University of Manitoba

The Development and Application of a Model to Investigate Road Safety Issues.

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A Thesis Submitted to the
Faculty of Graduate Studies in Partial Fulfilment
of the Requirements for the
Degree of Doctor of Philosophy

Department of Civil Engineering
Faculty of Engineering

Winnipeg, Manitoba

1993

ISBN 0-315-81687-2

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THE DEVELOPMENT AND APPLICATION OF A MODEL TO INVESTIGATE ROAD SAFETY ISSUES

BY

HAROLD S. DALKIE

A Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

To H.A.D.

ACKNOWLEDGMENTS

The success of this research effort was due to the support and cooperation of a number of organizations and individuals. Specifically, major contributions were made by the Royal Canadian Mounted Police, the City of Winnipeg Police Department, the Office of the Chief Medical Examiner, the Manitoba Health Services Commission, the Manitoba Public Insurance Corporation, the Manitoba Motor Vehicle Branch, the Manitoba Department of Highways, the City of Winnipeg Streets and Transportation Department and the Road Safety and Motor Vehicle Regulation Directorate, Transport Canada. These efforts were much appreciated.

I would also like to thank my mentor, Dr. G.W.N. Mulligan, M.D., F.R.C.S.(C) for instilling and then nurturing in me the importance of this particular field of multi-disciplinary research. In addition, this effort was made possible through the cooperation and support of family, friends and colleagues including Paul, Alan, Karen, Carole, Ken, Robert, Peter, Jake, Karen and Line.

Ultimately, I owe the largest depth of gratitude and thanks to my wife Monica whose life has been most greatly impacted by this effort and whose support was most essential and valued.

ABSTRACT

The objective of this research was to develop a model to investigate basic road safety issues so that the incidence and severity of motor vehicle collisions may ultimately be reduced. This objective was achieved by developing a model which efficiently identifies and assembles strategic information related to motor vehicle collisions and associated trauma, develops the ability to complete suitable analyses of the data, and provides the framework to identify, define, investigate or resolve a range of road safety issues. Development of the model was based on the requirement that use of existing data sources should be maximized, an appropriate analysis system must be available, an integrated systems approach to road safety should be implemented, the model must be feasible and sustainable and it must have general applicability.

Following a critical review of options available to construct such a model, an approach was selected which integrates three distinct components: a system to provide limited factual data describing the occurrence of motor vehicle collisions, a system to investigate the patterns of injuries sustained by various road users; and an information system based on the completion of in-depth collision investigations to provide a comprehensive understanding of specific types of collisions. Three specific sources of primary information were used; data from police-based investigation programmes, information from hospital-based programmes and knowledge obtained through the completion of in-depth collision investigations.

Given these primary sources of data, a model was developed by creating an analysis system using police-based data to provide general collision information; introducing new information into the hospital-based data-collection programme to enable the completion of analyses based on injury severity; and creating a framework from which in-depth collisions could be usefully completed within a broader evaluation effort.

Once the model was developed, it was then applied to investigate two basic safety issues; the introduction of mandatory seat-belt-use legislation and the introduction of motorcycle helmet-use legislation in Manitoba. Based on this application, injury and fatality trends associated with motor vehicle occupants and motorcyclists were examined; injury patterns including the distribution and severity of injuries sustained by motor vehicle occupants and motorcyclists were quantified; a significant change in the number of head injuries sustained by motorcyclists attributable to the introduction of mandatory-use legislation was determined; and important limitations of seat-belt use

were documented. Together, application of the model provided a comprehensive assessment of a major legislative intervention in the Province of Manitoba; the introduction of mandatory seat belt- and motorcycle helmet-use legislation.

It was concluded that this successful evaluation was only possible because the model used was comprehensive and included a variety of integrated components. Although this application was used to validate the model, it is recognized that this model is suitable for applications addressing a range of other safety issues and problems in other jurisdictions where basic safety-related data collection programmes exist.

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Chapter 1. Introduction

1.1 Research Need

Each year, road traffic accidents account for over 90% of all transportation fatalities which occur in Canada. In 1991, 3,684 persons were fatally injured in motor vehicle collisions while over 248,000 persons sustained non-fatal injuries. In Manitoba, 119 persons died and some 15,000 were injured. Despite the considerable societal cost associated with this trauma, and despite the four to five million dollars in public funds spent annually on road safety research in Canada (Barton et al,1990), knowledge regarding fundamental safety issues is often incomplete, based on intuition, or ignored when considering current practice. For example, Hauer reminds us that many current traffic safety standards and practices have evolved without a foundation of knowledge and that often the safety-related outcomes of engineering decisions are not known while, at other times, some knowledge exists but is not used (Hauer,1988).

This situation can be attributed, in part, to the less quantifiable and multi-disciplinary nature of safety, the lack of a formal academic infrastructure to deliver expertise in this area and the failure to develop a comprehensive information system which may be used to consider basic road safety-related problems and issues. These include such basic issues as effectiveness of legislative interventions; understanding of injury mechanisms and human tolerance to injury; development of vehicle-safety standards; specific road design criteria; and, counter-measure development programmes.

Given the catastrophic consequences of motor vehicle collisions and the need to consider a comprehensive or integrated approach to road safety issues, this research was undertaken.

1.2 Research Purpose and Objectives

The purpose of this multi-disciplinary research was to develop a model which can be used to increase the level of knowledge describing safety issues so that the incidence and severity of motor vehicle collisions may ultimately be reduced.

The specific objectives are to investigate information systems which are available to quantify and understand the characteristics of motor vehicle collisions; to propose a general model which can be used to investigate road safety issues concerning man, the vehicle and the environment in which the two interact; and to demonstrate the utility of the model by applying it to a specific issue.

1.3 Significance of this Research

One component of road safety research currently being conducted in Canada is a national data collection programme supported by Transport Canada involving detailed investigation of a sample of collisions. A comprehensive infrastructure recording police-reported motor vehicle collisions is also in place nationally while registries documenting usage of the health care system by persons injured in a motor vehicle collision also exists in the provincial health services commissions and in some health care centres.

While considerable financial and other resources continue to be spent on these primary data collection efforts, the knowledge actually derived is far less than desirable. For example, within the provincial government in Manitoba, even the most rudimentary ad hoc analyses of information describing police-reported collisions often requires the assistance of computer programmers involved in the maintenance of mainframe computer systems. As a result, the complexity of analysis generated by safety analysts is typically limited and is generally focused towards the production of standard annual summaries. With regard to the national effort undertaken by Transport Canada, only a marginal amount of analysis has been undertaken since detailed collision investigation programmes were initiated in the early 1970's.

This research demonstrates how these under-utilized sources of information can be modified and integrated into a multi-faceted model to substantially increase the level of knowledge related to fundamental issues and provide an opportunity to address these issues. To demonstrate the effectiveness of this model, it was applied to investigate the causal relationship between a specific safety related intervention and an anticipated outcome. This application was chosen because previous attempts to quantify the impact of specific safety-related legislative interventions have often not met with much success; and while these interventions, such as mandatory seat-belt-use laws, should intuitively produce a positive effect (ie. mitigate the severity of motor vehicle collisions), the ability to quantify the effects has generally been less than expected (Frieland,1987).

It is anticipated the this research could provide a significant input into the evolution of safety research activities in general and assist in focusing of future resources designed to reduce the incidence and severity of road trauma.

1.4 Thesis Organization

Chapter 2 presents the formulation and rationale of a model to investigate road safety issues. To provide the overall framework from which this model evolved, typical safety-related information sources are first described. These include the police-based collision investigation and reporting system, a hospital-based injury system and an in-depth investigation programme completed by specially-trained analysts. Given these basic sources of information, several strategic options for the development of an appropriate model are explored and evaluated with respect to the ability to meet specific criteria.

The recommended model is then described in terms of three informational components. Each of these three components is described by documenting the primary data typically available, summarizing the analysis techniques necessary to convert the best existing data into a usable format, assessing the reliability of the data, and providing a sample of the results which can be derived. Finally, the overall utility of the model is demonstrated by illustrating how use and integration of each component can provide a fundamentally superior understanding of basic road safety issues when compared to the more usual "single-source" analysis.

Following this overview, the application of the model is then presented in Chapter 3 by evaluating the effectiveness of mandatory seat-belt-use legislation and in Chapter 4 by evaluating the effectiveness of motorcycle helmet-use legislation in Manitoba. In this evaluation, a distinction is made between the results of the proposed integrative model and results obtained from single-source analyses. The superiority of the proposed model is clearly demonstrated considering this particular application.

Chapter 5 provides a summary of some basic issues including the applicability of the model, the need for an integrated approach to safety research, and an assessment of changes to existing safety programmes or requirements of new projects which should be implemented. Chapter 6 discusses the significance of this research and the practical problems it resolves. The relevant literature describing issues involved in the development and application of the model has been reviewed and is incorporated into the discussion of specific issues throughout the thesis.

Chapter 2. Model Development

2.1 Concept of a Safety Model

For the purposes of this research, a safety model is defined as a basic framework which recognizes the multi-disciplinary nature of safety research and uses existing road safety programmes to provide:

- the means to efficiently identify and assemble strategic information related to motor vehicle collisions and associated trauma,
- the ability to complete suitable analyses of the data, and
- the knowledge required to identify, define, investigate or resolve a range of road safety issues.

To describe development of the model, an overview of existing practices in specific data collection programmes is first presented. Strategic options available to develop the model are subsequently identified and evaluated. A recommended approach is then detailed with an emphasis on what practical considerations should be recognized when applying the model in a particular jurisdiction. Throughout the discussion, substantial deficiencies with existing data-collection activities and analysis capabilities are emphasized.

2.2 **Existing Information Programmes**

2.2.1 Overview

Prior to considering the development of a comprehensive model, existing sources of information available to characterize road-safety issues were examined. These include data collection programmes which have been developed for the sole purpose of examining road safety issues (through federal and provincial sponsorship) in addition to injury-data-collection programmes sponsored by the provinces. Specifically, these include:

- traffic accident collision investigations conducted by law enforcement agencies;
- data collection programmes characterizing injury profiles of victims treated in hospital following a motor vehicle collision; and
- in-depth investigations conducted by specialized and highly skilled collision investigators.

The following discussion first characterizes each programme. The typical use of the information collected is then described before a thorough discussion of the evolution of each programme in the United States, Canada and Manitoba is presented. Limitations of these general programmes or of specific practices are then identified. (Additional emphasis is placed on characterizing and identifying the fundamental limitations of previous in-depth investigation programmes because of the difficulty which would be encountered if this type of programme was to be integrated within a general model.)

2.2.2 Police-Based Investigation Programmes

Police-based programmes which use data collected from the reporting of motor vehicle collisions to law enforcement agencies are the simplest and most common type of road-safety information programme. This programme (Level 1) typically provides a general overview of all collisions occurring in a specific geographic area. Data collected include primarily factual information such as the time and location of the accident; the number of persons injured; the type of vehicles involved; and the type or configuration of the collision.

The information collected as part of this programme is often used to:

- assess the magnitude of general issues related to motor vehicle collisions and injuries sustained by involved persons;
- monitor trends or changes in the number and type of collisions which occur over a period of time;
- quantify other observations and findings resulting from other more detailed data collection exercises; and
- support and evaluate provincial or federal laws concerning road users as well as safety counter-measure-development initiatives.

A general observation regarding many Level 1 data collection programmes involves the inconsistent quality and reliability of the data. This can be attributed to numerous factors including the types of questions to be answered, the reporting process and the lack of an appropriate monitoring and feedback system to examine the information forwarded by the investigating police officer. For example, there is typically no automated verification procedure used during input of the data. In addition, sufficient human resources are also not available to thoroughly complete an individual investigation, verify driver-reported information and collect very subjective data such as the probable actions of the driver immediately preceding the collision. Analysis of this type of database has been reported by Mason (Mason et al,1989) where police reports describing collisions involving large trucks were found to contain misleading information including basic coding errors.

Recognizing these fundamental difficulties in the reliability of Level I police-reported collision data, any analysis must proceed with caution. Since reliability of the data is largely variable specific, some analyses are expected to yield credible results while others almost certainly would not be appropriate. In addition, data reliability can also be directly related to the type of collision, particularly the severity of a collision. Whereas a specific variable such as the precise geographic location of a collision may be determined accurately for collisions involving a fatally injured person, that variable may be less reliable when considering collisions involving an injury and even more questionable when considering property-damage-only collisions.

In the United States, Level 1 programmes exist in each State to collect police reports and enter the information into automated databases. These databases are subsequently used by state agencies and research organizations to fulfil specific needs. While the National Highway Traffic Safety Administration (NHTSA) attempted to collect state files and assemble a national collision database during the 1970's, the effort was aborted in favour of programmes considering only fatal accidents (the Fatal Accident File and Fatal Accident Reporting System). However, with more uniform data collection protocols in place today and with the evolution of data processing techniques, the use of state accident files as part of a national programme is now considered to be simpler and easier to complete (Lee and Fell,1988). Recently, NHTSA revised its data collection effort and introduced a new programme based on the Level 1 police accident reporting system, the General Estimates System (GES). This programme is based on a representative sample of police-reported collisions occurring throughout the United States (approximately 40,000 collisions per year are extracted from state police reports at 60 locations through the United States). The system is designed to yield a sample size which is sufficiently large enough to perform statistical analyses with known estimates of error.

In Canada, police-based programmes are typically in place at both municipal and provincial levels where traffic accident reports completed by local police forces are coded and entered into automated databases. In addition, the database maintained by each province is forwarded to Transport Canada where common data from all provinces is aggregated into a single data file (the Traffic Accident Information Data system or TRAID file). This file has become the principal statistical source of the Road Safety Directorate's safety policies and programmes (Road Safety and Motor Vehicle Regulation Directorate,1989). However, because of the nature of the data collection protocol, numerous limitations have been noted (Barton et al,1990) including:

- "reportable" collisions are defined under the Highway Traffic Act in each province and, therefore, are variable from province to province;
- data collection forms used by the various agencies are not identical;
- a unique vehicle identification number is not included; and
- the level of reporting of collisions is not uniform.

Given these difficulties, the Canadian Conference of Motor Transport Administrators (CCMTA) is currently undertaking a review of various means to increase the quality and reliability of this effort.

In Manitoba, the Level 1 police accident reporting programme and data collection exercise provides certain information on all collisions involving an injury or a vehicle sustaining damage exceeding a specified amount. The Manitoba Motor Vehicle Branch maintains a provincial database including all accidents occurring in the Province whereas the City of Winnipeg Streets and Transportation Department maintains a similar database which includes all police-reported collisions occurring in the City of Winnipeg. This apparent duplication of effort results from the different needs of both departments. For example, the City of Winnipeg Streets and Transportation Department typically uses environment-related data to characterize accidents with specific attention being paid to the precise location of the incident. The focus on these data elements is necessary because of the Department's more limited mandate for safety issues and because the data is most often used to calculate warrants for traffic control devices and other roadway improvements. As a result, some data elements such as the location of the collision are captured in a more precise and descriptive manner than the location coded by the provincial agencies. These agencies have a larger mandate including driver- and vehicle-related issues. As a result, these needs often do not necessitate the level of precision regarding location in an urban environment than that required by the local municipality.

2.2.3 Hospital-Based Programmes

Hospital-based programmes focus upon specific health care regions which assemble injury data from a number of units within a specific geographic area. They are part of the health-care-delivery system and often used for a multitude of different clinical research and epidemiological studies in both private and public health care environments. However, information from this source can also provide detailed injury data relating to trauma sustained by persons involved in motor vehicle collisions.

By using a system based on medical records within the scope of road safety research activities, applications can be undertaken to:

- address issues related to the health-care-delivery system and the incidence of motor vehicle crash injuries;
- evaluate measures designed to affect the frequency or distribution of injuries; or
- identify trends in motor vehicle injuries which should be recognized and further examined.

In addition, a comprehensive injury database can be used to provide an assessment of the statistical validity of hypotheses proposed through the completion of research in other areas such as multi-disciplinary collision investigations. In this example, anecdotal evidence or conclusions drawn from very small samples of data can be confirmed or rejected by providing a more comprehensive quantitative analysis using an alternative data source.

Unlike police-based traffic accident data, hospital-based injury data is generally very reliable. For example, in Manitoba, the database maintained by the Manitoba Health Services Commission (MHSC) is generally complete, continuously maintained and is considered highly reliable when appropriately used (Roos et al,1979). While it may be of somewhat higher quality than other North American databases (Johnson et al,1984), other Canadian provinces, such as Saskatchewan, probably have equally good data (West et al,1985). Specific studies on the Manitoba data have indicated that coding errors are minimal (Roos et al,1985), that this database is ideal for focusing on health outcomes characterized by major events, such as hospitalization (Roos et al,1987) and that health care researchers should seriously consider such sources of information prior to instituting additional primary data collection programmes.

However, a major limitation of the use of this type of database is the inability to automatically link information describing the nature of the collision because of the danger of breaching the rules of confidentiality and inconsistencies associated with the hospital- and police-based data-collection programme.

To address the problems typically encountered with regard to the confidential nature of the data being assembled in an automated format, numerous researchers (primarily those involved in the medical research field) have manually merged hospital-injury information with police collision-reported data describing specific events. These efforts have led to investigations related to alcohol involvement (Waller et al,1989), collisions involving bicyclists (Agran et al,1990), the effectiveness of occupant restraint devices (States et al,1989), injury severity coding systems (Yates et al,1989), (Copes et al,1989), injury patterns (Siegel et al,1989), collisions involving motorcyclists (Shankar et al,1990), elderly drivers (Sjogren et al,1990), and accurate trauma care (Cooper et al,1990).

While there has been some increase in these types of programmes in the United States and in Europe, few major activities have been successfully implemented or are being actively maintained in Canada. In Manitoba, such a project involving the manual linkage of hospital-based injury information with numerous other sources of data (including police-reported, ambulance, insurance and follow-up medical data) was undertaken during the early 1980's under the auspices of a medical doctor, Dr. C. Burns. This laborious process resulted in few published reports or papers and was subsequently terminated in 1986.

2.2.4 In-Depth Collision Investigation Programmes

In-depth collision investigation programmes use primary information obtained as part of a Level 1 investigation but also include a more comprehensive data-collection component and detailed analysis of the collision based on information compiled by collision reconstruction experts. Such programmes include level 2 and Level 3 collision investigations.

While data collected as part of both programmes include a comprehensive assessment of environmental, vehicular and human factor data associated with the pre-crash, crash and post-crash phases of the collision, the primary consideration of most Level 2 studies is generation of estimates that are representative of a larger universe of collisions. Level 2 programmes typically involve multi-disciplinary investigation teams which study a probability sample of injury crashes amounting to 100 to 150 specific collisions annually. Compared to Level 1 police investigations, they are completed to a greater level of accuracy, typically initiated within 72 hours of the accident, but require an additional primary data collection system to be implemented.

Level 3 investigations also involve multi-disciplinary research teams which typically include persons with backgrounds in engineering, medicine and/or the social sciences. However, the investigations are more exhaustive in nature and include a comprehensive case narrative describing all salient details of the incident. Since collisions investigated are few in number and are not randomly selected, the data file constructed cannot be used to generate general estimates nor determine overall trends. Typically, only 15 to 20 Level 3 investigations can be completed annually by a single research team. In contrast to Level 2 studies, this secondary investigation programme is initiated within hours of the incident, before vehicles are moved from the scene. Investigations contain an exhaustive amount of detail and are, without question, the most precise form of collision data collection exercise. They are also the most time-consuming and costly.

The information collected as part of in-depth collision investigation programmes often relates to:

- special crash types or configurations such as school bus accidents or other highly-focused studies where a particular variable is singled out for assessment;
- evaluation of existing vehicle safety standards;
- determining the need for new vehicle standards; and
- understanding the complex relationship between vehicle crash-worthiness and survivability.

These programmes have been undertaken and continue to be completed in Canada, the United States, Europe and other countries world-wide. During the late 1960's and early 1970's, Level 3 collision investigation programmes were initiated at various sites throughout the United States and were sponsored by the National Highway Traffic Safety Administration (NHTSA). Information was collected by University-based multi-disciplinary teams (with engineering and medical expertise), all with formal collision investigation training. Since there was no prescribed sampling programme and because research groups tended to select cases based on personal bias (ie. fatal collisions, collisions involving alcohol etc.), the databases constructed were not suitable for statistical analysis. However, these studies did show a correlation between certain collision configurations and injury profiles and provided feedback from real-world crashes concerning the dynamic performance of safety devices. Additional programmes were subsequently introduced where a protocol was established so that individual groups were directed to investigate particular collision configurations. While these investigations produced useful information on selected types of accidents, they, too, did not yield statistically significant or representative results.

In the late 1970's, implementation of the Level 2 National Accident Sampling System (NASS) marked the turn towards establishing a nationally representative database which facilitated:

- monitoring of national trends;
- identification of basic issues;
- development of new safety counter-measures; and
- evaluation and formulation of existing and new vehicle standards.

