs explicitly by changing the value found in cell A!B328.

A cautionary note prices recorded in this cell should be in 2004$ as the model will implicitly handle all adjustments for inflation. As a result the model will handle any changes in fuel prices that are purely inflationary. However the analyst may wish to change the fuel price in cell A!B328 if for example there is some shock to the world price for oil that causes the opportunity cost of fuel to change.

5. Vehicle occupancy factor

The model uses a vehicle occupancy factor of 1.5 to represent the average number of occupants in <u>all</u> vehicles. This is an assumed value based on studies of average automobile occupancy in the GTA of from 1.1 to 1.2. Recall that the 1.5 value is to account for all forms of vehicles including buses. The analyst can replace this value in cell A!B330.

Appendix C

The Value of Human Consequences Using Discounted Future Earnings

APPENDIX C: THE VALUE OF HUMAN CONSEQUENCES USING DISCOUNTED FUTURE EARNINGS

For the most part, the methods used here follow those applied by Ted Miller and described in Appendix D of the 1994 final report. Where more recent or improved data were available, the methods exploited them. Where previous results seemed questionable, the calculations were revised to bring the results into line with reasonable expectations. Some parts of the description that follows have been taken from the Appendix D referred to above. The application of the methods described here occurs in a spreadsheet file called "Discounted Future Earnings.xls".

A. DISCOUNTED FUTURE EARNINGS AND LOST HOUSEHOLD PRODUCTION

Losses are measured for foregone future earnings in three main types of case: fatalities, permanent disabilities (total and partial), and temporary disabilities and injuries.

Fatalities cost people future earnings in the form of their expected wages, fringe benefits, and household production for the lifespan that a life table suggests lay before them in the absence of their fatal collision. Permanent total disabilities have the same effect (although average losses differ because the age and sex distributions for fatal and nonfatal injuries differ). Permanent partial disabilities are assumed to cost an average of 17% of lifetime earnings (Monroe Berkowitz and John Burton Jr., *Permanent Disability Benefits in Workers' Compensation*, Kalamazoo MI: W.E. Upjohn Institute for Employment Research, 1987).

Probabilities of permanent disability are applied to the numbers of major, minor, and minimal injuries. These probabilities were taken from U.S. data (Ted Miller, Nancy Pindus, John Douglass, and Shelli Rossman, *Nonfatal Injury Incidence, Costs, and Consequences: A Data Book*, The Urban Institute Press, published in early 1994), as follows:

	Total	Partial
Hospitalized	.0162	.1493
Other Med Treated	.0006	.0115

MTO defines hospitalized injuries as major injuries. Other medically treated injuries closely resemble MTO's minor-injury category. Injuries not treated at hospital are MTO minimal injuries. We assign one-half the probability of total and partial permanent disability of other medically treated injuries to this group. Our assumption is that some injuries, including neck and back injuries, may not be immediately apparent.

They will not be treated at a hospital emergency, but will result in permanent disability. The three types of non-fatal injury were treated as either permanent disabilities (total or partial) or temporary disabilities according to the above probabilities.

This appendix first describes the estimation of discounted future lifetime earnings for deaths and permanent disabilities. Then it explains how days lost to temporary disabilities and loss per day were computed.

B. LIFETIME EARNINGS

Losses are calculated separately for death and non-fatal permanent disability. The relevant equations to estimate these losses are:

$$PV_{mortality} =$$

$$\sum_{n=y}^{99} P_{y,s}(n)\,[Y_s(n)\,E_s(n) + Y^h{}_s(n)\,E^h{}_s(n)] \times \frac{(l+g)^{n-y}}{(l+r)^{n-y}}$$

where: $PV_{mortality}$ = presented discounted value of loss due to injury death per person

$P_{y,s}(n)$ = probability that a person of sex s and age y will survive to age n

y = age at which the individual was injured

s = sex of the individual

n = future age of the individual (years of age over which the individual is deemed to have lost earnings and household production)

$Y_s(n)$ = mean annual earnings of an employed person of sex s and age n including the value of fringe benefits

$E_s(n)$ = proportion of the population of sex s and age n that are employed in the labour market