The methodology introduced as part of the NASS programme was based on a representative sample design with cases stratified to represent urban, suburban and rural collisions. While the resultant collision database has been described as one of the most important achievements in crash injury research, collision energy management researchers and specialists in the bio-mechanics of trauma subsequently demanded more detailed information on certain types of crashes (ie. side impacts), as well as data on more serious non-fatal collisions (Lee and Fell,1988).

As part of the evolution of collision data collection activities supported by NHTSA, new data collection safety programmes were initiated in the late 1980's and are now comprised of two distinct efforts. The first is essentially a Level 1 investigation programme as previously described: the General Estimates System (GES); while the second is a Level 2 programme: the Crashworthiness Data System (CDS). The objectives of the GES programme include the assessment of national collision characteristics while the CDS focuses on a subset of all collisions representing more severe outcomes. In addition, a third programme considers special investigations regarding specific types of collisions (ie. target/descriptive analyses) where a factor or variable of interest is examined and a small subset of data recorded. These studies are mostly observational in nature with limited or no statistical methods available to measure accuracy or draw inferences. Approximately 8,000 collisions are investigated annually by 36 NASS teams.

The first in-depth collision investigations conducted in Canada as part of a national programme were initiated during the early 1970's and paralleled similar Level 3 investigations then being completed in the United States. These Multi-Disciplinary Accident Investigation (MDAI) programmes were developed and supported by Transport Canada and were completed at numerous Universities across Canada. Similar to the U.S. programme and other programmes which evolved in Sweden, England, Australia, and Germany, much of the collision information was compiled by engineering or medical professionals with particular interests in the field of road safety. Results of these Canadian investigations were added to the collision database maintained at the University of Michigan in the United States.

Not surprisingly, the Canadian effort faced the same problems as comparable programmes in the United States. Without the benefit of a statistically valid survey design or a probability-based sampling method, all findings and observations lacked statistical significance and could not be related to the overall nature of all collisions. In the late 1970's, the Level 3 MDAI programme was aborted and a national Level 2 programme which focused on Light Truck- or Van-involved collisions was developed. Unlike the United States where the overall data collection programme was expanded and implemented largely within the private sector, the programme in Canada remained limited in size and was completed by University-based groups. Eventually, a database of approximately 2,000 collisions was constructed and maintained by the Road Safety and Motor Vehicle Regulation Directorate before the programme was terminated in 1984. Following the completion of this undertaking, a second national Level 2 programme was introduced. This Passenger Car Study (PCS) has focused on collisions involving at least one passenger car and is currently being conducted for Transport Canada. As part of these national Level 2 collision investigation programmes, approximately 1,500 incidents are investigated annually. The University of Manitoba participated in this programme through the Road Safety Research Unit which was affiliated with the Faculties of Engineering and Medicine as well as the Transport Institute.

Based on information from the Road Safety and Motor Vehicle Regulation Directorate (IBI Group,1989), the major types of research in which this Level 2 PCS or LTV data has been used include the following:

- abdominal injury patterns of belted occupants,
- collisions involving seat back damage,
- statistics on vision limitations, injury source, restraint hardware damage and steering column damage,
- fires in specific types of trucks,
- severity of occupant injuries relative to restraint use and seating position,
- rear seat ejections and fatalities relative to restraint use,
- fuel tank integrity loss and vehicle fires,
- the relationship between collision type, driver age, alcohol involvement, restraint use and injury severity,
- identification and analysis of road crashes approximating proposed test methods for side impact protection standards, and
- injury mechanisms in roll-over collisions.

Notwithstanding these research efforts, and the fact that expenditures for this programme represent approximately half of the Road Safety Regulation Directorate's annual research budget, the amount of <u>analysis</u> actually completed using this information has been limited (Road Safety and Motor Vehicle Regulation Directorate,1989). Problems with the sampling method, the quality and uniformity of the data as well as the availability of appropriate weighting factors have all contributed to the limited analysis done to date. For example, the PCS was operational well before a coding manual (Dalkie et al,1986) was developed to standardize procedures and ensure data quality and uniformity. In addition, it has been concluded that little use of the data is made by the Directorate when developing new regulations or amendments (IBI Group,1989). This was attributed to the limited number of statisticians available to analyze the data, lack of appropriate weighting factors and lack of co-ordination between accident investigation activities, analysis of the Traffic Accident Information Data system (TRAID) and regulatory development activities of the Directorate.

2.3 Strategic Options

Given the preceding description of existing information programmes available to develop a more comprehensive road-safety model, some basic strategic directions or options for this research can be considered. However, it should be recognized that the consideration of potential opportunities should recognize that, while existing programmes must change, the change must be reasonable. An important objective in assessing each potential option was that the safety model should result in a substantial increase in knowledge without a comparable increase in resources required to obtain that knowledge. To meet this objective in addition to providing an effective and usable framework to evaluate road-safety issues, a model should be based on the following criteria:

Use of existing data sources should be maximized.

At this time, numerous data collection programmes are in place to collect data describing motor vehicle collisions and the trauma associated with these events. These efforts must be utilized to their fullest extent prior to undertaking a new data collection activity or fundamentally changing existing programmes.

Appropriate analysis systems must be in place.

While an extensive amount of information related to motor vehicle collisions and associated trauma is currently being collected, comparatively little analysis related to road safety is being performed. To maximize the utility of these existing data collection activities, appropriate analysis techniques and procedures must be used. In addition, these techniques and procedures must be appropriate for practical use by agencies presently responsible for the design and implementation of road safety programmes.

An integrated systems approach to road safety should be implemented.

The approach must acknowledge the multi-disciplinary nature of motor vehicle collision investigations and recognize the need to integrate data collection and data analysis efforts. This includes the ability to assess road safety issues from the perspective of a traffic engineer, a specialist in bio-mechanics and human tolerance to injury, a social scientist, a statistician or a medical practitioner.

This may also include the examination of issues based on the practical analysis of specific real-world collision events or the more analytical manipulation of aggregate data describing a large number of collisions. Using this approach, limitations of basic data will more likely be recognized and the ability to infer conclusions related to the overall collision environment will be enhanced.

The system must be feasible and sustainable.

At a time when resources are limited, the approach should be cost effective, suitable and sustainable during periods of reduced economic activity. Rather than introducing a concept to investigate a particular issue and later not be useful, the model should provide a framework for identifying the need for further research in a specific area (ie. human, vehicle or environmental factors).

The model must have general applicability.

It is essential to recognize that the concept of a safety model developed through this research must be applicable in any jurisdiction where basic road-safety-data-collection programmes exist. The model must not be exclusive or only be readily applied to a few geographic areas.

In principle, this safety model can either be constructed by focusing on a single data collection activity and enhancing that system or it can be developed by retaining the basic structure of each data collection entity and focusing on integrating these essentially independent sources of information. Based on this assumption, five possible strategic options to develop a general road safety model were considered. These options were developed following the examination of road-safety-delivery programmes in place throughout Canada, in the United States and other jurisdictions.

The options considered were:

- Option 1. Expand the standard police-based collision reporting programme.
- Option 2. Expand the hospital-based programme to include police-reported accident information.
- Option 3. Expand the programme of in-depth collision investigations.
- Option 4. Link existing information systems through creation of a single automated system describing specific incidents.

- Option 5. Integrate existing information programmes through a coordinated analysis framework without merging data describing specific incidents.

These are described as follows:

Option 1. Expand the standard police-based collision reporting programme.

With this Option, the primary source of information would be the existing police reporting programme but data collection, processing and analysis techniques would be substantially revised to:

- obtain additional strategic information related to motor vehicle collisions and associated trauma,
- complete suitable analyses of the data, and
- permit the identification, definition, investigation or resolution of a range of fundamental road safety issues.

This Option would involve review of the quality and utility of data elements currently collected, identification of new elements to be obtained (ie. measures of collision severity and more detailed injury severity data), modification of the data collection protocol and direction of additional resources toward this data collection activity. To facilitate processing and analytical techniques, a quality control and data verification system would be needed, and more appropriate analysis techniques would have to be developed then implemented to process and analyze data collected. In addition, since this undertaking would require additional training of investigating police officers and collection of additional data elements (while still maintaining coverage of all collisions), a major increase in resources would be required.

Other major implications of adopting this Option as the framework for a comprehensive safety model are described in Table 2.1. These impacts are summarized based on the criteria used to evaluate the possible alternatives. The criteria include how existing data sources are used or not used, whether an appropriate data system is in place or can be used, whether an integrated approach would be utilized, whether the Option is feasible over the long-term, and whether the model could be more generally applied to a number of different jurisdictions.

Criteria	Implications
Maximize the use of existing data sources.	The existing police reporting system would be used, however major changes would be required to facilitate the collection of additional data elements so that the model could be used for more detailed analyses and assessment of basic safety issues. Use of other automated data sources describing specific data such as detailed injury data would not be utilized.
Use an appropriate analysis system.	A new system to verify and ensure the quality of specific data elements would be required. Due to the limited scope of data elements captured, an appropriate analysis system could be constructed without great difficulty.
Implement an integrated approach.	The approach is focused on statistical analysis of data with less regard for detailed injury information or a comprehensive understanding of complex relationships related to such matters as collision causation or crash survivability.
Ensure the option is feasible over the long term.	Fundamental changes in the way police collision data is collected, processed and analyzed would be required. Substantial additional financial and other resources would be required. Data collection for the purpose of safety research would become an even greater component of the total police effort.
Ensure the model can be more generally applied.	Cooperation with numerous police jurisdictions would be required. If implemented on a larger or national scale, standardization would be extremely difficult due to local issues, different jurisdictions as well as conflicting and competing objectives.

Table 2.1 Implications of developing a safety model based on expansion of the standard police-based collision reporting programme (Option 1).

Option 2. Expand the hospital-based programme to include police-reported accident information.

This Option would focus on the data collection system developed as part of the health-care-delivery system. The approach would use this generally high quality system and complementary analysis infrastructure. However, while detailed injury data could be provided, the sample of collisions would be restricted to those where a person was injured and received treatment in hospital.

To integrate information related to the collision event, data obtained through standard police investigations could be manually added to the database. While detailed injury data would be available for analysis purposes, certain key data elements such as collision severity and occupant restraint use would still be incomplete or unreliable. In addition, such a programme would fundamentally change the scope of existing hospital-based data collection programmes and would necessitate cooperation between local health care centres and police detachments. Other major implications of this Option are summarized in Table 2.2.

Criteria	Implications
Maximize the use of existing data sources.	The existing health care information system would be used, however major changes would be required to facilitate the collection of additional data elements so that the model could be used for detailed analyses and the assessment of basic safety issues. Automated data obtained through police collision investigations would not be utilized and these would have to be added manually.
Use an appropriate analysis system.	A new system to verify and ensure the quality of additional collision related data elements would be required. Due to the scope of the data elements captured, an appropriate analysis system could be constructed without difficulty.
Implement an integrated approach.	The approach is focused on the statistical analysis of data with less regard for a more comprehensive understanding of the complex relationships related to such matters as collision causation or crash survivability.
Ensure the option is feasible over the long term.	Fundamental changes in the way health care system data is collected, processed and analyzed would be required. Substantial additional financial and other resources would be required. Data collection for the purpose of safety research would become a new aspect of the existing data collection effort.
Ensure the model can be more generally applied.	Cooperation with numerous health care centres would be required. If implemented on a larger scale such as a national level, standardization would be extremely difficult due to local issues, different jurisdictions as well as conflicting and competing objectives.

Table 2.2 Implications of developing a safety model based on expansion of the hospital-based programme to include police-reported accident information (Option 2).

Option 3. Expand the programme of in-depth collision investigation.

With this Option, the programme of in-depth collision investigations would be expanded and would be the focus of the model. In-depth investigations could be similar to existing Level 2 programmes except that the number of investigations would be substantially increased to achieve the desired level of statistical significance and representativeness. Alternatively, a different approach could be introduced wherein, combined with other sources of information, an expanded in-depth investigation programme is developed to target specific safety issues and initiate a programme of in-depth investigations to address these issues. Such systems would benefit from the comprehensive data collection infrastructure which has evolved since the early 1970's and would facilitate a detailed and multi-disciplinary approach to addressing road safety issues.

However, to provide a comprehensive approach to general safety issues without a major change being made to other data collection activities, it would be necessary to fundamentally reorganize the way such in-depth collision investigation programmes are implemented. Based on the past experience of similar programmes it would be critical that an improved analysis infrastructure be developed prior to the implementation of the data collection programme and that this analysis system be recognized as a critical component throughout the data collection programme. Other major implications of this Option which relate to the basic criteria of a safety model previously described are summarized in Table 2.3.

Criteria	Implications
Maximize the use of existing data sources.	The existing system of conducting in-depth collision investigations across Canada could be utilized, however, additional resources would be required to expand the existing programme. Changes in data elements collected would not impact the overall data collection procedure or required infrastructure. The existing Level 1 police collision reporting system and other sources of information would provide the necessary data to facilitate use of the model for more detailed analyses.
Use an appropriate analysis system.	The system recently developed to verify and ensure the quality of specific data elements captured as part of the current federal in-depth investigation programme in Canada would be used and enhanced.
Implement an integrated approach.	Combined with use of other existing sources of data such as the standard police collision reporting system, a comprehensive and integrated approach to address a range of safety issues would be implemented.
Ensure the option is feasible over the long term.	Fundamental change in the way in-depth collision data is collected and processed would not be required. Substantial additional financial and other resources would be required.
Ensure the model can be more generally applied.	An existing programme of in-depth collision investigations would provide the necessary basis for the development of a larger programme.

Table 2.3 Implications of developing a safety model based on expansion of the programme of in-depth collision investigations (Option 3).

Option 4. Link existing information systems through creation of a single automated system describing specific incidents.

This Option for constructing a general road safety model focuses on linkage of existing automated data sources describing motor vehicle collisions and the trauma associated with these events. This linkage would be performed by merging data describing a specific incident from different sources. In this way information obtained through the police reporting system may be supplemented by other data such as detailed injury data thus enabling the analysis of a large comprehensive database of collisions.

While some changes in the existing data collection programmes would be required to facilitate the identification of unique events and individuals, most of the resources required to implement such a programme are related to the processing and analysis of the data rather than to data-collection efforts. As a result, the comprehensive coverage of motor vehicle collisions would afford the opportunity to complete an integrated analysis of major safety issues.

However, such an approach would require the development of an appropriate infrastructure to assemble primary data, ensure accuracy of the linkage and overcome fundamental obstacles relating to the confidential nature of data used. Other major implications of this Option are summarized in Table 2.4.

Criteria	Implications
Maximize the use of existing data sources.	The existing automated information based on the police reporting system, health care records system and other sources would be used. While some additional data elements must be collected to facilitate linkage of the data, detailed analyses could be completed without a major fundamental change in existing data collection efforts.
Use an appropriate analysis system.	A new system to verify and ensure the quality of specific data elements would be required. The processing and analysis system must recognize and overcome restrictions on use of the data due to the confidential nature of the information collected.
Implement an integrated approach.	The provision of an automated data system where information from different sources is linked to describe each motor vehicle collision provides an exceptional framework to address a range of safety issues.
Ensure the option is feasible over the long term.	Substantial additional financial and other resources would be required to develop and maintain the required data processing and analysis systems. The data collection effort would require some change to incorporate data elements which would specifically identify individual events to permit the linkage of data.
Ensure the model can be more generally applied.	Because confidentiality constraints and the use of an automated data information system, fundamental policy decisions regarding access to the information must be obtained. If implemented on a larger scale such as a national level, standardization would be difficult due to local issues, different jurisdictions and conflicting and competing objectives.

Table 2.4 Implications of developing a safety model based on linkage of existing information systems through creation of a single automated system describing specific incidents (Option 4).

Option 5. Integrate existing information programmes through a coordinated analysis framework without merging data describing specific incidents.

This Option for constructing a general road safety model focuses on maximizing use of existing automated data sources describing motor vehicle collisions and the trauma associated with these events. In the application, data describing a specific incident from a number of different sources would not be linked. Rather, summary information from each source of data would be used to address part of a safety issue. For example the police collision-reporting system would be used to provide aggregate information on all collisions while the hospital-based information system would provide information on a subset of collisions involving hospitalizations. Detailed information of specific collision types would be provided through the completion of a focused in-depth collision investigation programme.

This approach would not require change in the existing data collection programmes nor the allocation of major additional resources but would necessitate re-direction of priorities to fulfil the needs of a general safety model (particularly with respect to in-depth collision investigation programmes). Other major implications of this Option are summarized in Table 2.5.

Criteria	Implications
Maximize the use of existing data sources.	The existing automated information based on the police reporting system, health care records system and other sources would be utilized. No major structural change in existing data collection efforts would be required.
Use an appropriate analysis system.	A new system to verify and ensure the quality of specific data elements would not be required. Because data is not linked on a specific individual basis, the processing and analysis system is not impacted by the confidential nature of the information collected.
Implement an integrated approach.	A framework to address a number of safety issues using an integrated approach is provided.
Ensure the option is feasible over the long term.	Few additional financial and other resources would be required to develop and maintain the required data processing and analysis systems. The data collection effort would not require fundamental change.
Ensure the model can be more generally applied.	Because some confidentiality constraints and the use of an automated data information system, fundamental policy decisions regarding access to the information must be obtained. If implemented on a larger scale such as on a national level, complete standardization may be difficult, however similar efforts could easily be constructed using existing methods.

Table 2.5 Implications of developing a safety model based on integration of existing information programmes through a coordinated analysis framework without merging data describing specific incidents (Option 5).

2.4 Recommended Approach

Three of the Options considered to develop a model which could be used to address road-safety issues involved expansion to existing data-collection programmes, thus demanding substantial changes to the existing road-safety-delivery system. These are police-based (Option 1), hospital-based (Option 2), and in-depth collision-investigation-based programmes (Option 3).

The remaining Options maximize the use of existing data collection programmes. The primary difference between these Options is that, while one (Option 4) focuses on the linkage of all existing information programme through the creation of a single, automated system describing specific events, the other (Option 5) focuses on using each existing programme to provide different perspectives related to the same subject matter or issue. While information on specific events is not merged together, existing data programmes would be used in an integrative manner with each component addressing part of a larger issue.

To determine the recommend approach to develop an appropriate safety model, all Options were strategically evaluated with respect to five basic criteria. These criteria, having been previously discussed, can be summarized as the ability to:

- maximize the use of existing data sources without requiring fundamental change in the existing road-safety delivery system;
- establish an appropriate analysis system to ensure that the data being collected and analysis is of sufficiently high quality;
- provide a range of information considering general characteristics of all collisions in addition to knowledge relating to the detailed relationships involved in specific incidents;
- ensure that model can feasibly be implemented over the long term; and
- ensure that the model can be applied within a number of different jurisdictions.

The result of this evaluation is summarized in Table 2.6. Options which most appropriately satisfy each specific criterion are represented with a [●] ; those Options which fulfil the principle to a lesser degree are represented with a [•]; while those Options which do not adequately fulfil specific principles are represented with a [*blank*].

Criteria	Option				
	1	2	3	4	5
Maximize the use of existing data sources.	∘	∘	∘	●	●
Use an appropriate analysis system.	∘	∘	∘		●
Implement an integrated approach.			∘	●	∘
Ensure the option is feasible over the long term.	∘		∘		●
Ensure the model can be more generally applied.		∘			●

Table 2.6 A strategic evaluation of options to develop a safety model to address fundamental safety issues (● indicates the most desirable option; ∘ indicates a less desirable option; and [*blank*] indicates the least desirable option).

With regard to the first criteria, maximizing the use of existing data sources, all Options are predicated on the use of existing data-collection programmes. However, since Options 1, 2 and 3 represent alternatives dominated by a single type of data source, much relevant information contained in other data-collection programmes is not used. In contrast, both Options 4 and 5 are alternatives which maximize the use of all major sources of data respecting motor vehicle collision data.

When considering the use of an appropriate analysis system, including a system to verify and ensure the veracity of the data, serious difficulties are associated with Options 1, 2, 3 and 4. While the analysis system could be based on existing systems and be introduced within Option 1 and Option 2, both Options would require new procedures to considerably enhance the quality and completeness of the data collected. A similar condition would exist for Option 3, however, much more emphasis would be required to develop a more comprehensive quality assurance system as part of any existing or new in-depth collision investigation programme. Option 4 is clearly an inferior Option in that a new analysis system would be required and the difficult issue of confidentiality may compromise many applications of this particular alternative. The most desirable alternative, Option 5, not only is based on existing systems but it would not require extensive changes to existing practice because data elements achieving minimum quality assurance criteria would be selected from the most appropriate information source. (For example, data describing injuries would be derived from the highest-quality source, a hospital-based programme rather than attempting to obtain the information from a secondary source such as a police-based programme.)

In assessing each Option with regard to providing an integrated approach to road safety issues, Options 3, 4 and 5 are considered to be the most desirable approaches. Both Options 1 and 2 rely exclusively on statistical data and do not benefit from the type of information which can only be obtained through a more rigorous data-collection efforts such as an in-depth collision-investigation programme. Option 4 is the most precisely-integrated alternative where all data is linked to specific collisions while Option 5 is slightly inferior since all information assembled cannot be directed or linked to an individual incident.