$Y^h{}_s(n)$ = mean annual imputed value of homemaking services of a person of sex s and age n

$E^h_S(n)$ = proportion of the population of sex s and age n that are keeping house

g = rate of increase of labour productivity (variable, set at 1% to yield the summary data presented below)

r = is the real discount rate (variable, set at 4% to yield the summary data presented below)

$PV_{morbidity}$ =

$$\sum_{n=y}^{99} P^i_{y,s}(n)\, D(n)\, \frac{[Y_S(n)\, E_S(n) + Y^h_S(n)\, E^h_S(n)]}{365} \times \frac{(l+g)^{n-y}}{(l+r)^{n-y}}$$

where: $PV_{morbidity}$ = presented discounted value of earnings losses due to injury per person

D(n) = days restricted activity during the year of a person currently age n

$P^i_{y,S}(n)$ = probability that a person of sex s with injury i acquired at age y will survive to age n

n = future age of the individual (years of age over which the individual is deemed to have lost earnings and household production)

$Y_S(n)$ = mean annual earnings of an employed person of sex s and age n including value of fringe benefits

$E_S(n)$ = proportion of the population of sex s and age n that are employed in the labour market

$Y^h_S(n)$ = mean annual imputed value of homemaking services of a person of sex s and age n

$E^h_S(n)$ = proportion of the population of sex s and age n that are keeping house g = rate of increase of labour productivity (variable, set at 1% to yield the summary data presented below)

y = age at which the individual was injured

r = is the real discount rate (variable, set at 4% to yield the summary data presented below)

The Excel spreadsheet is used to apply the above calculations to compute discounted lifetime earnings and household production losses for deaths and permanently disabling injuries. (Note: household production losses are calculated using their relationships to earnings in 1993, as described below under "Input Data"; also, the rate of increase of labour productivity does not apply to the calculation of lost household production.)

C. SHORT-TERM PRODUCTIVITY LOSS

Short-term productivity loss includes both wage loss and household production loss from injuries that did not lead to death or permanent disability. Average daily earnings plus fringe benefits for workers and non-workers is estimated as hours worked per day worked times hourly wage times labour force participation times participants employed times 1.341 (to add fringe benefits, as above).

Household production was computed from the 1993 data in a manner parallel to that described above for the lifetime calculations.

D. INPUT DATA

The input data used by the spreadsheet consist of:

- Counts of fatalities and of major, minor, and minimal injuries, by sex and single years of age, for 2004.
- Annual employment income per person in Ontario, calculated as P * L * E * Y where:

    P = the population of Ontario, tabulated at zero years, 1-4, 5-9, five-year groups to 84, and 85 and over, from *Labour Force Historical Review, 2005, Statistics Canada 71F0004XCB*.

    L = the Ontario percentage labour force participation, from *Labour Force Historical Review, 2005, Statistics Canada 71F0004XCB*.

E = the Ontario probability of employment given participation, from *Labour Force Historical Review, 2005, Statistics Canada 71F0004XCB*.

Y = the average Ontario earnings if employed, from Statistics Canada (CANSIM).

The data on labour force participation and probability of employment were available by sex in five-year groups for five-year age groups from 15-19 to 65-69 and for 70 and over. We further subdivided the last group by five-year increments by prorating the pattern Miller reported in 1993. Similarly, earnings data were available for only certain age groupings (15-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65 and over). Again, we prorated the observed statistics over the required five-year age groups using the earnings pattern reported by Miller.

- Annual household production was calculated as the product of average employment income per person in Ontario and the ratio of Annual Household Production to Annual Earnings in Miller's data from 1993, in each five-year age group. The validity of this calculation requires an assumption that this ratio has not changed since then.
- Survival probabilities (of being alive a year later given one is alive at a particular year of age), from *Life Tables, Canada Provinces and Territories, 1995-1997, Statistics Canada 84-537-XIE*.
- Fringe benefits were assumed, as was the case in Miller's work, to equal 34.1% of wages based on data from *Employee Benefit Cost in Canada, 1991*, KPMG Peat Marwick Stevenson & Kellogg.

E. SUMMARY OF DFE LOSSES

The exhibit shows losses as discounted future earnings at a real discount rate of 4%, the rate chosen by Miller *et al.* (Ted Miller, Brooke Whiting, Brenda Kragh, and Charles Zegeer, "Sensitivity of Resource Allocation Models to Discount Rate and Unreported Accidents," Transportation Research Record 1124, pp. 58-65, 1987). Totals are based on unadjusted data from ORSAR as we do not know the characteristics needed for the DFE calculations of the adjusted injury and fatality data. More significant are the average costs which are used in the social cost model. Other discount rates can be easily applied using the spreadsheet.

EXHIBIT C-1 DFE Values for Ontario Highway Collision Injuries

Injury Severity	DFE ($)	Average/case
Fatality	$890,739,750	$1,114,818
Permanent Total Disability	98,165,086	1,121,079
Permanent Partial Disability	208,671,411	189,081
Major Injury*	22,933,133	7,709
Minor Injury*	33,566,112	1,136
Minimal Injury*	1,404,048	36
Total:	$1,255,479,539	--

* Excluding those resulting in permanent disability.

Appendix D

Value of Human Consequences of Collisions by Jurisdiction based on Alternate Assumptions

APPENDIX D: VALUE OF HUMAN CONSEQUENCES OF COLLISIONS BY JURISDICTION BASED ON ALTERNATE ASSUMPTIONS

Newfoundland and Labrador				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	41.4			41.4
Injuries:				
Major	0.1	1.9		2.0
Minor	0.1	5.6		5.7
Minimal	0.0	0.2		0.2
Total disability	0.4	9.2		9.6
Partial disability	0.7	22.9		23.6
HUMAN SUB-TOTAL	**42.7**	**39.8**		**82.5**
Willingness to pay--low scenario				
Fatalities	282.4			282.4
Injuries:				
Major	0.7	10.8		11.4
Minor	0.8	42.8		43.6
Minimal	0.0	2.1		2.2
Total disability	0.2	4.0		4.2
Partial disability	0.9	29.1		30.0
HUMAN SUB-TOTAL	**284.9**	**88.8**		**373.7**
Willingness to pay--high scenario				
Fatalities	741.7			741.7
Injuries:				
Major	3.4	53.8		57.1
Minor	3.9	213.9		217.9
Minimal	0.1	10.7		10.8
Total disability	0.8	20.2		21.0
Partial disability	4.4	145.5		149.9
HUMAN SUB-TOTAL	**754.2**	**444.1**		**1,198.4**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

Prince Edward Island				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	33.6			33.6
Injuries:				
Major	0.1	0.9		1.0
Minor	0.1	1.2		1.2
Minimal	0.0	0.0		0.0
Total disability	0.3	2.8		3.1
Partial disability	0.5	5.9		6.4
HUMAN SUB-TOTAL	**34.5**	**10.8**		**45.4**
Willingness to pay--low scenario				
Fatalities	228.9			228.9
Injuries:				
Major	0.6	4.8		5.4
Minor	0.5	9.0		9.5
Minimal	0.0	0.2		0.2
Total disability	0.1	1.2		1.4
Partial disability	0.6	7.6		8.2
HUMAN SUB-TOTAL	**230.8**	**22.9**		**253.6**
Willingness to pay--high scenario				
Fatalities	601.4			601.4
Injuries:				
Major	2.8	24.2		26.9
Minor	2.5	45.1		47.5
Minimal	0.0	1.1		1.1
Total disability	0.6	6.2		6.8
Partial disability	3.2	37.8		41.0
HUMAN SUB-TOTAL	**610.4**	**114.3**		**724.7**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