One of the most important criteria in evaluating the respective Options is that which considers whether the Option can be feasibly implemented and maintained over an extended period of time. While this is a very subjective assessment and would depend on how and where the model is implemented, the cost, complexity, and multitude of different organizations necessary to implement Options 1, 2, 3 and 4 would be substantial. Option 5 is considered the most desirable alternative because limited additional resources would be required to implement the model and existing data-collection programmes could be used without the necessity of implementing fundamental changes to these efforts.

Finally, with respect to ensuring that the model can be generally applied to other jurisdictions, Option 5 is substantially superior to the other alternatives. Option 1 would require a large degree of cooperation with numerous police jurisdictions with conflicting and competing objectives. Similarly, Option 2 would require a comparable change in the structure and objectives of the health-care-delivery system. While the precedence for implementing national in-depth collision investigation programmes exist, implementation of Option 3 would be the most comprehensive and costly. Option 4 would likely be the most difficult programme to be generally applied because of the difficulties associated with the confidential nature of automated data and the need to regularly ensure the quality of data being collected.

Based on this evaluation, it is clear that Option 5, which focuses on each existing data-collection programme within an integrative environment, provides the most appropriate framework from which a general safety model can be developed. This Option is the most desirable approach when considering the need to maximize the use of existing data sources, use an appropriate analysis system and ensure that the approach is feasible and generally applicable. It is recognized, however, that the linkage of information on specific incidents based on different data sources would ultimately provide the most comprehensive and truly-integrated approach to developing a safety model. However, it is also noted that such an approach may not be generally applicable, particularly due to the need to ensure confidentiality of information compiled.

An important consideration in the development of a model based on Option 5 is that, while each component is a self-contained entity, it is the integration with other sources of knowledge which make this approach superior in addressing important road safety issues. For example, while the one component of the model may provide a reasonable overview of the road crash problem, detailed information would be inadequate (ie. the nature, magnitude, severity and trends associated with motor-vehicle-related trauma). However, when combined with other sources of information, this void can readily be addressed. Using other components, the outcome of motor vehicle collisions expressed as trends (as defined by the injuries sustained by involved persons) can be characterized and monitored over a period of time. By using yet another component of the model, a detailed understanding of injury mechanisms and causation mechanisms related to crash type and configuration can be gained through the in-depth investigation of a specific subset of all collisions.

A more detailed description of this Option, including its basic components and how it could be constructed, is provided in the following section.

2.5 Detailed Content of the Proposed Model

Given existing sources of information, data collection and analysis programmes currently in place, as well as the historical precedents for road safety research activities in Canada and other jurisdictions, a general model to address road safety issues was strategically evaluated and proposed. This model is designed to ensure that the use of existing sources of data are maximized, that appropriate analysis systems are employed, that an integrated systems approach is followed and that such a model can easily be maintained and sustained.

Specifically, the model proposes the integration of three separate components or levels of information. The first considers the most general factual information on all motor vehicle collisions and is based on a standard police-based collision reporting programme. The second recognizes the need to provide additional information describing trauma associated with motor vehicle collisions and is based on precise injury data obtained from a hospital-based information recording programme. The third provides an opportunity to seek greater insights into crashes in which the outcome is a fruition of multi-variable inputs. The source of information for this component of the model is in-depth collision investigations.

The three components of the model have been defined as a "Collision Information System", an "Injury Information System" and "A System of In-Depth Collision Investigations" and are described in the following sections.

2.5.1 Collision Information System

The objective of the Collision Information System is to develop a basic framework which can provide general knowledge describing the frequency and nature of motor-vehicle collisions. The source of information which can be used is that collected as part of a typical police-accident reporting programme (Level 1 collision investigations). No other similar source of information is as readily accessible, complete or more generally available.

As discussed previously, data typically captured as part of a police-based reporting programme may vary from jurisdiction to jurisdiction. However, the following data elements are typical of information collected through a police-based programme:

- general classification variables (severity and type of collision, collision configuration, number of vehicles involved and persons injured);
- location descriptors (police jurisdiction, general location, road category / type / alignment, collision site and specific positional information describing the geographic location of the incident);
- variable identifiers (date, day, time, and light / weather / road and surface conditions);
- factual vehicle data (vehicle type and year, towed vehicle type,hazardous load information, point of impact, damage location number of passengers and direction of travel),
- data on injured persons (position, ejection, use of safety equipment, injury severity, age and sex),
- driver data (age, sex, experience and violations),
- pedestrian data (age, sex and action), and
- interpretive collision data (contributing factors to the collision and first or second harmful events).

To incorporate this primary source of data as a component of an integrated safety model, efforts were directed towards developing a more focused and effective analysis system. The rationale for this approach is that, if major changes to the existing police-based traffic accident investigation and reporting programme were proposed, this would necessitate a major expenditure of resources and fundamentally alter an existing programme with unknown and variable consequences. By focusing on the analysis system, the benefits associated with maximizing the utility of an existing programme could be realized without a major effort and the programme itself would not be directly affected. (It is recognized that, after all benefits are achieved as a result of an improved analysis system, efforts could then be directed to modifying the actual investigation and reporting protocol.)

The development of an appropriate analysis system for the purposes of this research was based on the premise that the mainframe computer system at the University of Manitoba was available to be used and that the specific techniques used were not intended to be implemented by another agency such as the Manitoba Motor Vehicle Branch. The implication of these basic assumptions is that other techniques could be used to adapt this concept to other practical conditions or situations. For example, this research effort relied on the use of a mainframe computer system and a powerful statistical analysis software package (Statistical Analysis Systems or SAS). If this framework did not exist elsewhere, alternative techniques could be developed using a micro-computer environment and other statistical analysis packages (such as SAS for the PC or other statistical software packages such as the Statistical Package for the Social Sciences or SPSS). In addition, by using a mainframe computer, the advantages of developing a relational database file structure which would facilitate the efficient storage of data were not pursued.

To illustrate how this component of a safety model could be developed, the primary police-based investigation programme in the Province of Manitoba was investigated and used. To obtain this data, a request was made to the Research Section of the provincial Motor Vehicle Branch. The information obtained was contained on a magnetic tape and stored as a variable file in a standard format. Each record represents a particular collision and contains information describing the general collision environment, the vehicles involved as well as data on each injured person.

While the format of the file has evolved since 1980 (including a major change in both the data collection form and collection procedure in 1984), the overall lay-out has remained consistent. Each record contains a fixed common element and up to thirty trailers describing the vehicle or pedestrian involved in the collision and up to thirteen trailers describing persons injured during the collision. Although this format efficiently minimizes the space required to store these data, it can be relatively difficult to complete even simple analyses such as frequency distributions and cross tabulations using basic programming methods.

To prepare the database, a standard statistical analysis package maintained on the University of Manitoba mainframe computer system was used (SAS). The first task involved reading the original variable length data file including variables which had been stored in non-standard formats. Programmes were then developed to construct two fixed length data files. In the first file, each record represents a unique vehicle involved in a collision. The record contains information relating to the collision as well as data related to a specific involved vehicle. Whereas the original file might contain 36,000 records representing 36,000 collisions, this first, fixed-length file contained over 50,000 records representing the number of involved vehicles. In the second file, each record represents a unique injured person. The record contained detailed information related to each injured person as well as information which associated that person with a specific vehicle involved in a particular collision. Using these two data files a third file was created which merged all information related to the collision and the appropriate vehicle to each injured person.

In addition, other variables created to facilitate easier manipulation of the data, were added to the data file. For example, variables were included to identify the mix of vehicles involved in the collision (ie. passenger vs passenger car collisions or collisions involving passenger cars and light trucks or vans) and variables which consider whether the injured person sustained a near-side impact or a far-side impact. While the procedure was modified to incorporate changes in the format of the original data obtained from this Manitoba Motor Vehicle Branch on a yearly basis, the basic technique and programmes used are comparable. To facilitate further use of this model, samples of the programmes used are appended in Appendix A. However, the completion of a detailed users guide providing a comprehensive discussion of all data elements was considered to be beyond the scope of this research. (Such users guides have been completed to assist in the analysis of collision databases, including Transport Canada's Level 2 Passenger Car Study (PCS) (German,1989) and Light Truck and Van Study (LTV) (Lawson et al,1987).)

Using the resultant data file, analyses involving collision, vehicle, and injury information can be completed efficiently with minimal effort. To address difficulties related to the sheer size and manageability of the file, separate subsets could also be produced for subsequent analyses. These refined files could then be suitable for down-loading into a micro-computer environment where necessary or desired. An example demonstrating this application is illustrated in Appendix B. To produce this image, data was analyzed using SAS, downloaded into a micro-computer environment, and then imported into a basic mapping software package. The graphic illustrates the frequency of all collisions occurring along segments of the provincial highway system. (Data from other sources such as traffic volumes or road characteristics can easily be incorporated to illustrate detailed collision data based on a geographically-referenced information system.)

In summary, the Collision Information System can be used to replicate (with relative ease) analyses published annually by Research Section of the Manitoba Department of Highways and Transportation: Driver and Vehicle Licensing Division. This component of a general safety model can also be used to easily create ad hoc analyses based on specific issues or needs and could be tailored to use similar police-based collision investigation and reporting programmes in place in other jurisdictions.

2.5.2 Injury Information System

The objective of the Injury Information System is to capture detailed data describing the frequency and nature of trauma sustained by persons involved in motor vehicle collisions. This hospital-based information can be obtained either from data systems related to the delivery of health care or from data systems maintained by public (ie. the Manitoba Public Insurance Corporation and the Insurance Corporation for British Columbia) or private (ie. the Insurance Institute for Highway Safety and the Highway Data Loss Institute in the United States) insurance organizations. Because the source of this information is highly dependent on local conditions, the choice of the most appropriate data source can only be made after reviewing the specific programmes available where the model is to be applied.

In general, hospital-based information includes the following type of data:

- hospital data (which hospital person was admitted to, date of admission and separation, the number of days in hospital and the hospital the person was transferred to or from);
- factual information related to the injured person (age, sex and birth-date);
- detailed descriptive injury data; and
- detailed information describing medical procedures performed.

To incorporate typical hospital-based information within a component of an integrated safety model, it was recognized that these automated systems often describe injuries according to an internationally-recognized and applied coding system, the 9th Revision of the World Health Organization's International Classification of Diseases Clinical Modification (ICD9-CM). This system was developed to allow the classification of morbidity data, the indexing of medical records, medical care and programme review as well as being used to provide basic health statistics (Commission on Professional and Hospital Activities,1980). In addition to the codes used to describe injuries, this coding system also includes a special code which permits the classification of environmental events, circumstances and conditions which caused the injury. This includes coding of those persons injured as a result of motor vehicle traffic accidents. Using this specific "E code", the record can be classified in terms of whether the person was:

- a driver of a motor vehicle other than a motorcycle,
- a motorcyclist,
- an occupant of a streetcar,
- a rider of an animal or animal drawn vehicle, or
- a pedestrian.

However, to use ICD9-CM information for the purposes of motor vehicle research, it was recognized that the primary injury data must be reclassified and described in terms of injury severity. This required the conversion of the ICD9-CM codes to an internationally recognized injury severity coding system used in motor vehicle collision research: the Abbreviated Injury Scale (AIS) and the Occupant Injury Classification (OIC) systems. These injury severity systems evolved from in-depth collision investigations in the early 1970's when researchers in the field of road safety recognized the need to develop a standardized system for categorizing the type and severity of injuries sustained by persons involved in motor vehicle collisions. To address this need, the Abbreviated Injury Scale was developed thus representing a standardized method to produce a numerical ranking of injury severity. (While this assessment of injuries is useful in measuring the severity of the injury itself it does not provide a measure of impairments or disabilities which may result from that injury.)

Since the first Abbreviated Injury Scale was published in 1971, subsequent revisions have provided additional injury descriptions, more comprehensive techniques associated with coding certain injuries such as brain injuries, as well as improved scaling practices related to outcome and overall injury assessment. In addition, recent revisions have been made to facilitate the coding of penetrating trauma and provide a more clinical description of injuries sustained. The most current revision of the scale provides additional coding guidelines to assist in the interpretation of specific reported injuries; provides additional opportunities for the coding for penetrating injuries; incorporates the effect of age as it is associated with the probable outcome of specific injuries; provides the framework to incorporate an additional injury scale relating to impairment; and provides improved coding procedures for external injuries (injures to the skin) and injuries to the brain (Committee on Injury Scaling,1990). Currently, use of the Abbreviated Injury Scale has transcended applications based on motor-vehicle-related trauma research and is widely used in more general epidemiological research, trauma studies to predict survival probability, as well as patient outcome evaluation and health care systems research.

The Occupant Injury Classification (OIC) was developed by collisions researchers to assist in the analysis of injury mechanisms including the identification of specific injuries to specific contact points (Marsh,1973). This code is a string of five characters denoting the body region, aspect, type of lesion, body system or organ affected and the severity level (as per the Abbreviated Injury Scale) of a specific injury. The AIS ranking and appropriate OIC descriptive codes have been incorporated into the standard coding manuals developed for collision investigations.

Since no linkage between the AIS and ICD9-CM coding systems was available when this research was initiated, a conversion table ascribing an injury severity code to each ICD9-CM descriptive injury code was developed. To complete this task, a frequency analysis of a representative hospital-based information programme was performed to determine whether specific codes ICD9-CM were commonly or infrequently reported. This information was then used in assessing the significance of any errors which may be introduced if the conversion to an Abbreviated Injury Scale code (AIS80) based on the 1980 revision (Committee on Injury Scaling, 1980) was not truly appropriate. Once the most specific ICD9-CM codes were assigned AIS80 descriptors, the remaining codes were assigned with the assistance of a trauma surgeon actively involved in the delivery of acute care services. Coders at a specific health care centre were also consulted to determine how particular injuries might be interpreted. While some difficulties arose in attempting to merge these two coding systems, these were addressed through the assignment of non-specific codes and the adoption of basic coding conventions (Appendix C). The completion of the conversion table developed as part of this research, and documented in Appendix D, provided a completely new opportunity for the use of databases using the ICD9-CM coding system.

Recognizing that both the AIS and ICD9-CM injury coding systems are continuously being reviewed and updated, computer algorithms were developed to ensure that future revisions could easily be incorporated and reflected in the analysis of primary data. These revisions could consider ICD9-CM to AIS85 conversion table developed by MacKenzie (MacKenzie et al,1986) and other conversion tables produced to incorporate the latest AIS revisions. With regard to the reliability of the concept of merging the two coding systems, it should be noted that others have since developed similar conversion tables and the latest refinements in the AIS coding system facilitates a more straightforward conversion of the two systems.

To investigate how this component of the model could be constructed, two basic sources of data describing the nature, frequency and severity of injuries sustained by persons involved in motor vehicle collisions in the Province of Manitoba were considered. These included information available from the Manitoba Public Insurance Corporation (MPIC) and information from the Manitoba Health Services Commission (MHSC).

Data from the MPIC generally contains details which describe the extent of injuries sustained by persons injured in a motor vehicle collision and who have subsequently submitted a claim to the Corporation. While information also exists relating the nature of the collision and the costs of the claim, the appropriate data is not captured in the existing automated data information system maintained by the Corporation and, therefore, was excluded from further consideration.

Information obtained from the MHSC and used for this research contains information on each hospital admission and is designed to keep track of patient contacts with providers and be maintained for payment and control purposes (Roos et al,1979). It includes a description of injuries sustained by persons who were involved in a motor vehicle collision and subsequently admitted to hospital for treatment. For each person, all injuries are described and coded according to an accepted protocol and entered into an automated data information system. It is noted that the information contained in this database is limited to injury data; no information is available to describe the actual crash event.

To obtain access to the data, approvals from both the College of Physicians and Surgeons and the Manitoba Health Services Commission were necessary. In addition, approval from the University of Manitoba Faculty Committee on the Use of Human Subjects in Research was sought and received. To maintain confidentiality, no data were provided which would allow the identification of a specific individual. In addition, as a condition of using the data, it was agreed that the hospital injury information would not be linked to any other data source.

Given the development of an ICD9-CM to AIS conversion table, programmes using the University of Manitoba mainframe computer system and the SAS analysis package were developed to introduce the AIS80 variable to the sample database. Subsequently, other computer algorithms were written to calculate overall measures of injury severity such as the Injury Severity Score, ISS (Baker,1974) and the Maximum Abbreviated

Injury Score (MAIS) in each body region. (The Injury Severity Score or ISS was developed by researchers investigating the correlation between AIS-described injuries and mortality, and is simply the sum of the squares of the highest AIS codes in each of the three most-severely-injured body regions. This Maximum Abbreviated Injury Score or MAIS is the highest AIS code ascribed to injuries sustained by an injured person.) Sample programmes used to automate the coding of injuries described using the ICD9-CM coding system are included in Appendix E.

Using the resultant data file, analyses describing the frequency and nature of trauma sustained by various road users involved in motor vehicle collisions can easily be completed. Results of analyses which characterize the Injury Information System derived from primary information from the Manitoba Health Services Commission (1982-1986) are presented in Appendix F. These analyses document the number, age and sex of persons involved, and estimates of overall injury severity (as defined by the Injury Severity Score (ISS), the Maximum Abbreviated Injury Scale rating (MAIS) and the number of days the injured person was hospitalized). Examples of more detailed analyses which detail the frequency, severity and body regions of injuries sustained by different road users described in the Injury Information System are presented in Appendix G.

In summary, the Injury Information System can be used to generate, with relative ease, appropriate descriptive analyses of injury patterns sustained by various road-user groups. The analysis framework can be tailored to produce standard summaries and complete ad hoc analyses such as a trend analysis in injury patterns over time.

2.5.3 A System of In-depth Collision Investigations

The objective of completing an in-depth collision investigation programme as part of an overall safety model is to provide a comprehensive and detailed understanding of specific collision events. In Canada, this programme could be based on either the national collision investigation and data collection programme sponsored by Transport Canada, or the programme could be based on the investigations of specially-trained police traffic accident investigations. The specific characteristics of these investigation programmes are presented in Table 2.7.

Characteristic	National Collision Investigation and Data Collection Programmes	Police Investigations completed by Specially Trained Traffic Analysts.
Criteria Collisions	Random sampling of collisions involving fatally and non fatally injured persons.	All motor vehicle collisions involving a fatally-injured person.
Personnel	Collision investigators or technicians with input from expert safety professionals.	Trained police collision investigators.
Primary Purpose	Provide input into a national data collection programme designed to formulate and evaluate future and existing motor vehicle safety standards.	Assess fault and provide a rationale for subsequent charges and litigation proceedings.
Scope	Typical Level 2 investigations providing comprehensive information relating to all aspects of the collision.	Modified non-standard Level 2 investigations relating to a specific aspects of the collision.
Methods	Investigations are typically initiated within 72 hours of the incident. No on-scene data collection. Relatively comprehensive and consistent data collection protocol.	Investigations are typically initiated within hours of the incident. Comprehensive on-scene data collection. Relatively consistent data collection protocol which is related to specific objectives.
Reliability	Investigations involving a fatally injured occupant use information obtained from the police collision investigations and are highly reliable and of excellent quality. Investigations involving a non-fatally injured occupant are less reliable and contain data of inconsistent and variable quality.	Investigations are completed with a high degree of precision.
Documentation	Information is coded and stored in an accessible electronic media format according to a standardized protocol.	Documentation is variable and is a direct function of the individual investigator and used for internal purposes only. The information is not stored in an accessible or automated format.

Table 2.7 Characteristics of in-depth collision investigations conducted as part of Transport Canada's national data collection programme compared with investigations of fatal collision completed by specially trained police accident investigators.

The choice of an appropriate means to conduct in-depth collision investigations is a non-trivial task, particularly since past programmes have been less than successful in terms of meeting initial expectations. In particular, such a programme requires a significant data collection infrastructure, substantial financial resources, personnel with specialized training, cooperation from numerous private and public agencies and the respect from the general public or community where the programme is to be conducted. Recognizing the inadequacy of the existing Level 2 in-depth collision investigation programmes, the writer communicated this conclusion to senior officials responsible for NHTSA'S NASS programme at an international conference in Detroit early in 1986 and subsequently to senior participants involved in Transport Canada's PCS programme. It is noted that the NASS programme was aborted shortly thereafter while the PCS programme has been re-examined and will be terminated by 1993. In addition, through investigator training programmes sponsored by the Canadian Police College, the number of competent, specially-trained police traffic analysts across Canada has increased substantially.

As a result, this research effort focused on the establishment of a framework from which an in-depth investigation programme could be developed as part of an integrative road safety model. This framework would be equally applicable whether the programme was completed as part of a national programme such as Transport Canada's university-based studies or whether the programme was based on investigations completed by specially-trained police personnel. The key elements to consider prior to, during and following the introduction of an appropriate in-depth collision investigation programme include:

Define objectives.

Prior to initiation of an in-depth collision investigation programme, a proactive approach must be taken which identifies the specific objective and the methodologies which are to be undertaken and fulfilled.

Define the scope of the activity or the concept.

Since the number of collisions which can feasibly be investigated is limited to a relatively small proportion of all collisions, additional information is needed for to determine how representative those collisions investigated as part of an in-depth programme are relative to the overall collision population. Completion of this task may not be required if the collisions investigated constitute a representative sample of all collisions which meet the sampling criteria (for example, investigations of all collisions involving a fatally-injured motor vehicle occupant).

Determine basic data and reference requirements.

Given the objectives of the data-collection programme and the assessment of other information which may be available, the required data elements must be identified. In larger programmes, each element should be formulated to fulfil a specific objective or provide information or knowledge contributing to the attainment of a known objective. As part of a typical Level 2 investigation, the following data elements are typically captured:

- collision scene and road environment information,
- vehicle type and characteristics,
- vehicle damage data,
- occupant and non-occupant information,
- detailed injury data,
- driver data,
- cargo information and trailing vehicle data,
- active restraint use and characteristics,
- seat back and head restraint data,
- occupant entrapment or ejection data,
- vehicle defect data,
- rear seat information,
- vehicle instability and steering information,
- fire/tire/brake characteristics,
- rollaway vehicle information, and
- child restraint system usage and characteristics.

In addition to these coded variables, the level 2 investigation also includes a detailed narrative presenting the salient details of the collision event, scene diagram, sketches of vehicle damage and injury locations as well as representative photographs of the scene and vehicles involved.

Prior to any data-collection activity, appropriate reference material must be assembled to ensure that collisions are investigated and the data collection forms are completed with accuracy, consistency and timeliness. In larger in-depth programmes where collisions are investigated by different personnel in distinct geographic areas, the need for standard reference material, such as a coding manual, is self-evident.

Identify appropriate personnel.

Personnel involved must be trained and provided with the basic equipment and knowledge necessary to complete the investigations.

Develop the necessary data collection, data assurance and analysis protocol.

While the development of an appropriate data input and analysis system is dependent on the scope of the data-collection exercise, the analysis should make use of current methods and techniques wherever possible. In addition, to ensure data quality, a system must be in place to monitor the accuracy of information from the initial data-collection activities through the analysis phase of the programme. The need for a rigorous quality control system becomes even more essential when larger national investigation programmes are considered. Such a system would include the validation and verification of data as it is input into an automated system as well as the analysis of multiple variables to identify possible inconsistencies, errors or commissions.

Given this framework, a collision investigation programme could be initiated. In some cases, the completion of a pilot programme would be recommended in order to thoroughly evaluate the programme's objectives, concept, data-collection requirements, references, personnel, and data collection, assurance and analysis protocol.

To apply this component of the general safety model within the Province of Manitoba, it is recognized that in-depth collision investigations have been performed by the Road Safety Research Unit (RSRU) since the early 1970's. Currently, approximately 110 collisions are investigated annually as part of Transport Canada's Passenger Car Study (PCS). These include a representative sample of collisions involving non-fatally injured persons and a more complete sample of collisions involving a fatally injured motor vehicle occupant. To accomplish this undertaking, the RSRU developed a sound working relationship with numerous agencies and organizations including investigating police personnel, the Manitoba Public Insurance Corporation, the Office of the Chief Medical Examiner, as well as officials representing various hospital and government organizations and agencies. Through development of this cooperative environment over an extended period of time, detailed multi-disciplinary collision investigations were generally completed with a high level of precision and completeness. As a member of this team during the years of 1982 to 1987, the writer made certain modifications to the data collection protocol and co-authored a data priority assurance reference manual subsequently applied both locally and nationally (Dalkie et al,1986).

In summary, it is evident the infrastructure and expertise for conducting an in-depth collision investigation programme was developed in the Province of Manitoba. In addition, it is also clear that such programmes have been established across Canada as a result of the long standing commitment by Transport Canada to complete multi-disciplinary collision investigations as part of a national safety research effort. However, with recent improvements in the level of investigations completed by specialized police investigators, a second police-based infrastructure is also in place to provide knowledge based on in-depth collision investigations. Therefore, it is concluded that the choice of the most appropriate source of the primary information should be subject to local constraints where the model is to be applied. The most important consideration in the application of this component of the larger safety model is that the proposed framework is implemented as part of the in-depth investigation programme.

2.6 Summary

As previously stated, the purpose of this research is to develop a model which can be used to increase the level of knowledge describing safety issues so that the incidence and severity of motor vehicle collisions may ultimately be reduced. To achieve this end, an integrative model is proposed. This model integrates three basic components or sources of information, each of which has already been developed and is routinely maintained. These components include knowledge gained through analysis of data collected as part of the police accident reporting programme; through the identification of injuries sustained by persons involved in motor vehicle collisions and admitted to hospital; and through the implementation of a clearly-defined and focused in-depth collision investigation programme. The approach recognizes that each component, individually, is likely to be inadequate and inappropriate to address most safety issues in a comprehensive manner. However, use of the proposed model allows the feasible and effective analysis of specific safety issues to a depth not possible through consideration of the individual components alone.

With regard to the use of existing data sources, it is important to note that the Collision Information Data System (Section 2.5.1) and the Injury Information System (Section 2.5.2) included components developed by the writer to enhance the use of primary data collected by others. In addition, while a new data collection effort is proposed as part of the in-depth collision investigations component of the model (Section 2.5.3), this model enhances the use of an existing infrastructure and data collection system current in place to collect data as part of a national investigation programme sponsored by Transport Canada.

To test the model developed to address safety issues, it was applied to two specific issues in the Province of Manitoba. The first was the introduction of mandatory seat-belt-use legislation (Chapter 3) while the second was the introduction of mandatory motorcycle-helmet-use legislation (Chapter 4). These issues were selected because of difficulty often encountered when attempting to demonstrate a direct correlation between the introduction of a safety counter-measure and a measurable effect within the road-user population and because of the potential benefit which could accrue due to increased use of both protective safety devices. To describe the application of the model to each selected issue, an overview of the appropriate background information is first presented. Then, the application of each model component is detailed with an emphasis on how this integrative approach recognizes the multi-disciplinary nature of safety research and maximizes existing information programmes to assemble the appropriate strategic information, analysis system and knowledge to adequately address the particular issue.

Chapter 3. Model Application: Introduction of Mandatory Seat Belt Legislation in Manitoba

3.1 Background

To complement the application of the proposed model to assess the introduction of mandatory seat belt legislation in Manitoba, several initiatives were completed by the writer. These investigations assessed the existing state of knowledge regarding what is known about the general effectiveness of seat belts, the effectiveness of seat-belt-use legislation as well as what is known about overall usage and selective recruitment of belt users in Manitoba. It is noted that such supplemental data sources, research activities or ad hoc requirements will always be required whenever the model is applied. Because of the flexibility and practicality of the proposed integrative model, these requirements will effectively improve the applicability of this approach.

The following discussion describes appropriate background information by considering:

- seat belt effectiveness;
- the effectiveness of seat-belt-use legislation; and
- seat belt usage in Manitoba.

The effectiveness of seat belt use in reducing the severity of injuries sustained by motor vehicle occupants has been exhaustively addressed in the scientific literature. Of particular relevance to this research are various techniques used to quantify the magnitude of restraint use effectiveness. These methodologies have been categorized in terms of clinical studies, matched comparisons and statistical analyses (Hedlund,1986).

Early clinical studies involved a detailed examination of specific collisions and included a subjective assessment of how effective a restraint device would have been in reducing the severity of injuries sustained by an unrestrained occupant. This type of analysis suggested that use of three point seat belts would have been 30 to 40% effective in preventing fatal injuries sustained by unrestrained motor vehicle occupants (Wilson and Savage,1973; Griffiths et al,1976; and Huelke et al,1978). Restraint system effectiveness has also been estimated by comparing collisions involving unrestrained occupants with collisions of similar injury producing potential in which the occupants were restrained (Pursel et al,1978). Restraint-system effectiveness based on multi-disciplinary-collision investigations involving restrained motor vehicle occupants have also been widely reported in the scientific literature (Arajarvi,1988; Schmidt,1987; Otte et al,1987; Argan and Winn,1987). Through this and previous research, a good understanding of occupant-restraint-system effectiveness and injury mechanisms has been derived and documented (Green et al,1987).

In addition, other more theoretical investigations have been completed to estimate restraint-system effectiveness. These include studies using large collision databases to compare the type, severity and frequency of injuries of unrestrained occupants relative to restrained occupants. However, the results of these investigations can often be unreliable and misrepresent restraint system effectiveness because of fundamental differences between restraint users and non-users. For example, it has been demonstrated that restrained drivers tend to drive differently and become involved in different types of collisions than unrestrained drivers (O'Day and Flora,1982).

One technique which has successfully eliminated the potential biases inherent in these types of effectiveness studies is referred to as the double-paired comparison (Evans,1986a). This method considers vehicles containing two occupants (a "subject" occupant and a "control" occupant), at least one of whom is fatally injured. The probabilities of a fatality to the subject occupant under two conditions (ie. unrestrained and restrained) are compared. The control occupant simply provides a normalizing role. Evans has applied this technique (Evans,1986b) using data from the Fatal Accident Reporting System (FARS) in the United States to estimate the effectiveness of three-point lap and shoulder belts as being (42 ± 4)% effective in preventing a fatality for motor vehicle drivers; and (39 ± 4)% effective for motor vehicle passengers using lap and shoulder belts. The effectiveness of two-point lap belts used by outboard rear-seat passengers has subsequently been estimated to be (18 ± 9)% (Evans,1988). (In each case the error limit indicates one standard error.) These estimates of effectiveness are comparable to the results of a major review of the available knowledge regarding restraint system effectiveness completed by the National Highway Traffic Safety Administration (NHTSA,1984) prior to the widespread introduction of mandatory- use law in the United States.

A final technique used to assess seat belt effectiveness has involved evaluation of injury and fatality patterns in jurisdictions where seat belt use rates changed substantially over a short period of time. Such dramatic changes in use rates have occurred following the introduction of mandatory seat belt use legislation. With the recent introduction of these laws throughout the United States, a plethora of research has been conducted to evaluate the effectiveness of this type of legislation. As previously reported in other jurisdictions (Canada, the United Kingdom, France, Australia, and Germany) a wide range of methodologies have been used to examine the effectiveness of use laws. To relate these studies to this research effort, it is useful to consider the investigations in terms of:

- the source of the primary information (police-reported collision data; records compiled from hospital admissions; the combination of police and hospital records information; data from multi-disciplinary investigations; or other sources of information such as insurance-based records);
- the type and detail of the information used to measure the effectiveness of the legislation (total fatalities; total injuries; or detailed injury information describing the severity and distribution of injuries); and
- the techniques applied to determine the number of collisions or injuries which would have been expected had no legislation been introduced (simple before and after comparisons; time-series modelling; simple linear regression estimates, comparisons with control groups; or other techniques).

As illustrated in Table 3.1, the majority of studies reported in the literature use information obtained from police-based accident reporting programmes. This information generally provides data over a period of time to quantify the total number of fatalities or injuries occurring on a yearly or monthly basis. Other studies use more detailed injury information derived from hospital-based programmes. This data generally provides a greater insight into injury patterns by describing the frequency, type and severity of injuries sustained by persons involved in motor vehicle collisions. It is noteworthy that multi-disciplinary accident investigation data has not been used to evaluate the effectiveness of mandatory-use legislation.

Given the various sources of data, a wide range of techniques have been applied to estimate differences between observed injury patterns following the introduction of mandatory use legislation and the number and type of injuries which would have been expected had the legislation not been introduced. While the majority of these studies have generally associated the introduction of mandatory-use laws with a reduction of motor vehicle occupant fatalities and injuries, the extent of this reduction is rarely consistent, is often less than expected, and usually lacks statistical significance. This can be attributed, in part, to the observed change in actual seat-belt use rates, the

Study	Data Source					Measure of Effectiveness			Estimation Technique for Expected Incidents				
	1	2	3	4	5	1	2	3	1	2	3	4	5
(States et al 1989) Munroe County, NY, USA		●				●		●	●			●	
(Salmi et al 1988) Lyon, France		●			●			●	●		●		
(Wagenaar and Margolis. 1990), Michigan, USA			●				●			●			
(Lund et al 1987) 4 States, USA	●					●				●			
(Campbell et al 1989) 9 States, USA	●						●			●		●	
(Trinca and Dooley. 1977) Victoria, Australia	●					●	●				●		
(Henderson and Wood. 1973), N.S. Wales, Aust.	●					●					●		
(Pratt et al 1973) Victoria, Australia	●					●	●			●			
(Hoxie and Skinner. 1987), 17 States, USA	●					●							●
(McCartt et al 1987) New York, USA	●					●	●		●				

Data Source:
1-Police Only
2-Police & Hospital
3-Hospital Only
4-Multi-Disciplinary
5-Other

Measure of Effect:
1-Total Fatalities
2-Total Injuries
3-Injury Frequency Distribution/Severity

Estimation Techniques:
1-Before/After Comparisons
2-Time Series
3-Linear Regression
4-Use of Control Groups
5-Other

Table 3.1 Summary of some major studies describing the effectiveness of mandatory seat belt use legislation.

analytical methods used and, most importantly, the interaction of a number of factors which typically confound the analysis. These factors include the:

- normal variability of motor vehicle collisions and injuries;
- failure to establish a definitive technique to predict how many fatalities or injuries would have been expected had the legislation not been introduced;
- introduction of other legislative initiatives such as speed limit changes introduced at the same time as mandatory seat-belt use legislation; or
- selective recruitment of seat-belt users resulting in the use of seat belts by occupants who are less likely to become involved in a collision compared to non-users.

To apply these observations to the application of the safety model in Manitoba, two basic characteristics of motor vehicle drivers were investigated. The first is the actual change in observed seat belt use rates following the introduction of mandatory-use legislation. The second considers the possibility that those drivers who do choose to use their available restraints are those persons who are less likely to become involved in a collision.

To estimate seat-belt-use rates, results from annual observational surveys conducted by Transport Canada since 1979 were considered. These surveys use a stratified multi-stage probability sample design to estimate use rates in the general motoring population. In addition to these estimates, several other similar surveys were completed during the period following the introduction of the mandatory use legislation. These surveys were generally designed to replicate those conducted by Transport Canada. Included were surveys conducted for the Manitoba Traffic Safety Committee immediately prior to and following the introduction of the mandatory use legislation which came into effect on January 1, 1984; surveys designed and managed by the writer (Lai and Dalkie,1987); and surveys completed by others to document the effectiveness of Selective Traffic Enforcement Programmes (STEP) to increase the use of seat belts.

As illustrated in Figure 3.1, seat belt use rates by motor vehicle drivers (as measured by Transport Canada surveys) increased marginally from 6% to 10% between 1979 and 1983. With the commencement of a police enforcement programme in April of 1984, use rates may have increased from 32% to 82% before stabilizing at approximately 60% (as measured by others). Between 1985 and 1989, it can be observed that use rates have steadily increased and currently exceed 70%. It is noted that, during that time period, three Selective Traffic Enforcement Programmes were implemented. The first, initiated by the writer as Chairman of the Manitoba Selective Traffic Enforcement Committee (a sub-committee of the Manitoba Traffic Safety Committee), resulted in use rates increasing from 58% to 76% in the summer of 1985. The second campaign, completed in the spring of 1986, was somewhat less successful (increases in use rates from 65% to 75% were observed), while the third, in the fall of 1986, did not produce a measurable change in observed seat belt use.

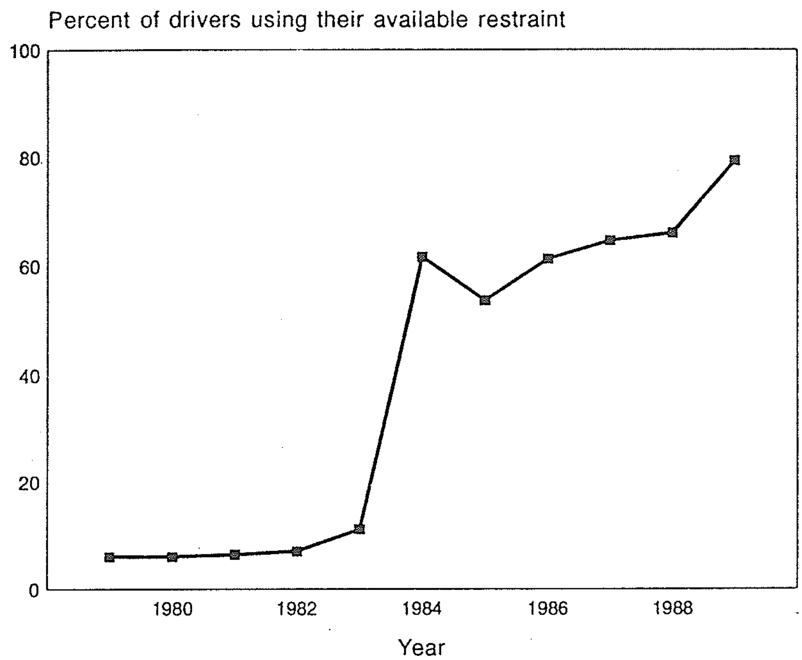

Figure 3.1. Seat belt use rates in the Province of Manitoba annual surveys completed by Transport Canada).

It is important to note that, while these surveys showed that introduction of mandatory seat-belt-use legislation was associated with a dramatic increase in the wearing of seat belts by Manitobans, they provided no insight into use rates by the crash-involved population. To investigate the relationship between seat-belt use and those exhibiting other forms of risk-taking behaviour, a supplemental investigation was undertaken by the writer (Dalkie and Mulligan,1987a). Four measures of driver risk-taking behaviour (not mutually exclusive) were considered: the number of collisions recorded on the driver's record; the number of convictions; the number of speeding violations; and the amount of fines paid due to speeding or other traffic-related convictions.

This investigation was based on observations of seat belt use made from surveys of seat belt use in June, 1985. During the roadside survey, 2,766 observations of drivers stopped at a traffic control device were made where the licence plate of the vehicle was also recorded. Based on the age and sex of the registered owner and the sex and estimated age of the observed driver, an attempt was made to determine whether the observed driver was the registered owner of the vehicle observed. Of the 2,766 observations, 488 (18%) failed to match because the age of the registered owner did not fall within the age category estimated by the roadside observer; 560 (20%) failed to match because the sex of the registered owner did not match the sex of the driver observed; 276 (10%) failed to match because the vehicle was registered as a commercial vehicle; 366 (13%) failed to match because a driving record could not be obtained; and 132 (5%) failed to match because it was likely that the licence plate number was erroneously recorded. While the remaining 944 observations were successfully matched, an additional 59 drivers were subsequently excluded from consideration because there was no restraint system available or the availability of the restraint system was unknown.

Analysis of these observations showed that unrestrained male drivers experienced more collisions; were more often convicted of a traffic-related offence or speeding violation; and were levied a greater amount of fines for traffic-related violations than restrained drivers. The results of this analysis are summarized in Tables 3.2 through 3.4.

Driver category	Restraint use	Number	Measure of risk taking behaviour			
			Collisions	Convictions	Speeding Violations	Fines
Male	Restrained Unrestrained	397 300	0.16 0.25	0.71 1.25	0.42 0.69	$33.45 $57.78
Female	Restrained Unrestrained	132 56	0.07 0.05	0.34 0.32	0.21 0.18	$21.90 $15.98
All Drivers	Restrained Unrestrained	529 356	0.14 0.22	0.62 1.11	0.37 0.61	$30.57 $51.21

Table 3.2 Average number of collisions, convictions, speeding violations per driver, and average amount of fines paid per driver by restrained and unrestrained drivers in Manitoba (Dalkie and Mulligan,1987a).

Measure of risk taking behaviour	Restraint Use				
	Sex		Age		
	Male	Female	< 25	25 to 50	> 50
No collisions One or more collisions	58% 53%	70% 75%	64% 63%	56% 53%	69% 55%
No convictions One or more convictions	60% 47%	71% 65%	71% 57%	58% 47%	70% 53%
No speeding violations One or more speeding violations	60% 45%	71% 60%	67% 59%	58% 45%	70% 30%
No fines Less than $200 in fines More than $200 in fines	60% 44% 50%	71% 57% 73%	69% 50% 65%	58% 45% 46%	70% 55% 33%

Table 3.3 Restraint usage based on driver age and sex and various measures of risk-taking behaviour in Manitoba (Dalkie and Mulligan,1987a).

Measure of risk taking behaviour	Estimate of relative odds by age group			
	Less than 25	25 to 50	Over 50	All drivers
Collision involvement	1.2	1.0	2.1	1.1
All traffic related convictions	2.1	1.3	2.5	1.5
Speeding violations	1.3	1.5	5.2	1.7
Fines paid due to convictions	1.7	1.3	2.5	1.5

Table 3.4 Estimate of relative odds of an unrestrained driver becoming involved in a collision, having a traffic-related conviction or speeding violation, or paying fines due to a traffic-related conviction in Manitoba compared to restrained drivers (Dalkie and Mulligan,1987a).

3.2 Application of the Collision Information System

The purpose of applying this component of the safety model within the context of investigating the introduction of mandatory seat-belt-use legislation is to:

- quantify the number of motor vehicle occupants sustaining an injury over a period of time prior to and following the introduction of the legislation; and
- compare the number of incidents occurring during the post-legislation phase to the number of incidents which would have been expected if the legislation had not been introduced.