Nova Scotia				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	100.7			100.7
Injuries:				
Major	0.3	3.2		3.5
Minor	0.2	6.2		6.5
Minimal	0.0	0.1		0.1
Total disability	1.0	11.9		12.9
Partial disability	1.8	26.8		28.6
HUMAN SUB-TOTAL	**104.1**	**48.3**		**152.4**
Willingness to pay--low scenario				
Fatalities	686.8			686.8
Injuries:				
Major	2.0	17.8		19.7
Minor	1.8	47.5		49.3
Minimal	0.0	1.4		1.4
Total disability	0.4	5.2		5.6
Partial disability	2.3	34.1		36.4
HUMAN SUB-TOTAL	**693.3**	**106.0**		**799.3**
Willingness to pay--high scenario				
Fatalities	1804.1			1804.1
Injuries:				
Major	9.8	88.9		98.7
Minor	8.9	237.6		246.5
Minimal	0.1	6.8		6.9
Total disability	2.1	26.1		28.2
Partial disability	11.4	170.5		181.9
HUMAN SUB-TOTAL	**1,836.4**	**529.9**		**2,366.3**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

New Brunswick				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	79.5			79.5
Injuries:				
Major	0.3	4.2		4.4
Minor	0.2	6.1		6.3
Minimal	0.0	0.1		0.1
Total disability	0.7	13.7		14.4
Partial disability	1.3	28.7		30.0
HUMAN SUB-TOTAL	**81.9**	**52.8**		**134.7**
Willingness to pay--low scenario				
Fatalities	541.8			541.8
Injuries:				
Major	1.5	23.2		24.7
Minor	1.2	46.6		47.8
Minimal	0.0	0.8		0.8
Total disability	0.3	6.0		6.3
Partial disability	1.6	36.5		38.2
HUMAN SUB-TOTAL	**546.4**	**113.2**		**659.6**
Willingness to pay--high scenario				
Fatalities	1423.2			1423.2
Injuries:				
Major	7.3	116.2		123.5
Minor	6.0	233.2		239.2
Minimal	0.1	3.8		3.8
Total disability	1.5	30.0		31.5
Partial disability	8.2	182.7		190.8
HUMAN SUB-TOTAL	**1,446.2**	**565.8**		**2,012.1**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

Quebec				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	724.2			724.2
Injuries:				
Major	2.1	67.1		69.2
Minor	2.0	112.4		114.3
Minimal	0.0	3.5		3.5
Total disability	6.3	252.6		258.9
Partial disability	12.5	567.6		580.1
HUMAN SUB-TOTAL	**747.0**	**1,003.2**		**1,750.3**
Willingness to pay--low scenario				
Fatalities	4937.5			4937.5
Injuries:				
Major	11.7	375.4		387.1
Minor	14.9	856.3		871.2
Minimal	0.4	44.9		45.3
Total disability	2.8	110.4		113.2
Partial disability	15.9	721.7		737.5
HUMAN SUB-TOTAL	**4,983.2**	**2,108.6**		**7,091.8**
Willingness to pay--high scenario				
Fatalities	12969.2			12969.2
Injuries:				
Major	58.6	1876.8		1935.5
Minor	74.5	4281.4		4355.9
Minimal	2.2	224.4		226.7
Total disability	13.8	552.0		565.8
Partial disability	79.3	3608.3		3687.7
HUMAN SUB-TOTAL	**13,197.7**	**10,542.9**		**23,740.6**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

Ontario				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	894.3			894.3
Injuries:				
Major	2.4	38.2		40.7
Minor	1.8	67.2		69.0
Minimal	0.0	2.1		2.1
Total disability	7.0	146.5		153.6
Partial disability	13.4	332.1		345.6
HUMAN SUB-TOTAL	**919.0**	**586.2**		**1,505.2**
Willingness to pay--low scenario				
Fatalities	6097.5			6097.5
Injuries:				
Major	13.7	213.8		227.5
Minor	13.6	512.0		525.6
Minimal	0.4	26.7		27.2
Total disability	3.1	64.0		67.1
Partial disability	17.1	422.2		439.3
HUMAN SUB-TOTAL	**6,145.4**	**1,238.8**		**7,384.2**
Willingness to pay--high scenario				
Fatalities	16016.1			16016.1
Injuries:				
Major	68.4	1069.2		1137.6
Minor	68.1	2559.8		2627.9
Minimal	2.2	133.5		135.8
Total disability	15.3	320.2		335.6
Partial disability	85.5	2111.3		2196.7
HUMAN SUB-TOTAL	**16,255.7**	**6,194.0**		**22,449.6**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

Manitoba				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	110.8			110.8
Injuries:				
Major	0.5	5.5		6.0
Minor	0.2	9.2		9.4
Minimal	0.0	0.2		0.3
Total disability	1.3	20.3		21.6
Partial disability	2.3	45.3		47.5
HUMAN SUB-TOTAL	**115.1**	**80.5**		**195.5**
Willingness to pay--low scenario				
Fatalities	755.5			755.5
Injuries:				
Major	2.8	30.7		33.5
Minor	1.7	69.8		71.5
Minimal	0.0	3.2		3.2
Total disability	0.6	8.9		9.4
Partial disability	2.9	57.5		60.4
HUMAN SUB-TOTAL	**763.4**	**170.1**		**933.5**
Willingness to pay--high scenario				
Fatalities	1984.5			1984.5
Injuries:				
Major	13.8	153.6		167.4
Minor	8.3	349.0		357.3
Minimal	0.1	16.0		16.1
Total disability	2.8	44.4		47.2
Partial disability	14.4	287.7		302.1
HUMAN SUB-TOTAL	**2,023.9**	**850.7**		**2,874.6**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

Saskatchewan				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	141.0			141.0
Injuries:				
Major	0.3	5.7		6.0
Minor	0.2	4.4		4.6
Minimal	0.0	0.1		0.1
Total disability	0.8	16.6		17.4
Partial disability	1.6	32.3		33.8
HUMAN SUB-TOTAL	**143.8**	**59.0**		**202.9**
Willingness to pay--low scenario				
Fatalities	961.6			961.6
Injuries:				
Major	1.5	31.8		33.3
Minor	1.4	33.5		34.8
Minimal	0.1	1.3		1.4
Total disability	0.3	7.3		7.6
Partial disability	2.0	41.0		43.0
HUMAN SUB-TOTAL	**966.8**	**114.8**		**1,081.6**
Willingness to pay--high scenario				
Fatalities	2525.7			2525.7
Injuries:				
Major	7.3	159.1		166.3
Minor	6.8	167.4		174.2
Minimal	0.5	6.3		6.9
Total disability	1.7	36.3		38.0
Partial disability	9.9	205.0		214.9
HUMAN SUB-TOTAL	**2,551.9**	**574.2**		**3,126.0**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

Alberta				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	433.2			433.2
Injuries:				
Major	2.0	35.5		37.5
Minor	1.5	37.6		39.1
Minimal	0.0	1.1		1.1
Total disability	5.7	114.1		119.9
Partial disability	11.1	235.7		246.8
HUMAN SUB-TOTAL	**453.5**	**424.1**		**877.7**
Willingness to pay--low scenario				
Fatalities	2953.4			2953.4
Injuries:				
Major	11.1	198.8		209.9
Minor	11.5	286.6		298.1
Minimal	0.4	14.1		14.5
Total disability	2.5	49.9		52.4
Partial disability	14.1	299.7		313.8
HUMAN SUB-TOTAL	**2,992.9**	**849.1**		**3,842.0**
Willingness to pay--high scenario				
Fatalities	7757.5			7757.5
Injuries:				
Major	55.6	993.8		1049.4
Minor	57.3	1433.2		1490.5
Minimal	2.0	70.6		72.6
Total disability	12.6	249.4		262.0
Partial disability	70.5	1498.6		1569.1
HUMAN SUB-TOTAL	**7,955.4**	**4,245.6**		**12,200.9**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

British Columbia				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	481.3			481.3
Injuries:				
Major	1.3	23.2		24.5
Minor	0.9	35.3		36.2
Minimal	0.0	0.6		0.6
Total disability	3.6	79.6		83.2
Partial disability	6.8	170.7		177.5
HUMAN SUB-TOTAL	**493.9**	**309.4**		**803.2**
Willingness to pay--low scenario				
Fatalities	3281.5			3281.5
Injuries:				
Major	7.1	129.8		136.9
Minor	7.0	268.7		275.7
Minimal	0.2	7.6		7.8
Total disability	1.6	34.8		36.4
Partial disability	8.6	217.0		225.6
HUMAN SUB-TOTAL	**3,306.0**	**658.0**		**3,964.0**
Willingness to pay--high scenario				
Fatalities	8619.4			8619.4
Injuries:				
Major	35.5	649.2		684.7
Minor	35.1	1343.6		1378.7
Minimal	0.8	38.1		38.9
Total disability	7.8	174.0		181.8
Partial disability	43.2	1084.8		1128.1
HUMAN SUB-TOTAL	**8,741.9**	**3,289.8**		**12,031.6**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