This component was applied by analyzing the databases constructed from the automated police-reported collision data obtained from the Manitoba Motor Vehicle Branch. Using basic statistical analysis techniques, summary statistics were developed. Additional information describing similar police-reported data was obtained through analyses completed using the Traffic Accident Information Data system (TRAID).

While it can be shown that the number of injured motor vehicle occupants increased slightly between the two-year period following the introduction of mandatory-use legislation compared to the two years prior to its implementation (Figure 3.2), this change is of little significance without first estimating the number of incidents which would have been expected during the post-legislation phase had no such law been enacted.

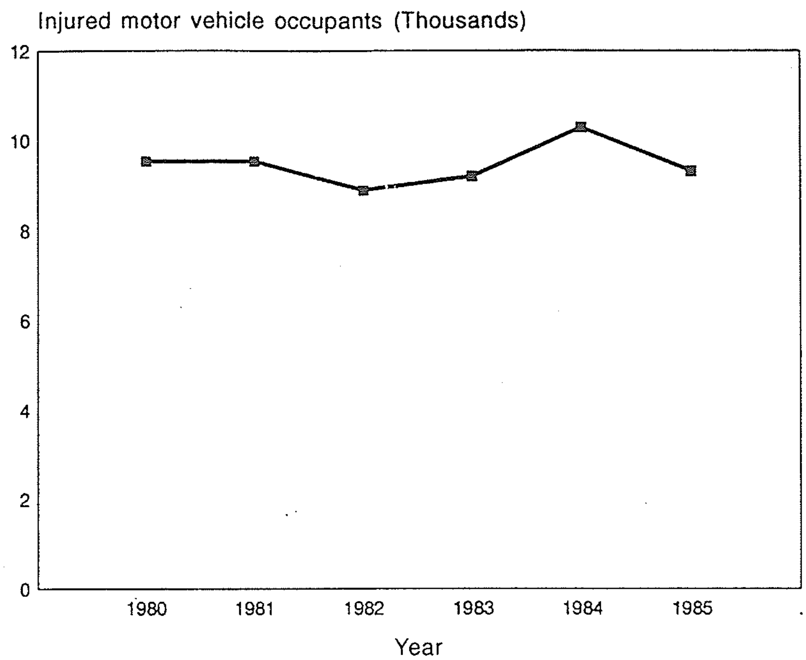

Figure 3.2. Injured motor vehicle occupants in Manitoba (Dalkie and Mulligan,1987a).

To estimate the <u>expected</u> number of incidents, several methods were considered. These methods involved the identification of the following control groups or trends:

- the change in the number of pedestrians and cyclists injured in the two-year post-legislation period compared to the two-year pre-legislation period in Manitoba;

- the number of vehicle occupants injured in collisions throughout Canada, between 1980 and 1985; and
- the number of vehicle occupants injured in collisions occurring in British Columbia, Alberta, Saskatchewan, Ontario and Quebec between 1980 and 1985.

By applying these different techniques, no clear evidence could be produced to definitively support a conclusion regarding the possible effect introduction of mandatory seat-belt-use legislation had on the incidence of injured motor vehicle occupants (Dalkie and Mulligan,1987a). For example, if the number of injured pedestrians in Manitoba was used as a control group, it could be argued that introduction of mandatory-use legislation increased the number of motor vehicle occupants. Conversely, if the number of injured motor vehicle occupants in other provinces injured between 1980 and 1986 were considered, a positive effect of the legislation might be inferred.

Notwithstanding the lack of any apparent trend or useful information derived from this component of the model, it is also recognized that a fundamental change in the method of reporting collisions occurred co-incident with the introduction of mandatory-use legislation in Manitoba. The actual police report form including the description of injuries underwent a major change and the police officer rather than the person involved was required to complete the new report forms.

Such major changes in the reporting system and the marginal changes in motor vehicle occupant injuries which were reported preclude a more rigorous analysis of this information. As a result, the application of the Collision Information System could not be used to determine any causal relationship between the number of motor vehicle occupants sustaining injuries and the introduction of mandatory seat-belt-use legislation in Manitoba.

3.3 Application of the Injury Information System

The purpose of applying this component of the safety model is to assess the number and pattern of injuries sustained by road users during the two-year period following the introduction of mandatory seat-belt-use legislation (1982-1983) compared to the two-year period prior to its introduction (1984-1985). As shown in Table 3.5, more than 700 persons sustained injuries of a severity AIS$\geq$1 during the two-year pre-legislation period. Additionally, almost 600 sustained injuries of a severity AIS$\geq$2, while over 200 sustained injuries AIS$\geq$3. In each injury severity category (AIS$\geq$1; AIS$\geq$2; AIS$\geq$3), little change was observed between the pre- and post-legislation periods.

Maximum Injury Severity	Time Period	Motor Vehicle Drivers	Motor Vehicle Passengers	All Occupants
AIS1	Before (1982-83)	774	753	1527
	After (1984-85)	783	702	1485
AIS2	Before (1982-83)	572	541	1113
	After (1984-85)	551	511	1062
AIS3 or greater	Before (1982-83)	250	227	477
	After (1984-85)	264	226	490

Table 3.5 Change in the number of occupants, by overall injury severity, admitted to hospital following the introduction of mandatory seat-belt legislation, by overall injury severity, in Manitoba (analysis of hospital-based injury data using the Injury Information System).

However, when the pattern of AIS$\geq$3 to 5 injuries was considered, 6% fewer injuries in this severity range were reported in the post-law period compared to the two-year period preceding the introduction of the use law. Decreases in injuries to the head, face, neck, in most cases untreatable, were observed while incidence of more treatable chest and abdominal injuries were observed to increase. These observations are illustrated in Figure 3.3 (motor vehicle drivers only) and Figure 3.4 (motor vehicle passengers only). (The primary data for these figures is contained in Appendix G.)

While the application of the Injury Information System provided some basic information regarding the pattern of injuries sustained by motor vehicle occupants prior to and following the introduction of mandatory seat-belt-use legislation, no definitive change occurred which could reasonably be attributed to the introduction of the legislation.

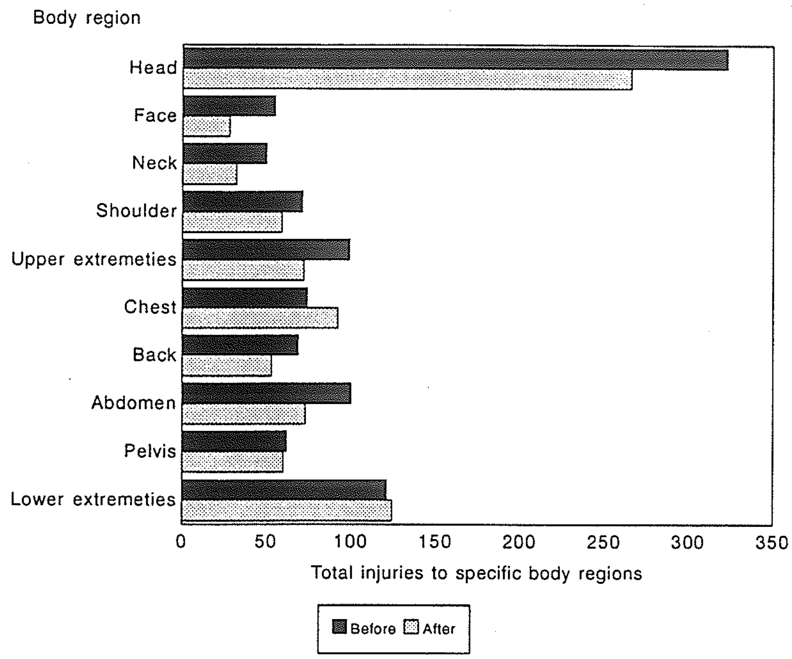

Figure 3.3. Total number of injuries (AIS≥2) sustained by motor vehicle drivers prior (1982-1983) to and following (1984-1985) the introduction of mandatory seat-belt-use legislation in Manitoba (analysis of hospital-based injury data using the Injury Information System).

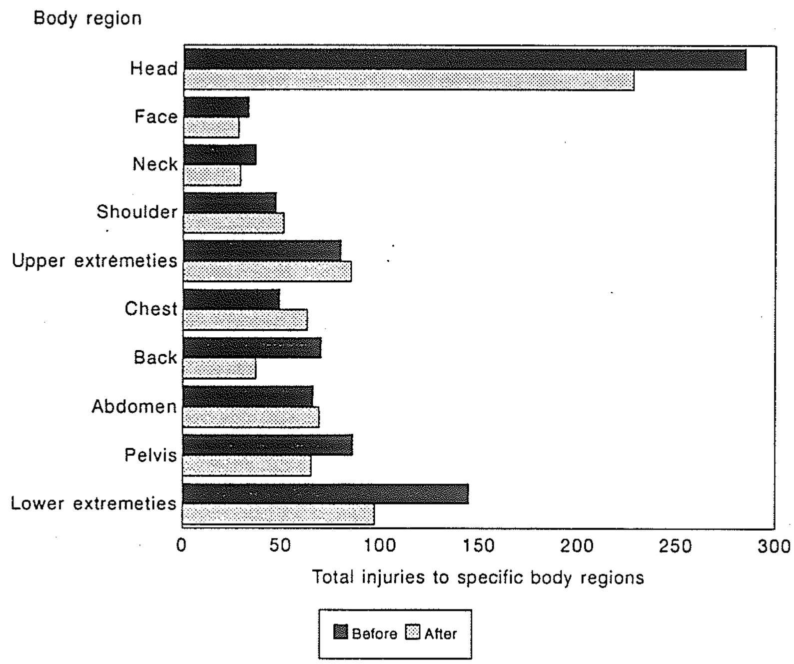

Figure 3.4. Total number of injuries (AIS≥2) sustained by motor vehicle passengers prior (1982-1983) to and following (1984-1985) the introduction of mandatory seat-belt-use legislation in Manitoba (analysis of hospital-based injury data using the Injury Information System).

3.4 Application of a System of In-depth Collision Investigations

The application of this component of the model involved implementation of the framework for conducting such a programme of in-depth collision investigations. As previously described, the key elements of this programme are:

- definition of objectives;
- determining the scope of the activity or the concept;
- establishing basic data and reference requirements;
- identifying appropriate personnel to assist in the completion of this multi-disciplinary activity;
- establishing the necessary data collection, data assurance and analysis protocol;
- application of the framework through completion of the collision investigations;
- completion of the analysis to fulfil the objectives as defined.

The following discussion describes these elements as part of a framework for an in-depth collision investigation programme implemented as a component of the general safety model.

Objectives

The primary rationale for completing this component of the model was to define injury causation mechanisms and human tolerance levels thereby permitting an assessment of the potential for injury reduction had an unused seat belt been correctly used; or the probable effect of seat-belt use as a contributor to injury when a restrained occupant was fatally injured.

Scope of the activity or concept

To facilitate the accomplishment of these objectives, a comprehensive field-data collection programme was proposed to consider all collisions involving a fatally-injured motor vehicle occupant during the two-year period following the introduction of mandatory seat-belt-use legislation.

Data requirements and reference material

To achieve the above-noted objectives, typical Level 2 and Level 3 data collection programmes were investigated (ie. Transport Canada's Passenger Car Study (PCS) and early multi-disciplinary investigations (MDAI) as well as the National Highway Traffic Safety Administration's NASS Programme in the United States). Typical data elements which were most important in assessing seat belt use and effectiveness were identified for special consideration. These include:

- assessment of the principal direction of force;
- extent of vehicular crush;
- intrusion into the occupant space; and
- type and damage to the available restraint system.

The data quality reference manual adopted for use in completing the PCS programme (Dalkie et al,1986) and other material from the NASS programmes were also used to develop a comprehensive resource base from which data would be appropriate collected. Specific data collection forms to assist in the investigation were also developed (Appendix H).

Personnel

Due to the emphasis on injury mechanisms and injury tolerance in this application of the model, the personnel required to complete the application of this component must include those with specialized collision investigation experience. As a result, the data-collection activity relied on the assistance of members of the University of Manitoba Road Safety Research Unit (RSRU).

Protocol

To achieve the previously-noted study objectives, the protocol developed to investigate targeted collisions was based on the following criteria:

- the scene of the collision involving a fatally-injured motor vehicle occupant should be attended by the writer or experienced member of the Road Safety Research Unit (RSRU) within 24 hours;

- detailed inspection of all vehicles involved in all incidents should be competed within 72 hours by the writer or a member of the RSRU; and
- data-collection forms designed by the writer specifically for the purpose of this research, documenting environmental, vehicular, and human factors should be completed by those conducting the initial investigations.

For each collision investigated as part of this research, a comprehensive analysis was undertaken by the writer. This included a defensible reconstruction of the incident, an assessment of crash severity and determination of injury causation mechanisms. The reconstruction of the collision was completed using all available information and applying typical analytical accident-reconstruction techniques. The severity of the collision was also objectively assessed using a standard computer algorithm (CRASH3). The addition of other information such as maintenance of occupant compartment integrity, direction of applied forces and occupant kinematics enabled a reasonable measure to be made of the exposure to injury experienced by the occupants. Estimates were then made to identify the probable injury sources and mechanisms in the context of accepted injury tolerance levels of various body systems and organs. This element of the research was assisted by a trauma surgeon with in-depth knowledge on injury-causation mechanisms, human response to impact stress, and the reconstruction of motor vehicle collisions.

Results

To permit peer review of this element of the research and demonstrate the credibility of analysis, the results of this data-collection effort were extensively documented (Dalkie and Mulligan,1987b). For each collision, an annotated case narrative was completed providing salient details characterizing the collision event. In addition, a scene diagram illustrating the vehicle and occupant kinematics was completed. The document also contained a series of representative photographs which are essential to the documentation and presentation of analysis and conclusions. Appendix I documents the format developed by the writer for presenting data obtained through multi-disciplinary collision investigations. Supplemental documentation describing details of injuries sustained by each involvee and the results of the crash severity analysis is available for inspection at the RSRU.

Of the 154 fatally-injured occupants involved in collisions investigated as part of this research effort during the two years following the introduction of mandatory seat-belt-use legislation, use of the available restraint system could not be ascertained in three instances (Dalkie and Mulligan,1987a). Two involved vehicle submersions in water, while sufficient information was not available to determine restraint system use for the third. Similarly, those persons not occupying a seating position where a restraint device was available (ie. the rear of a light truck) were not considered. Effectively, this leaves 145 out of 151 fatalities available for analysis. In addition, three fatally-injured occupants, situated on the lap of another occupant, were not included in this sample because no appropriate restraint device was available to afford protection to the fatally-injured occupant.

During the two years following introduction of mandatory seat belt use legislation, 43 occupants were fatally injured while using their available occupant restraint system, representing 28% of all fatally injured motor vehicle occupants. (This represents 30% of all fatally-injured occupants available for subsequent analysis.) These collisions were studied to determine how use of the seat belt affected the severity of injuries sustained by the deceased. Three basic categories were identified and classified as to whether use of the seat belt:

- reduced the overall severity of injuries, yet did not prevent a fatality;
- did not affect the severity of the injuries sustained; or
- resulted in injuries which were more severe than those which would have been received had the occupant been unrestrained.

Twenty-eight occupants who were fatally injured while wearing a three-point restraint system were involved in a collision so severe that survival, whether the available restraint system was used or not, was highly improbable. There were instances in these severe collisions where use of the restraint probably reduced the severity of injuries sustained by a body region, yet the cumulative effect of injuries to multiple body regions was severe enough to cause death.

Seven occupants restrained with three-point belts died in collisions which were deemed survivable. The fatal outcome in these events was attributed, in part, to advanced age (four); partial ejection of the driver during a complex roll-over sequence (one); and, partial ejection of the driver wearing the torso portion under the arm (one) during a simple roll-over. The seventh was a restrained driver involved in a frontal collision, who had moved the front seat to the full forward position. During the impact she sustained a severe head injury as a result of striking the steering wheel during webbing "spool out" and stretch. In each of these incidents it was concluded that the use or misuse of the restraint system did not cause injuries which were greater than those expected had the victim not been restrained.

Eight occupants were fatally injured while wearing two-point lap belts. Five were front seat occupants involved in a roll-over. Three were seated in the rear of vehicles involved in a frontal collision. All front seat fatalities occurred when the occupant was partially or, in one case, completely ejected during the collision. It was considered highly probable the injuries sustained by these occupants would have been similar had they been unrestrained. Three lap-belted rear seat occupants sustained injuries of a severity greater than expected had the restraint system not been used. In each case,the occupant was wearing a lap belt in the rear seat of a vehicle involved in a frontal impact. In one involving a central frontal impact with a tree, the occupant died from a ruptured abdominal aorta from lap-belt loading while four unrestrained occupants survived with only minor injuries. Crash data prior to impact showed that the lap belt was correctly applied over the load resistant region of the pelvis but moved up onto the soft part of the abdomen as he submarined due, in part, to the soft bench seat. In a second incident, a male age 88 died of massive skeletal and visceral injuries to the chest and abdomen. (A lap-belted female, age 60, seated beside him also sustained life-threatening injuries to a hollow abdominal viscus.) The third and final lap-belted fatality was a female, age 59, who died from a ruptured abdominal aorta and laceration of the small and large bowel mesentery. In the first two cases the involved vehicle was a full-sized American sedan; the third was a late-model mini-van.

In the two years following introduction of mandatory seat belt use legislation, <u>102 unrestrained motor vehicle occupants were fatally-injured</u>. This represented approximately 70% of all fatally injured motor vehicle occupants available for analysis. The collisions which resulted in these fatalities were analyzed to assess how use of the available occupant restraint system would have affected the severity of injuries and outcome. The method used to estimate the potential effectiveness of the available restraint system was based on an assessment of four collision-based parameters and three occupant-specific characteristics. The collision-based parameters include:

- the direction of principal force applied to the subject vehicle;
- the extent of crush to the vehicular structure;
- the extent of intrusion into the occupant space due to the vehicle deformation or intruding objects; and

- the estimated velocity change during the violent phase of the collision.

The occupant-specific parameters include:

- the seat position of the fatally-injured occupant;
- the type of occupant restraint available (ie. a three-point lap and shoulder restraint or a two-point lap belt); and
- the physical characteristics of the occupant (ie. age and infirmity) with respect to ability to tolerate forces generated during the collision.

In addition, additional factors such as outcomes in similar collision configurations and the outcome experienced by other occupants in the motor vehicle were considered in developing a conservative estimate of the probable effectiveness of the available seat belt. For each fatally-injured occupant, this estimate was made independently by the writer and a trauma surgeon with extensive experience in injury mechanisms, human tolerance to injury and motor vehicle crash reconstruction. These estimates were then jointly reviewed to provide an agreed upon estimate of potential effectiveness. The actual scale used to estimate the probable effectiveness of a seat belt in preventing death was as follows:

- $0 \leq 10\%$ (essentially no change for survival);
- $10 \leq 30\%$ (survival possible but unlikely);
- $30 \leq 60\%$ (survival probable);
- $60 \leq 90\%$ (survival very likely); and
- $90 \leq 100\%$ (survival essentially certain).

Of the 102 unrestrained fatally-injured motor vehicle occupants, estimates of potential restraint system effectiveness was made for 98 occupants. (In four cases, insufficient data was available to provide a reasonable basis from which to assess the potential effectiveness of the available restraint.) Of these occupants, survival was considered essentially certain ($P= 0.9 \leq 1.0$) in 34 cases; very likely ($P= 0.6 \leq 0.9$) in 13 cases; probable ($P= 0.3 \leq 0.6$) in 10; possible ($P= 0.1 \leq 0.3$) in 5; and highly improbable ($P= 0 \leq 0.1$) in 36 cases.

To calculate the number of possible lives which could have been salvaged, the number of occupants in each category of effectiveness was multiplied by the probability of survival estimates. Summation of these estimates then provided a range of effectiveness from which the potential number of lives saved was determined. Based on a clinical assessment of unrestrained motor-vehicle-occupant fatalities, therefore, it was estimated that proper use of the available restraint system would have prevented between 41 and 57 deaths during the 2-year period following the introduction of mandatory seat-belt-use legislation. This can be expressed as follows:

Number of Lives Saved (minimum) = (0.9)(34)+(0.6)(13)+(0.3)(10)+(0.1)(5)+(0)(36) = 41
Number of Lives Saved (maximum) = (1)(34)+(0.9)(13)+(0.6)(10)+(0.3)(5)+(0.1)(36) = 57

In summary, the application of the third component of the general safety model (a framework for conducting a programme of in-depth collision investigations) provided the opportunity to assess the impact of seat-belt-use legislation on a specific subset of all collisions: those collisions involving a fatally injured motor vehicle occupant. Based on the programme of in-depth collision investigations developed and applied as part of this research, observations were made which:

- documented the failure to use the available restraint systems by the majority of fatally-injured motor vehicle occupants during the two-year period following the introduction of the seat-belt-use law;
- determined that a substantial proportion of these fatally-injured motor vehicle occupants would probably have survived had the available restraint device been used during the collision;
- identified the limitations of seat belts in protecting involvees in severe collisions; and
- provided further documentation related to the limited effectiveness of two-point lap belts, particularly those located in rear-seating positions.

Chapter 4. Model Application: Introduction of Mandatory Motorcycle Helmet Use Legislation in Manitoba

4.1 Background

To complement the application of the proposed model to assess the introduction of mandatory motorcycle helmet-use legislation in Manitoba, several initiatives were completed by the writer. These investigations assessed the existing state of knowledge regarding what is known about the general effectiveness of motorcycle helmets, the effectiveness of helmet-use legislation as well as what is known about helmet usage by motorcyclists in Manitoba. As previously described, these data sources, research activities or ad hoc requirements will be required whenever the model is applied.

The following discussion describes appropriate background information by considering:

- motorcycle helmet effectiveness;
- the effectiveness of motorcycle-helmet-use legislation; and
- helmet usage in Manitoba.

As discussed by Pedder, the effectiveness of motorcycle helmets was first observed during the 1940's (Pedder et al,1985). While numerous programmes based on in-depth collision investigations have been completed since then, one of the most comprehensive studies related to the efficiency of helmets was completed in the State of California (Hurt,1981). Considering helmet effectiveness, it was concluded that given collisions of the same severity, a motorcyclist using a helmet had a lower probability of sustaining a head injury than an un-helmeted motorcyclist. In addition to this particular study and other similar in-depth investigation programmes, the effectiveness of motorcycle helmets has been determined using the double-pair comparison techniques described previously (Evans,1986a). Using data from the Fatal Accident Reporting System (FARS) data base between 1976 through 1986, it was concluded that helmets were $(28 \pm 8)\%$ effective in preventing fatalities to motorcycle riders (Evans and Frick,1988). (In each case, the error limit indicates one standard error.)

With the completion of in-depth collision investigation programmes demonstrating the utility of helmets, many countries introduced mandatory-use laws during the 1960's. The most significant estimate of the effectiveness of these legislative interventions used data from the United States during the mid-1970's and early 1980's. At this time, many states had introduced mandatory-use laws because the Department of Transportation was required to withhold funds to states which did not pass laws mandating the use of motorcycle helmets. However, as a result of subsequent legal challenges a number of states repealed or weakened their legislation during the 1970's. Thus, a unique opportunity was presented to assess the impact of these legislative changes.

To quantify the impact of this change, two types of studies were conducted. The first involved a simple before/after approach and considered injuries sustained by motorcyclists in a particular state where the legislation was repealed. In this case, the number of motorcyclists injured prior to the change in the legislation was compared to the number injured following the change in legislation. While these studies generally indicated that a decrease in helmet use was associated with an increase in head injuries and deaths, the analyses did not attempt to predict how many deaths or injuries would have been expected had the legislation not been changed.

The second approach involved the examination of the number of fatalities occurring in those states where helmet use legislation was repealed, compared to the number of fatalities observed in states where the legislation did not change. While initial estimates of the effect of motorcycle helmet use legislation ranged from being negligible (Adams,1983) to causing a 40% increase in fatalities (Watson et al,1981), a subsequent comprehensive investigation concluded that motorcyclist fatalities increased by 25.6% in states where helmet use legislation was changed compared to states where the legislation was not changed (Chenier and Evans,1987). These differences in determining the effect of this legislative change can be attributed to the analytical techniques used and the means by which the expected number of fatalities was estimated.

To provide appropriate background data to apply the model to the assessment of mandatory motorcycle helmet-use legislation in Manitoba, estimates of helmet use were determined by the writer. Because no regular programme was in place to estimate the use of helmets, two methods were used to estimate use in the two-year period prior to the introduction of the legislation and the two-year period following its introduction. Since no observation-based data were available to describe helmet use in the pre-legislation time period, the Collision Information System was applied to provide an estimate of usage by motorcyclists involved in a collision during 1982 and 1983.

This methodology assumed that a reasonable estimate could be made based on self-reported use. (Since no law was being contravened and no other incentives were provided, a non-user would not obviously be encouraged to be untruthful.) Self-reported use rates associated with motorcyclists involved in collisions of varying degrees of severity were determined. As indicated in Table 4.1, helmet use by motorcyclists involved in a property-damage-only collision (ie. no reported injuries) was comparable to usage reported by motorcyclists sustaining minor (not hospitalized) and more severe injuries (requiring hospitalization). Given this relationship and the observation that the threshold for reporting of motorcycle collisions in the Province is very low (based on a detailed manual review by the writer of all police-reported collisions involving a motorcycle in 1983), it was concluded that use rates in the general riding population would not have been substantially different.

Injury Severity	1982	1983	1984	1985
Not injured	24%	27%	UNK	--
Injured (Not Hospitalized)	32%	29%	85%	--
Injured (Hospitalized)	25%	27%	82%	--
Observed - Spring - Fall	-- --	-- --	-- 96%	96% 86%

Table 4.1 Estimates of helmet use by motorcyclists in Manitoba, 1982-1985, (Dalkie and Mulligan,1987a).

To estimate helmet use in the two year post-legislation time period, three surveys were designed and managed by the writer. Observations were taken between 0730 hrs and 2400 hrs and were made at sites selected to maximize the total number of observations. Over 2,000 observations throughout the Province were made during the conduct of these surveys. Based on these observations, it can be assumed that helmet-use rates increased from between 25 and 30 % during the two-year period prior to the introduction of mandatory use legislation to over 85% following its enactment.

4.2 Application of the Collision Information System

The purpose of applying this component of the safety model within the context of investigating the introduction of mandatory motorcycle-helmet-use legislation is to:

- identify any changes in the number of motorcycle collisions occurring during a period of time following the introduction of mandatory helmet-use legislation; and

- consider the relationship between the observed number of injured motorcyclists in the two-year post-legislation period and the expected number of motorcyclists who would have been injured during the same time period.

This component of the model was applied by analyzing the databases constructed from the automated police-reported collision data obtained from the Manitoba Motor Vehicle Branch. Using basic statistical analysis techniques, summary statistics were derived and combined with the similar police-reported data obtained through analyses completed by others using the Traffic Accident Information Data system (TRAID).

By applying the Collision Information System, it can be determined that the number of collisions involving non-fatally-injured motorcyclists declined by 25% during the two-year post-legislation period compared to the two-year pre-legislation period. Considering other data from the TRAID database, it can also be shown that, while this observed change was similar to that experienced in Saskatchewan, motorcyclist injuries sustained in Ontario continued to increase from 1982 to 1985 (Dalkie and Mulligan,1987a).

Again, the lack of an appropriate control group from which to estimate the expected number of injured motorcyclists confounds a rigorous use of this data. If the number of motorcyclists injured in Saskatchewan was used as a control group, introduction of mandatory helmet-use legislation in Manitoba could be shown to have no effect on the number of injured motorcyclists. In contrast, if the number of motorcyclists injured in Ontario was used as a control group, introduction of mandatory helmet-use legislation in Manitoba could be shown to have a positive effect, reducing the number of injured motorcyclists relative to the expected number of incidents. Of course, the major change (in January 1984) in the way injuries were described in the standard police reporting system and the methods used to complete the forms severely limits any further analysis of this data.

However, when the police-reported data describing properly-damage-only collisions is considered, interesting results become apparent. It can be shown that not only did the incidence of injured motorcyclists decrease during the two-year period following the introduction of mandatory helmet-use legislation, the number of property-damage-only collisions also declined by an equivalent amount. Thus, any attempts to associate changes in the number of injured motorcyclists with the introduction of mandatory helmet-use legislation must recognize that motorcycle collisions of all types were observed to decrease. This is important because it is anticipated that the impact of mandatory helmet-use legislation on property-damage-only collisions could either have been negligible or should have caused an increase in the number of police-reported events. The rationale for this conclusion is as follows:

The number of property-damage-only collisions could remain unchanged because: assuming that a collision of a severity = P occurred during the pre-legislation period, it would not result in any injury to the motorcyclist but would be reported as a property-damage-only collision; during the post-legislation period, the same collision (severity = P) would also be reported as a property-damage-only collision since the increased probability of helmet use by the motorcyclist would not affect the injury producing potential of the event.

On the other hand, the number of property-damage-only collisions could be expected to increase because: assuming that a collision of a severity > P occurred during the pre-legislation period, it would be reported as a personal injury collision; during the post-legislation period there is a higher probability that this incident would be reported as a property damage only collision since the potential of a motorcyclist sustaining an injury has decreased with an overall increase in helmet use.

Since the number of property-damage-only collisions were found to decrease substantially, the number of injured motorcyclists would also be expected to decrease. As a result, it is essential to recognize this trend when assessing more detailed injury trends. In particular, it is important to determine whether the incidence and number of injuries sustained by motorcyclists can be attributed to:

- reducing the probability of a motorcyclist sustaining a head injury during a collision (through the protection of the head), or
- reducing the probability of a motorcyclist being involved in a collision in the first instance (no effect of increased probability of head protection being worn).

In the latter case, there is some evidence that exposure levels decreased due to significantly better weather during the two-year post-legislation period and also anecdotal suggestions (based on the completion of in-depth collision investigations) of a possible reduction in kilometres travelled by motorcyclists dissuaded from riding due to the imposition of the law. (The total number of motorcycles registered in Manitoba actually increased by 3% during this time period.)

In summary, this component of the safety model was used to consider the overall change in motorcycle collisions during the two-year period following the introduction of mandatory helmet-use legislation compared to the two-year period prior to its introduction. It was determined that a change in number of injuries was observed; however, it was also noted that this change may not be attributable to the introduction of mandatory use law. Specifically, the number of motorcycle-involved collisions resulting in property damage only was found to decrease during the post-legislation period. This evidence is most important when considering the results of the second component of a general safety model, the more detailed assessment of the type and severity of injuries sustained by motorcyclists which cannot be determined by applying the Collision Information System.

4.3 Application of the Injury Information Data System

By applying the Collision Information System, evidence was produced describing a reduction in the number of motorcyclists injured in the two-year period following the introduction of mandatory helmet-use legislation compared to the two-year pre-legislation period. However, changes in the police accident report system (as described in Section 3.2.2) and the inability to assess the nature of injuries sustained by injured motorcyclists clearly suggests that a more comprehensive analysis is required. This analysis, including a detailed assessment of the number and pattern of injuries sustained by motorcyclists, can be generated through application of the second component of the safety model, the Injury Information System.

Using this component, it can be shown that the change in the number of motorcyclists admitted to hospital following a collision is comparable to the change in the number of motorcyclists reported injured through the application of the Collision Information System. The number of police-reported injured motorcyclists declined by 26% and the number of motorcyclists whose most severe injury was AIS$\geq$1 also decreased by 23% during the post-legislation time period. The number with AIS$\geq$2 injuries decreased by 24% while the number with AIS$\geq$3 injuries decreased by 15%, compared to the two-year pre-legislation period.

To assess whether this change in the number of injuries can be attributed to the introduction of motorcycle helmet-use legislation, this component of the overall safety model was applied to quantify the number of injuries (AIS$\geq$2) sustained by <u>different body regions</u>. Figure 4.1 describes this change in the average number of injuries sustained annually by motorcycle drivers following the introduction of mandatory helmet-use legislation. Figure 4.2 describes the change in the average number of injuries sustained annually by motorcycle passengers following the introduction of the law.

Based on the application of the Injury Information System, the total number of injuries (AIS≥2) sustained by all riders was observed to decrease, and the greatest reduction occurred in injuries to the head, face and neck regions. Head injuries were reduced by 58%, face injuries by 43% and neck injuries by 77%.

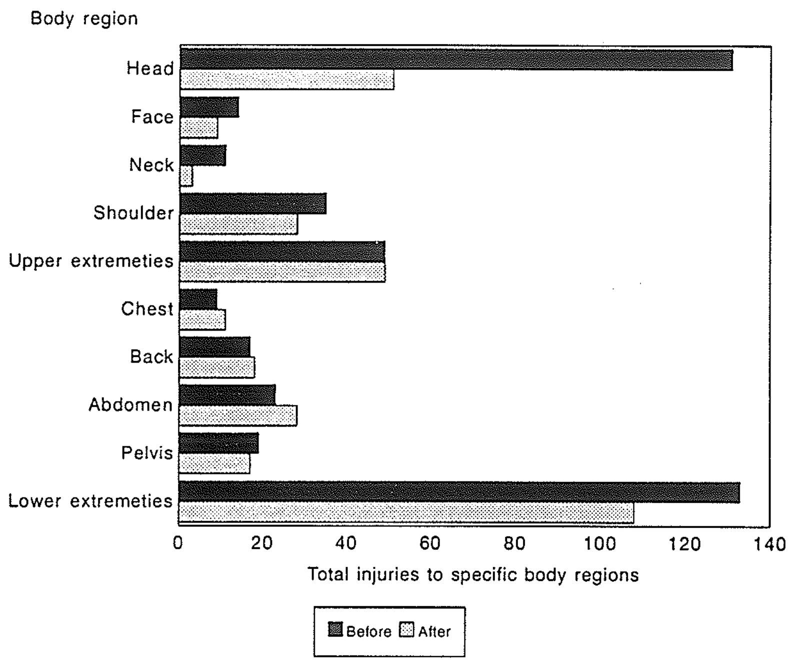

Figure 4.1. Total in the average number of injuries (AIS≥2) sustained by motorcycle drivers prior (1982-1983) to and following (1984-1985) the introduction of mandatory helmet-use legislation (analysis of hospital-based injury data using the Injury Information System).

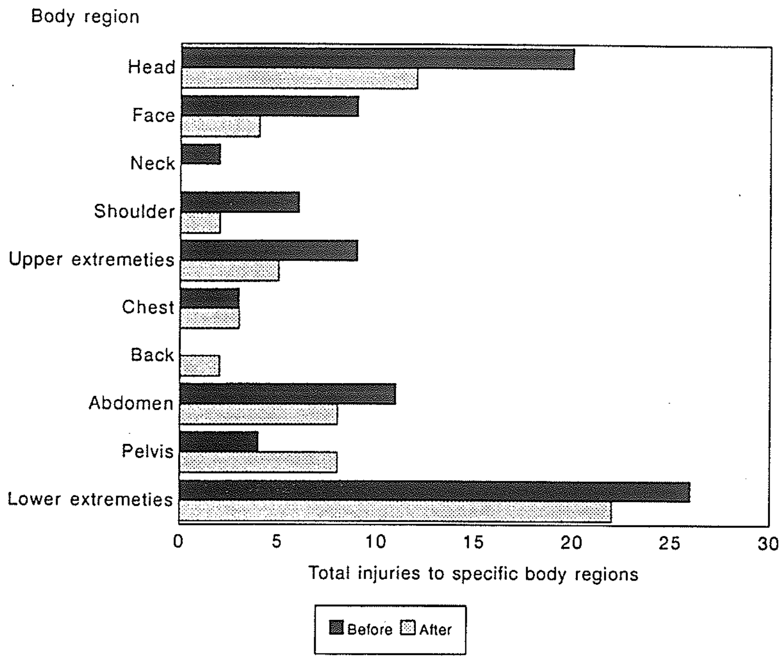

Figure 4.2. Total in the average number of injuries (AIS$\leq$2) sustained by motorcycle passengers prior (1982-1983) to and following (1984-1985) the introduction of mandatory helmet-use legislation (analysis of hospital-based injury data using the Injury Information System).

A second means of assessing the change in injury patterns is to consider the number of injured persons rather than the number of injuries. In this analysis, the number of persons who sustained an injury to the head was determined and compared to the number of persons sustaining injuries to body regions other than the head or face. (It is noted that these two categories are not mutually exclusive since a person could sustain injuries to the head as well as to other body regions.)

Considering only motorcycle drivers, it was noted that persons sustaining head injuries decreased by 58% during the two-year post-legislation period compared to the two-year pre-legislation period while persons sustaining injuries to body regions other than the head or face decreased by only 9%. This change in the distribution of injuries sustained during the post-legislation period compared to the pre-legislation period is described in Figure 4.3.

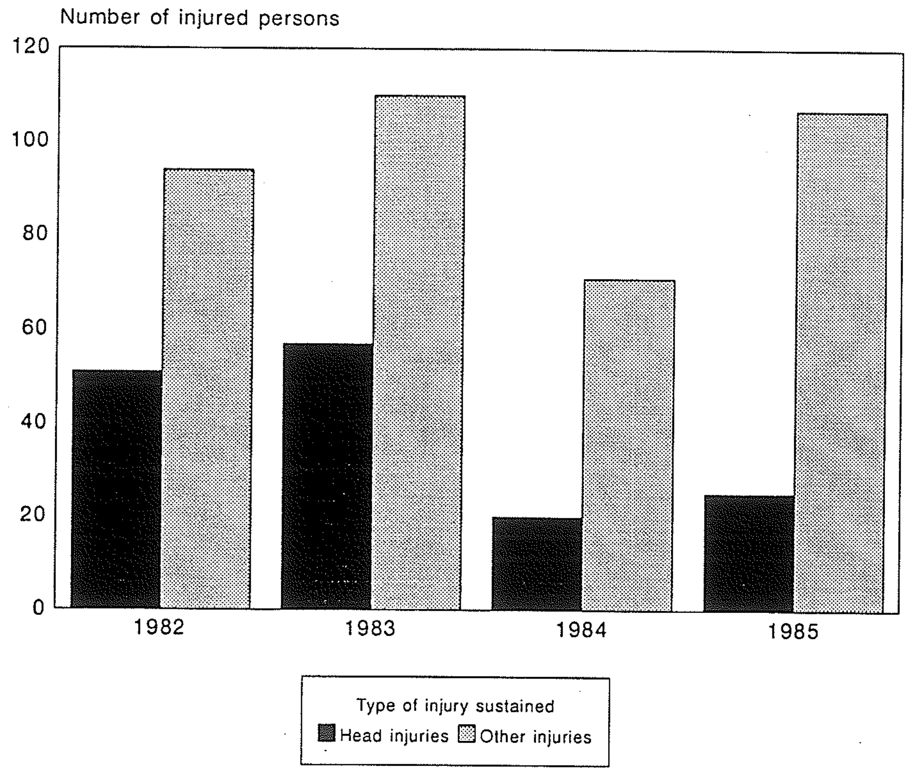

Figure 4.3. The number of motorcycle drivers sustaining injuries to the head compared to persons sustaining injuries to body regions other than the head or face (analysis of hospital-based injury data using the Injury Information System).

These observations are consistent with the hypothesis that use of a motorcycle helmet should reduce the probability a motorcyclist involved in a collision would sustain a head or face injury if the helmet worn provides full protection and not necessarily affect the probability a motorcyclist would sustain an injury to another body region (ie. an injury to the abdomen or lower extremity).

This analysis is most useful if it is assumed that injuries sustained to body regions other than the head or face are not related to helmet use and that hospitalization as a result of these injuries is independent of any injuries to the head. Given this assumption, then the number of persons sustaining injuries to regions other than the head or face could be used as a control to estimate the expected number of persons sustaining head injuries during the two year post-legislation period.

As shown in Figure 4.3 the number of motorcycle drivers sustaining head injuries (AIS≥2), during the two-year post-legislation period decreased substantially compared to the two-year pre-legislation period. In contrast, drivers sustaining injuries to body regions other than the head or face decreased only marginally during the same period. Compared to the expected number of persons sustaining head injuries (based on the number of persons sustaining injuries to other body regions), it was concluded that the number of motorcycle drivers sustaining head injuries decreased by 32% during the post-legislation period. This decrease is highly significant ($p<0.001$). the number of motorcycle passengers sustaining head injuries also declined but the change was not significant. When all riders were considered as a group, the number of persons sustaining head injuries decreased by 29% ($p<0.001$). In addition, facial injuries to both drivers and passengers decreased by 35% although only the change in injuries to drivers was statistically significant ($p<0.05$).

To test whether differences in the number motorcyclists sustaining head injuries might be due to an unknown anomaly associated with the data base or the injury reporting system, two other groups of road users were examined. As described in Figure 4.4 there was an <u>increase</u> in the bicyclists sustaining head injuries and a corresponding increase in the proportion of head injuries.