Nunavut				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	1.1			1.1
Injuries:				
Major	0.0	0.1		0.1
Minor	0.0	0.1		0.1
Minimal	0.0	0.0		0.0
Total disability	0.0	0.3		0.3
Partial disability	0.0	0.6		0.6
HUMAN SUB-TOTAL	**1.2**	**1.1**		**2.3**
Willingness to pay--low scenario				
Fatalities	7.6			7.6
Injuries:				
Major	0.0	0.7		0.7
Minor	0.0	0.5		0.6
Minimal	0.0	0.0		0.0
Total disability	0.0	0.1		0.1
Partial disability	0.0	0.8		0.8
HUMAN SUB-TOTAL	**7.7**	**2.1**		**9.9**
Willingness to pay--high scenario				
Fatalities	20.0			20.0
Injuries:				
Major	0.1	3.4		3.5
Minor	0.2	2.6		2.8
Minimal	0.0	0.1		0.1
Total disability	0.0	0.7		0.7
Partial disability	0.2	3.9		4.1
HUMAN SUB-TOTAL	**20.5**	**10.7**		**31.2**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

Northwest Territories				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	3.4			3.4
Injuries:				
Major	0.0	0.2		0.2
Minor	0.0	0.1		0.2
Minimal	0.0	0.0		0.0
Total disability	0.0	0.5		0.6
Partial disability	0.1	1.0		1.1
HUMAN SUB-TOTAL	**3.5**	**1.9**		**5.4**
Willingness to pay--low scenario				
Fatalities	22.9			22.9
Injuries:				
Major	0.0	1.0		1.0
Minor	0.2	1.0		1.2
Minimal	0.0	0.0		0.0
Total disability	0.0	0.2		0.2
Partial disability	0.1	1.3		1.4
HUMAN SUB-TOTAL	**23.2**	**3.6**		**26.8**
Willingness to pay--high scenario				
Fatalities	60.1			60.1
Injuries:				
Major	0.0	5.2		5.2
Minor	1.2	4.8		6.1
Minimal	0.0	0.2		0.2
Total disability	0.0	1.2		1.2
Partial disability	0.4	6.6		7.0
HUMAN SUB-TOTAL	**61.8**	**18.1**		**79.9**

Exhibit D-1 Value of Human Consequences of Collisions by Jurisdiction Based on Alternate Assumptions (cont'd)

Yukon				
	Collision Severity			
	Fatal	Injury	PDO	TOTAL
Discounted Future Earnings				
Fatalities	5.6			5.6
Injuries:				
Major	0.0	0.3		0.3
Minor	0.0	0.3		0.3
Minimal	0.0	0.0		0.0
Total disability	0.0	0.8		0.9
Partial disability	0.1	1.7		1.8
HUMAN SUB-TOTAL	**5.8**	**3.1**		**8.8**
Willingness to pay--low scenario				
Fatalities	38.2			38.2
Injuries:				
Major	0.1	1.6		1.7
Minor	0.0	2.2		2.2
Minimal	0.0	0.0		0.0
Total disability	0.0	0.4		0.4
Partial disability	0.1	2.1		2.2
HUMAN SUB-TOTAL	**38.4**	**6.3**		**44.7**
Willingness to pay--high scenario				
Fatalities	100.2			100.2
Injuries:				
Major	0.6	7.8		8.4
Minor	0.2	11.0		11.2
Minimal	0.0	0.2		0.2
Total disability	0.1	1.8		1.9
Partial disability	0.5	10.6		11.1
HUMAN SUB-TOTAL	**101.6**	**31.4**		**133.1**

Appendix E

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APPENDIX E: REFERENCES

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