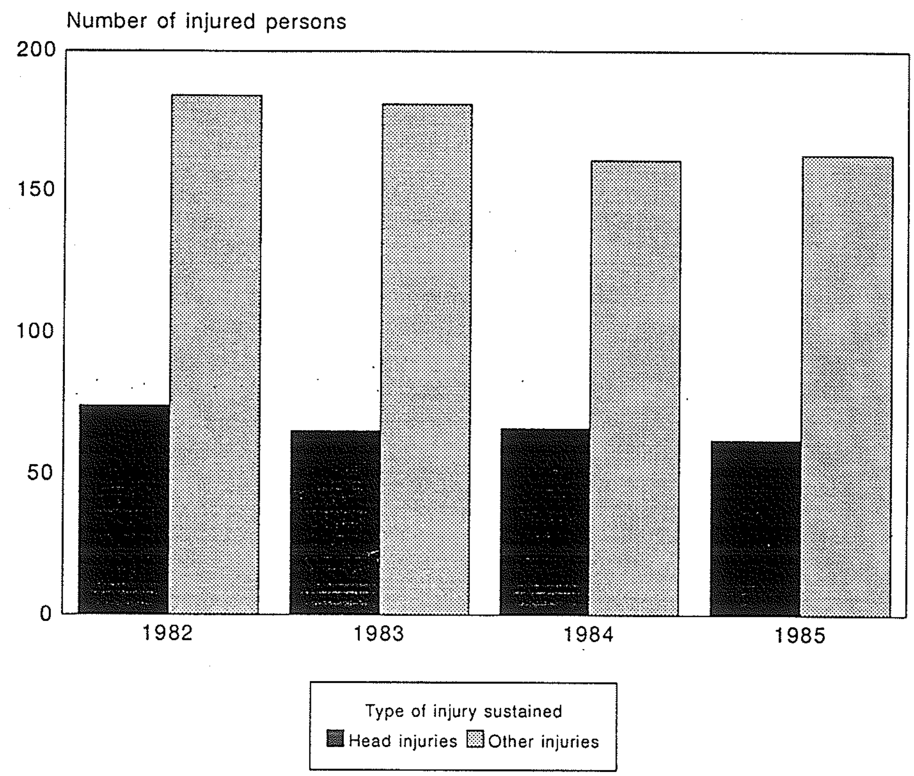

Figure 4.4. The number of bicyclists sustaining injuries to the head compared to the number sustaining injuries to body regions other than the head or face (analysis of hospital-based injury data using the Injury Information System).

When injured pedestrians were considered (Figure 4.5), the total number of pedestrians injured and the distribution of the injuries sustained was shown to be relatively constant over the four-year period. Comparing the number of persons sustaining head injuries to all injuries between 1982/1983 and 1984/1985, bicyclists sustaining head injuries increased by 15% while pedestrians sustaining head injuries increased by 7%. Neither change was statistically significant. As a result, since the frequency of head injuries to pedestrians or bicyclists did not decline, it is highly unlikely that the decrease in the number and proportion of motorcyclists sustaining head injuries can be attributed to factors other than the introduction of helmet-use legislation. Furthermore, if the pattern of injuries sustained by bicyclists and pedestrians is used to estimate the expected number of motorcyclists sustaining head injuries, the observed decrease in head injuries during the post-legislation period would be greater than 30%.

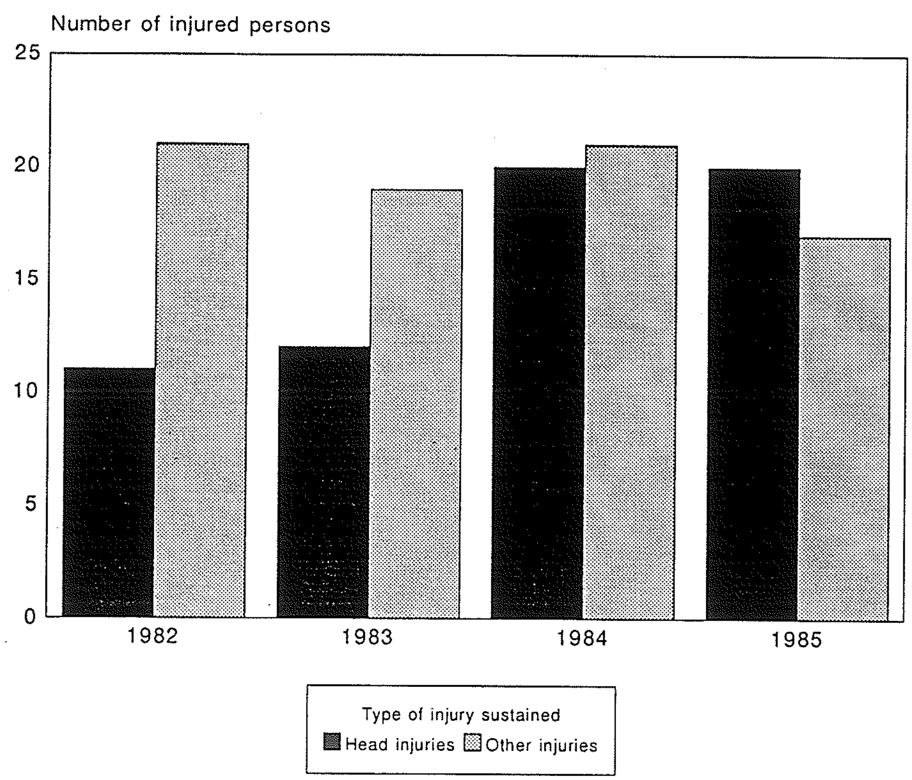

Figure 4.5. The number of pedestrians sustaining injuries to the head compared to the number sustaining injuries to body regions other than the head face or neck (analysis of hospital-based injury data using the Injury Information System).

In summary, this component of the safety model was used to successfully quantify a change in the number and pattern of injuries sustained by motorcycle riders and passengers during the two-year period following the introduction of a helmet-use law compared to the preceding two-year period. These changes were consistent with changes expected due to the introduction of this safety-related legislative intervention (ie. a reduction in the number of head injuries). It is also important to note that observations resulting from the application of the Collision Information Data System complemented the use and interpretation of analyses completed in applying this component of the overall model.

4.4 Application of a System of In-Depth Collision Investigations

The application of the third component of the safety model involved the implementation of the framework for conducting a programme of multi-disciplinary collision investigations. As previously described, the key elements of this programme are:

- defining objectives;
- determining the scope of the activity or concept;
- establishing basic data and reference requirements;
- identifying appropriate personnel to assist in the completion of this multi-disciplinary activity;
- establishing the necessary data collection and analysis protocol;
- application of the framework through completion of the collision investigations;
- completion of the analysis to fulfil the objectives as defined.

The following discussion provides an overview of how this framework for an in-depth collision investigation programme was implemented as a component of the general safety model.

Objectives

The primary rationale for conducting the multi-disciplinary investigations was to establish injury causation mechanisms permitting an estimation of the potential injury reduction which could be expected had a motorcycle helmet been correctly used by a fatally-injured (un-helmeted) motorcyclist; or the probable effect of helmet use as an injury-contributing mechanism considering a fatally-injured helmeted motorcyclist. In addition, this programme also has to provide a comprehensive understanding of collisions involving motorcyclists, including typical collision configurations and causation factors as well as occupant kinematic responses and injury patterns related to collisions involving non-fatally-injured motorcyclists.

Scope of the activity or concept

In applying the third component of the safety model, a comprehensive field-data-collection programme to fulfil the study's objectives was developed based on two categories of collisions. Included were:

- all collisions involving a fatally-injured motorcyclist occurring during the two-year period following the introduction of mandatory motorcycle helmet-use legislation on January 1, 1984 in Manitoba; and
- a representative sample of collisions involving a non-fatally injured motorcyclist occurring during the same two-year period.

Data requirements and reference material

Since the typical national general Level 2 data-collection programmes provide only a cursory assessment of motorcycle-involved collisions, several other data-collection programmes which focused specifically on motorcycle-involved collisions were considered. As noted previously, the most comprehensive programme was that completed by Hurt (Hurt et al,1981). By modifying the data requirements used in these programmes, a specific data-collection protocol was developed to achieve the objectives of this particular application of an in-depth collision-investigation programme. Samples of the data collection forms used are included in Appendix H.

Personnel

Due to the scope of this application, in particular the emphasis on motorcycle injury mechanisms and injury tolerance, the personnel required to complete the application of this component must include persons with specialized collision investigation experience. As a result, the data-collection activity relied on the assistance of members of the University of Manitoba Road Safety Research Unit (RSRU).

Protocol

To achieve the previously-noted study objectives, the protocol developed to investigate targeted collisions was based on the following criteria:

- the scene of the collision involving a fatally-injured motorcyclist should be attended by the writer or a member of the RSRU within 24 hours;
- the scene of the collision involving a non-fatally-injured motorcyclist should be attended by the writer or a member of the RSRU within 72 hours;
- autopsies of fatally-injured motorcyclists should be attended by the writer or a member of the RSRU;

- the inspection of all vehicles involved in all incidents should be competed within 72 hours by the writer or a member of the RSRU;
- forms developed by the writer specifically for the purpose of this research should be documenting environmental, vehicular and human factors should be completed by those completing the initial investigations.

With regard to the writer's attendance at specific autopsies, this was considered necessary to minimize the loss of injury detail, advise the pathologist on vehicle and occupant kinematics concerning the crash environment, and to raise suspicion and press for dissection beyond standard protocols.

For each collision investigated as part of this research, a comprehensive analysis was undertaken by the writer. This included a reconstruction of the incident, an assessment of the crash severity and estimation of injury-causation mechanisms. The reconstruction of the collision was completed using all available information and applying typical analytical techniques. Based on all available information, estimates were made to assess the probable injury source and mechanism. This element of the research was completed with the assistance of a trauma surgeon with in-depth knowledge in the subject of human tolerance to impact stress, the bio-mechanics of injury, as well as extensive experience in the reconstruction of motorcycle-involved collisions.

Results

To permit peer review of this research and demonstrate the credibility of the analysis, these findings have been extensively documented (Dalkie and Mulligan,1987c). (Supplemental documentation concerning the details of the injuries sustained by each involved individual remains available for inspection at the RSRU.)

During the two-year period following the introduction of mandatory motorcycle helmet-use legislation in Manitoba, 24 collisions involving 29 fatally injured motorcyclists were investigated in detail. This represents virtually all motorcycle fatalities which occurred in Manitoba over that period of time. Of the 29 fatalities (26 males and 3 females), 23 were drivers while 6 were passengers. Only 1 driver was female. Four fatally-injured persons were less than 16 years of age (14%), 7 were aged 16-20 years (24%), 12 were aged 21-25 years (41%) and 6 were over 25 years of age (21%). Sixteen collisions (67%) occurred on the rural road network or on roads within urban limits but which were rural in character. Seven of the 8 urban collisions occurred on a major urban arterial while 1 occurred at a minor residential intersection.

Overall, 12 collisions involved only the motorcycle while 12 involved two vehicles. Not surprisingly, 6 of the 8 urban collisions involved two vehicles. In 4 of the 12 multi-vehicle collisions the other vehicle attempted to complete a left turn in front of the oncoming motorcycle. The motorcycle and other vehicle collided in an intersecting configuration in 4 incidents. Two were head-on collisions and 2 were motorcycle front-to-rear-of-car impacts. Nineteen of the 29 fatalities (66%) were wearing an approved motorcycle helmet at the time of the collision, 8 were un-helmeted. In one case the rider was wearing an unapproved helmet which came loose during the crash, while in another helmet use could not be determined. Nineteen (66%) of all fatally-injured riders were involved in a collision where the motorcycle operator was impaired due to the consumption of alcohol. Twelve of these alcohol-related collisions involving 13 fatalities occurred between 1800 and 0600 hours.

Based on the in-depth investigations completed as part of the application of this component of the model, two deaths were attributed, in large part, to failures within the emergency health-care-delivery system. In one, the motorcyclist died in a small rural hospital seven hours post-crash due to a mismanaged ruptured spleen. He did not sustain a head injury and was conscious until shortly before death. The second involved a moderate-speed, urban incident where the motorcyclist overturned and then slid into the side of a passenger car. He was transported to a regional suburban hospital where liver lacerations as a result of blunt abdominal trauma were diagnosed. He was not transferred to a tertiary-care facility until two days post-crash for treatment of peritoneal bleeding and eventually died 26 days later from sepsis and liver failure.

With regard to other persons who sustained fatal injuries while helmeted, five sustained a fracture/dislocation of the atlanto-occipital articulation of the neck (upper cervical spine). In one instance the neck injury was associated with severe trauma to the head, while in all other cases the deceased also sustained severe life-threatening injuries to the chest and/or abdomen. Each was involved in a high-speed collision with another vehicle, which was considered unsurvivable. In three cases the helmet retention system failed during the impact. In one case the deceased was wearing a 3/4 type helmet and died due to a severe basal skull fracture caused by an impact to her face, while in another, the helmeted rider died due to drowning. In the remaining cases, 2 fatalities were attributed primarily to head-only injuries, 6 sustained severe life-threatening injuries to the chest or abdomen while 3 sustained multiple, life-threatening injuries to both the head and other body regions.

With regard to non-helmeted fatalities, eight fatally-injured riders were not wearing a helmet at the time of the collision. In addition, one incident occurred where an extensively damaged helmet was located at the scene (the retention system was unfastened and undamaged) and no tissue was found in the inner liner despite the severe open head injury sustained by the deceased. In this instance, it is highly probable that the deceased was not helmeted. Based on these in-depth collision investigations, it was determined that all un-helmeted fatalities experienced high levels of deceleration and velocity change. Although the cause of death in most instances was due to injuries to the head and other body regions, one fatality was considered potentially salvageable. The motorcyclist sustained only a severe head injury which may have been prevented had an approved helmet been worn.

Considering the representative sample of collisions involving non-fatally injured motorcyclists during the two-year period following the introduction of mandatory helmet-use legislation in Manitoba, 58 collisions were subject to an in-depth investigation and subsequent analysis by the writer. Of those investigated, 35% were single vehicle and 65% multi-vehicle collisions. Six (22%) of the 37 multi-vehicle collisions involved a motor vehicle (other than a motorcycle) which attempted to turn left in front of the motorcyclist. Thirteen percent of the riders possessed only a beginners motorcycle licence, while 8% did not have a valid motorcycle drivers licence of any kind. Twenty-seven percent of the operators involved in a collision were licensed to operate a motorcycle for less than one year. Approximately 50% were licensed to operate a motorcycle for less than two years prior to becoming involved in a collision.

Based on the implementation of this in-depth collision investigation programme, no evidence could be found which would attribute helmet use to the cause of the crash either through visual restrictions, hearing impairment or heat build up. Also, in no case was it determined that use of a motorcycle helmet caused injuries which were greater than injuries which would have been expected had the motorcyclist not been helmeted.

Based on the system of in-depth collision investigations which were developed and then applied as part of this research, observations could be made which:

- documented injury mechanisms related to motorcyclists sustaining fatal injuries during the two-year period following the introduction of the helmet use law;
- determined that all fatally-injured motorcyclists were involved in collisions of such a severity that survival was highly unlikely whether the rider was using a motorcycle helmet or not; and
- could not provide any evidence of helmet use contributing to the cause of a motorcycle collision.

Chapter 5. Observations

5.1 Applications

The model proposed through this research was based on the importance of integrating different sources of information which are generally available and routinely maintained. As part of the model, each source of information would be examined within the context of a larger perspective to provide a piece of knowledge required to assess a safety issue. Together, these apparently separate and distinct sources of knowledge describing either overall collision trends, detailed injury patterns or the complex relationships involved in a specific collision should facilitate a much greater understanding of most safety issues. The primary sources of information to be used include data collected as part of a standard police accident-reporting programme; data assembled for the maintenance of a health-care-delivery system; and information obtained from in-depth collision investigations. Using these primary sources of information, three components of the overall model were defined.

- a collision information system;
- an injury information system; and
- a programme of in-depth collision investigations.

Once these components of the model were developed, the model was evaluated by applying it to two specific issues in the Province of Manitoba; the introduction of mandatory seat-belt- and motorcycle-helmet-use legislation. These issues were selected because the information systems available in Manitoba were not unlike those generally available and because the model could be most conveniently applied within this geographic area. They were also among the most significant provincial safety counter-measures ever introduced in the Province of Manitoba and were considered by the general public and media as being significant enough to warrant considerable attention.

With respect to the assessment of mandatory seat-belt-use legislation, applying the first two components of the model (the Collision Information System and the Injury Information System) produced a comprehensive description of the number and type of injuries sustained by injured motor vehicle occupants. This effort maximized the use of existing police- and hospital-based data sources and applied a comprehensive analysis system to derive measures of trauma associated with motor vehicle collisions. However, while some evidence of changes in the number and pattern of injuries was observed, no overwhelming evidence was produced which could precisely correlate the introduction of this safety counter-measure with a measurable impact on injuries sustained by motor vehicle occupants involved in a collision. Obviously, use of only these two components of a safety model, or use of a less flexible or less integrated approach, would severely limit any observations or conclusions which could have been reached on this subject. To be sure, any contribution to furthering the state of knowledge would be marginal.

However, since the model also proposed a framework for the completion of a comprehensive in-depth collision investigation programme, this new source of information was used to go beyond the manipulation of statistical data and probed the complex relationships which define or characterize motor-vehicle-related trauma. By applying this component of the integrative model, an understanding of probable impacts related to seat belt use or non-use was achieved. While this involved an exhaustive and expensive data-collection exercise, it also provided knowledge describing how injuries relate to seat belt use, why simple analyses of statistical data often fail to disseminate the multiple factors contributing to a collision event and their outcome, and what factors continue to contribute to the incidence of fatal motor vehicle collisions.

With regard to the assessment of mandatory motorcycle-helmet-use legislation, this research successfully identified a correlation between a legislative safety intervention and a change in the pattern of injuries sustained by motorcyclists. The complementary use of both the Collision Information System and the Injury Information System enabled observations to be made which not only demonstrated that the incidence of injured motorcyclists decreased following the introduction of mandatory helmet-use legislation, but also showed that the change was associated with a reduction in the number of motorcyclists sustaining head injuries. This would be consistent with a legislative initiative causing more motorcyclists to wear helmets.

By applying the third component of the model, knowledge was gained which could be used to interpret the results of this statistical data and also investigate issues which cannot be measured by simply monitoring the number of collisions or injuries. This relates to the recognition of the more limited fatality-reducing potential of motorcycle helmets compared to other safety devices such as seat belts. For example, the vulnerability of motorcyclists was demonstrated by recognizing the high levels of exposure to stress often associated with severe motorcycle collisions and the lack of a protective environment afforded to this road-user group. The framework developed as part of the model also allowed the completion of this investigation programme in a reasonably cost-effective manner.

Specifically, this model yielded results which:

- identified injury and fatality trends associated with motor vehicle occupants and motorcyclists;
- defined injury patterns including the distribution and severity of injuries sustained by motor vehicle occupants and motorcyclists;
- demonstrated a significant change in the number of head injuries sustained by motorcyclists which can be attributed to the introduction of mandatory use legislation; and
- identified limitations of seat-belt use and evidence demonstrating the importance of proper use of the available restraint system.

Together, these observations provided a comprehensive assessment of a major legislative intervention in the Province of Manitoba; the introduction of mandatory seat belt- and motorcycle helmet-use legislation. It ought to be emphasized, however, that the level of assessment was only possible because the research included a variety of integrated components which were identified as part of the model. If only general collision data had been considered, few inferences could be developed regarding the impact associated with the introduction of mandatory seat-belt-use legislation and it could not be determined whether the decrease in the number of injured motorcyclists was related to the introduction of mandatory motorcycle helmet-use legislation of some other factor. (The difficulty interpreting any data based on the police accident-reporting programme was also complicated by a fundamental change in the way collisions were reported beginning in January of 1984.)

If only injury data had been considered, few conclusions could be made regarding the impact associated with the introduction of seat-belt-use legislation while no insights could be established regarding the nature of the number of fatally-injured motor vehicle occupants or motorcyclists. If only in-depth collision investigations were considered, no conclusions could be made in the substantial majority of motor vehicle incidents where use of protective safety devices should have affected the outcome of the incident (ie. collisions not involving a fatality).

However, it should be emphasized that the utility of completing an appropriate in-depth investigation programme as part of a comprehensive model was clearly emphasize by documenting:

- the potential effectiveness of seat belts to unrestrained motor vehicle occupants fatally-injured in Manitoba,
- the effect of occupant restraint use to fatally injured restrained occupants;
- the mechanisms of injury sustained by motorcyclists involved in collisions;
- the potential effects of helmet use or non-use in mitigating or contributing to injuries sustained by fatally injured motorcyclists; and
- the impact of motorcycle helmet use or non-use among motorcyclists injured in collision.

In summary, the proposed integrative model was successfully applied to investigate two similar yet complex safety issues. The application maximized the use of existing data sources and a complementary data analyses system to provide an integrated approach to interpret and understand subtle implications of a specific issue. Not only was this approach demonstrated to be realistic and feasible within the Province of Manitoba, it successfully used basic primary sources of information which are typical of the most basic requirements of road-safety-delivery systems.

5.2 **Model Design**

The concept developed and applied as part of this research provides a reasonable, comprehensive, and cost-effective framework from which road safety issues may be identified and addressed. These objectives have been achieved by maximizing the use and integrating existing data sources and infrastructures. The concept includes components which range from cursory data on all motor vehicle collisions to detailed data describing a limited number of incidents.

However, it is essential to recognize that, as isolated components, the value of each specific data source is limited. For example, any analysis based solely on general police accident data would be severely restricted: only marginal injury information is available, and reliable data regarding collision kinematics or injury mechanisms cannot be determined. Similarly, with regard to in-depth collision investigation programmes, if general information regarding the entire collision population is not used to develop an appropriate sampling system or weighting factors or the programme is not designed to meet specific pre-defined objectives, then the value of such programmes is severely limited.

Based on a review of the scientific literature, this integrated approach is deemed to be both innovative and superior to existing safety research initiatives. First, it recognizes the multi-disciplinary nature of road safety by incorporating aspects of engineering, epidemiological, statistical and humanities-related research. Second, it focuses on maximizing the use of existing data systems, organizations and infrastructures to develop a comprehensive yet simple approach to the understanding (clarification) of road safety issues.

This is not to say that multi-disciplinary collision investigations have not been conducted elsewhere, that hospital injury information has not been used to evaluate motor vehicle trauma, nor that general information extracted from traffic accident reports have not been analyzed. What did not exist however, is an approach where each component is integrated into a focused objective. With the model proposed in this work, the basic structure is in place to substantially enhance, in a cost effective manner, the level of knowledge concerning motor vehicle collisions and the resultant societal impact in any jurisdiction.

5.2.1 Collision Information System

Through the completion of this research it became apparent that the current analysis of police-accident-reported data is limited. Nationally, analysis of the Traffic Accident Information and Data (TRAID) system to evaluate the effectiveness of mandatory seat belt and motorcycle-helmet-use legislation indicated major problems with uniformity and consistency of even the most basic data elements. In Manitoba, analysis capabilities at the Motor Vehicle Branch are limited due, in part, to the use of an inflexible and difficult coding language and restricted use of the mainframe computer system.

In addition, it was noted that the analyses typically reported were not the type of analyses which could contribute to a more fundamental understanding of road-safety issues. Most of the analysis currently being reported relates more to a passive assessment of the data being collected and does not reflect an active or analytical approach to safety problems or issues. An example of this active or analytical approach can be contrasted with the standard passive analyses typically produced using the police data-collection system in Manitoba (Department of Highways and Transportation,1990). As summarized in Table 5.1, the existing analysis of collision data is limited to simple statements of fact with little regard to real or potential causal factors or the utility of the knowledge in effecting policy or addressing fundamental safety issues.

In contrast to this passive type of analysis, the procedures employed as part of a safety model should be used to systematically address defined issues or investigate possible areas of interest requiring further investigation. For example, it could be used to review provincial policies regarding winter snow clearing or sanding operations, road design issues such as appropriate road cross-sections, or identifying road users who exhibit a greater probability of becoming involved in collisions. Similarly, this type of analysis could be applied to other variables such as those related to vehicle design.

Passive Data Analyses (Department of Highways and Transportation, 1990)	**Active or Analytical Analyses**
71% of all accidents occurred when the weather condition was reported as being clear; 15% of accidents occurred when the weather condition was reported as being cloudy.	Using estimates of exposure and prevailing weather conditions: determine the probability of becoming involved in a collision which is dependent on weather.
24% of all collisions occurred when the road surface condition was reported as ice; 10% when reported as snow; 93% of all collisions occurred when the road condition was reported as good.	Examine the type of collisions occurring when the road surface is reported as ice or snow and determine whether these collisions are different than those collisions occurring when the road conditions are reported as being normal; assess the significance and impact of any change in policies related to snow removal or sanding operations.
85% of all collisions occurred when the road alignment was reported as being level and straight.	Assess the frequency and characteristics of collisions at rural non-intersection locations to evaluate the possible number of collisions where the lack of visual stimuli or other road design factors such as paved or unpaved shoulders may have been relevant to the cause of the collision.
75% of vehicles involved in traffic collisions were passenger cars.	Based on estimates of exposure, determine the extent to which the probability of collision involvement is dependent on specific vehicle types.
53% of total vehicles were moving straight when the collision occurred.	Provide appropriate tabulations of collision configurations and the type of collisions involved.
63% of all persons reported injured were drivers; 45% of these drivers sustained only minimal injuries.	Assess whether the severity of injuries sustained by drivers is a function of the type of vehicle, the collision configuration and/or the reporting jurisdiction.

Table 5.1 Comparison of passive data analyses currently reported by the Manitoba Department of Highways and Transportation and other active or analytical analyses which could be undertaken using the Collision Information System and other sources of data.

With regard to the quality and reliability of police-based collision information, it is evident that efforts should be undertaken to enhance this data. However, any process to address specific data-quality issues should first consider that information which is fundamental to the use of the police-reported data: demographic and factual data. Efforts to improve this data may include an on-line quality control system or the use of feedback directed towards the existing data collection infrastructure. This may take the form of:

- providing summaries and highlights of aggregate information related to specific geographic areas;
- providing analyses of reported data identifying inconsistencies or abnormalities in the reported data; or
- completing consistency checks of particular data items (such as the precise geographic location of collisions including the coding of control section numbers or street identifiers).

By providing this information to local police jurisdictions as well as those involved in the coding and entry of collision data, the quality of information available for analysis purposes should improve. In addition, substantial benefits may ultimately accrue to the community in which the collision took place as the overall relevance of road safety issues is increased.

It should be emphasized that only after the quality of this basic demographic and factual data reaches an appropriate level should attempts be made to address other data elements which require interpretations or subjective decisions on the part of the investigating officer.

5.2.2 Injury Information System

A basic condition of accessing the hospital-based injury data used in the specific application of the general safety model was that information from separate automated databases would not be linked to achieve a single data file because of the confidential nature of the injury data. However, during the application of the model, it became evident that some automated linkage of detailed hospital injury data and traffic accident-report-based data may be feasible without breaching the confidentiality clause.

This linkage could be achieved by merging the two databases by considering age and sex of the injured person, as well as the date of admission to hospital. The effectiveness and reliability of this merge could be improved if the variable describing the type of road user from the injury data base (ie. motor vehicle driver or motorcycle passenger) was matched with the variable describing the type of vehicle contained in the general collision data base (ie. passenger car vs motorcycle) in a subsequent merge.

As a result, more specific sub-sets of collisions could also be identified and then linked. For example, if only motor vehicle drivers were considered, information such as the first initial of the driver's given name could be used to enhance the quality of the merge. Of course, this process would violate the terms under which the data was originally obtained for the purposes of this research and would have to be the subject of further negotiations, beyond the scope of this thesis.

It should also be emphasized that the primary information typically captured as part of health-care-based data collection activities is generally inadequate for the purposes of motor vehicle trauma research because measures of injury severity are not typically incorporated into the data system. This research effort included the development of a system which can be used to introduce a measure of injury severity to injuries recorded in such data-collection activities and, therefore, considerably increase the value of this data-collection activity vis-a-vis motor vehicle-related research.

Given the state of available information systems, development of the proposed model was arguably a substantial improvement to the available state of knowledge and ability to investigate other safety issues. Further enhancements to this method are a function of the jurisdiction where the model is applied and the conditions upon which access to the information is granted.

5.2.3 System of In-depth Collision Investigations

In-depth collision investigation programmes can often involve the collection of large quantities of data which may not provide answers to focused questions. As part of this research, many of the limitations of typical in-depth investigation programmes have been addressed. Most importantly, this research clearly identified the <u>need to explicitly detail the framework which must be established prior to implementing any in-depth collision investigation programme</u>. This framework includes the following key elements:

- identifying specific objectives of the multi-disciplinary collision investigation prior to the collection of data;
- stratifying the collision population to a sufficiently detailed level and designing an appropriate data-collection protocol and procedures required to fulfil specific objectives;
- maximizing the use of the available expertise and infrastructure;
- integrating the observations with the analysis of general collision- or injury-information systems;
- identifying potential safety-related issues problems which can be addressed through other mechanisms; and
- reporting the findings in a logical and usable format.

While this research has documented a role for multi-disciplinary collision investigation, it is essential that any programme be implemented cautiously and only after the objectives of the programme are explicitly identified and other sources of data are in place to put into context any findings or conclusions which may result from such a programme.

Chapter 6. Conclusions

This research was initiated because of the considerable societal impact associated with motor vehicle-related trauma and the poor use of the limited, yet substantial, resources which are expended on road-safety research. These resources are typically focused on isolated activities which do not provide a comprehensive foundation of knowledge nor the ability to address many basic safety issues. Of specific concern is the fragmented state of the road-safety-delivery system where safety policies are often based on intuition rather than a solid factual base of knowledge; where existing information programmes are grossly under-utilized; and where a comprehensive multi-disciplinary approach to safety issues is abandoned in favour of a uni-dimensional applications or advocacy-related activities. As part of this research, a new approach was developed to address safety issues from a more reasonable foundation of knowledge.

To accomplish this objective, an existing source of information was identified, the police-based traffic accident investigation and reporting programme, and modified to demonstrate how its utilization could be improved simply by using more appropriate analytical methods including statistical and geographic information-based systems. By applying these practical enhancements, the value of this source of information can be more fully realized and further efforts to enhance this source of information can be targeted, then addressed.

This research also examined a second source of information maintained as part of a broad health-care-delivery system, which could be exploited to add value to analyses focused on the narrower issue of road safety. To facilitate this link, an automated procedure was developed to convert the original data describing motor vehicle-related trauma into a form which could appropriately describe the nature and severity of the injuries sustained by persons injured in motor vehicle collisions. This was accomplished while maintaining the confidential and sensitive nature of the original information. Thus, an opportunity was provided to build on the integration of this and other automated sources of data and develop the ability to complete a more comprehensive assessment of road-safety issues.

In addition, this research developed a role of in-depth collision investigations. An appropriate framework was established where this research activity is defined and where knowledge relating to the complex elements of a motor vehicle collision can be used to fulfil specific objectives and allow a greater understanding of issues investigated through the automated information systems described previously.

Given this basic concept, the model developed was applied to two issues in the Province of Manitoba as an example. This application demonstrated how an integrated approach could be used to assess impacts associated with the introduction of mandatory motorcycle helmet- and seat belt use-legislation. A comprehensive analysis was provided which documented changes in the patterns of injuries; defined general trends associated with the occurrence of motor vehicle collisions; and provided a thorough understanding of the actual or potential effectiveness of these safety devices in specific collision configurations.

In conclusion, this research has offered a contribution to the state of knowledge available to describe road safety issues and provided an approach which integrates a multitude of different data sources within a multi-disciplinary framework. This can assist in the understanding and analysis of motor vehicle collisions so that informed decisions can ultimately be made to reduce the immense cost associated with these incidents.

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APPENDIX A: COLLISION INFORMATION SYSTEM: SAMPLE PROGRAM LISTINGS

The purpose of this program (file = F84A) is to transfer data obtained from the Manitoba Motor Vehicle Branch in a standard magnetic tape format onto the Universityof Manitoba mainframe computer system.

```
//MOTORS JOB '0294-24,,,T=10,L=5,I=10','HDALKIE'
/*ROUTE PRINT REMOTE3
/*D6250 BIN# 2483 SER# MVB
// EXEC PGM=IEBGENER
//SYSIN DD DUMMY
//SYSPRINT DD SYSOUT=A
//SYSUT1 DD
DSN=HDALKIE.MVB84.DATA,DISP=OLD,DCB=DEN=4,
// VOL=SER=MVB,LABEL=(3,SL),UNIT=D6250
//SYSUT2 DD DSN=HDALKIE.MVB.YY84,UNIT=DISK,
// SPACE=(TRK,(560,5),RLSE),
// DCB=(RECFM=VB,LRECL=2644,BLKSIZE=18512),
// DISP=(NEW,CATLG),VOL=SER=WEEK01
```

This program (file = F84B) is used to read the data describing each collision as provided in the primary data set describing the results of the typical police-based collision investigation and reporting programme. Procedures are then performed to create specific records for each injured person. Only appropriate variables defining the collision event are appended to each record. Due to data processing limitations, this program considers only those incidents occurring prior to 1200 hours.

```
// JOB '0294-24,I=80,T=4M,L=30,','HDALKIE'
// EXEC SASV5,REGION=1536K
//READ DD DSN=HDALKIE.MVB.YY84,DISP=SHR
//SAVE DD DSN=HDALKIE.HD,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(2,1),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
DATA ORIG;
INFILE READ;
INPUT
@ 1 CASENO PD4. SEV $5 @ 6 DATE PD4. DAY 10 TIME 11-12
ACTYPE $ 13 PDDAM $ 14 CONFIG 15-16 POL 17 ATPOL $18 HR
$19 LOC 20-21 HWYNUM 22-24 CONTROL 25-31 KM 32-34
INTERS $ 35-44 LIGHT $ 45 WEATH $ 46 RDTYPE $ 47 RDCOND
$ 48 RDSURCON $ 49 RDCAT $ 50 RDALIGN $ 51 SITE $ 52
NOVEH 53-54
NOPERK 55-56 NOPERI 57-58 NUMTRAIL 59-60 @;
VEH='1';
DO I=1 TO NUMTRAIL;
INPUT TYPE $ 1. @;
IF TYPE = 'V' THEN INPUT LIC $ 12. TVEH 2. VEHINFO $ 45. @;
ELSE INPUT
VEHN1 $ 2. POS1 $ 1. EJECT1 $ 1. INJ1 $ 1. AGE1 $ 2. SEX1 $ 1.
SAFE1 $ 2.
VEHN2 $ 2. POS2 $ 1. EJECT2 $ 1. INJ2 $ 1. AGE2 $ 2. SEX2 $ 1.
SAFE2 $ 2.
VEHN3 $ 2. POS3 $ 1. EJECT3 $ 1. INJ3 $ 1. AGE3 $ 2. SEX3 $ 1.
SAFE3 $ 2.
VEHN4 $ 2. POS4 $ 1. EJECT4 $ 1. INJ4 $ 1. AGE4 $ 2. SEX4 $ 1.
SAFE4 $ 2.
VEHN5 $ 2. POS5 $ 1. EJECT5 $ 1. INJ5 $ 1. AGE5 $ 2. SEX5 $ 1.
SAFE5 $ 2.
FILLER $ 9. @;
IF TYPE='I' THEN OUTPUT; END;
DATA ORIGINAL; SET ORIG; IF TIME LE 12 THEN OUTPUT ;
DATA ONE; SET ORIGINAL;
KEEP CASENO SEV DATE DAY TIME ACTYPE PDDAM CONFIG
POL LOC ATPOL HR HWYNUM CONTROL KM INTERS LIGHT
WEATH RDTYPE RDCOND  RDSURCON RDCAT RDALIGN SITE
NOVEH NOPERK NOPERI VEHN1 POS1 EJECT1 INJ1 AGE1
SEX1 SAFE1;
RENAME VEHN1=VEH POS1=POS EJECT1=EJECT INJ1=INJ
AGE1=AGE SEX1=SEX SAFE1=SAFE;
DATA TWO;
SET ORIGINAL;
KEEP CASENO SEV DATE DAY TIME ACTYPE PDDAM CONFIG
POL LOC ATPOL HR HWYNUM CONTROL KM INTERS LIGHT
WEATH RDTYPE RDCOND RDSURCON RDCAT RDALIGN SITE
NOVEH NOPERK NOPERI
VEHN2 POS2 EJECT2 INJ2 AGE2 SEX2 SAFE2;
RENAME VEHN2=VEH POS2=POS EJECT2=EJECT INJ2=INJ
AGE2=AGE SEX2=SEX SAFE2=SAFE;
DATA THREE;
SET ORIGINAL;
KEEP CASENO SEV DATE DAY TIME ACTYPE PDDAM CONFIG
POL LOC ATPOL HR HWYNUM CONTROL KM INTERS LIGHT
WEATH RDTYPE RDCOND RDSURCON RDCAT RDALIGN SITE
NOVEH NOPERK NOPERI VEHN3 POS3 EJECT3 INJ3 AGE3
SEX3 SAFE3;
RENAME VEHN3=VEH POS3=POS EJECT3=EJECT INJ3=INJ
AGE3=AGE SEX3=SEX SAFE3=SAFE;
DATA FOUR;
SET ORIGINAL;
KEEP CASENO SEV DATE DAY TIME ACTYPE PDDAM CONFIG
POL LOC ATPOL HR HWYNUM CONTROL KM INTERS LIGHT
WEATH RDTYPE RDCOND RDSURCON RDCAT RDALIGN SITE
NOVEH NOPERK NOPERI VEHN4 POS4 EJECT4 INJ4 AGE4
SEX4 SAFE4;
RENAME VEHN4=VEH POS4=POS EJECT4=EJECT INJ4=INJ
AGE4=AGE SEX4=SEX SAFE4=SAFE;
DATA FIVE;
SET ORIGINAL;
KEEP CASENO SEV DATE DAY TIME ACTYPE PDDAM CONFIG
POL LOC ATPOL HR HWYNUM CONTROL KM INTERS LIGHT
WEATH RDTYPE RDCOND RDSURCON RDCAT RDALIGN SITE
NOVEH NOPERK NOPERI VEHN5 POS5 EJECT5 INJ5 AGE5
SEX5 SAFE5;
RENAME VEHN5=VEH POS5=POS EJECT5=EJECT INJ5=INJ
AGE5=AGE SEX5=SEX SAFE5=SAFE;
DATA COMPILE;
SET ONE TWO THREE FOUR FIVE;
IF VEH=' ' THEN DELETE;
IF VEH='01' THEN VEH='1';
IF VEH='02' THEN VEH='2';
IF VEH='03' THEN VEH='3';
IF VEH='04' THEN VEH='4';
IF VEH='05' THEN VEH='5';
IF VEH='06' THEN VEH='6';
IF VEH='07' THEN VEH='7';
IF VEH='08' THEN VEH='8';
IF VEH='09' THEN VEH='9';
DATA SAVE.INJ;
SET COMPILE;
```

This program (file = F84C) is identical to the previous listing (file = F84B), however it considers those incidents which occurred after 1200 hours.

```
// JOB '0294-24,I=80,T=4M,L=30,','HDALKIE'
// EXEC SAS,REGION=1536K
//READ DD DSN=HDALKIE.MVB.YY84,DISP=SHR
//SAVE DD DSN=HDALKIE.I2,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(2,1),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
DATA ORIG;
INFILE READ;
INPUT
@ 1 CASENO PD4. SEV $5 @ 6 DATE PD4. DAY 10 TIME 11-12
ACTYPE $ 13 PDDAM $ 14 CONFIG 15-16 POL 17 ATPOL $18 HR
$19 LOC 20-21 HWYNUM 22-24 CONTROL 25-31 KM 32-34
INTERS $ 35-44 LIGHT $ 45 WEATH $ 46 RDTYPE $ 47 RDCOND
$ 48 RDSURCON $ 49 RDCAT $ 50 RDALIGN $ 51 SITE $ 52
NOVEH 53-54
NOPERK 55-56 NOPERI 57-58 NUMTRAIL 59-60 @;
VEH='1';
DO I=1 TO NUMTRAIL;
INPUT TYPE $ 1. @;
 IF TYPE = 'V' THEN
 INPUT LIC $ 12. TVEH 2.
 VEHINFO $ 45. @;
ELSE INPUT VEHN1 $ 2. POS1 $ 1. EJECT1 $ 1. INJ1 $ 1. AGE1
$ 2.
SEX1 $ 1. SAFE1 $ 2. VEHN2 $ 2. POS2 $ 1. EJECT2 $ 1. INJ2 $
1. AGE2 $ 2.
SEX2 $ 1. SAFE2 $ 2. VEHN3 $ 2. POS3 $ 1. EJECT3 $ 1. INJ3 $
1. AGE3 $ 2.
SEX3 $ 1. SAFE3 $ 2. VEHN4 $ 2. POS4 $ 1. EJECT4 $ 1. INJ4 $
1. AGE4 $ 2.
SEX4 $ 1. SAFE4 $ 2. VEHN5 $ 2. POS5 $ 1. EJECT5 $ 1. INJ5 $
1. AGE5 $ 2.
SEX5 $ 1. SAFE5 $ 2. FILLER $ 9.
@;
IF TYPE='I' THEN OUTPUT;
END;
DATA ORIGINAL; SET ORIG; IF TIME GT 12 THEN OUTPUT ;
DATA ONE; SET ORIGINAL;
KEEP CASENO SEV DATE DAY TIME ACTYPE PDDAM CONFIG
POL LOC ATPOL HR HWYNUM CONTROL KM INTERS LIGHT
WEATH RDTYPE RDCOND RDSURCON RDCAT RDALIGN SITE
NOVEH NOPERK NOPERI VEHN1 POS1 EJECT1 INJ1 AGE1
SEX1 SAFE1;
RENAME VEHN1=VEH POS1=POS EJECT1=EJECT INJ1=INJ
AGE1=AGE SEX1=SEX SAFE1=SAFE;
DATA TWO;
SET ORIGINAL;
KEEP CASENO SEV DATE DAY TIME ACTYPE PDDAM CONFIG
POL LOC ATPOL HR HWYNUM CONTROL KM INTERS LIGHT
WEATH RDTYPE RDCOND RDSURCON RDCAT RDALIGN SITE
NOVEH NOPERK NOPERI VEHN2 POS2 EJECT2 INJ2 AGE2
SEX2 SAFE2;
RENAME VEHN2=VEH POS2=POS EJECT2=EJECT INJ2=INJ
AGE2=AGE SEX2=SEX SAFE2=SAFE;
DATA THREE;
SET ORIGINAL;
KEEP CASENO SEV DATE DAY TIME ACTYPE PDDAM CONFIG
POL LOC ATPOL HR HWYNUM CONTROL KM INTERS LIGHT
WEATH RDTYPE RDCOND RDSURCON RDCAT RDALIGN SITE
NOVEH NOPERK NOPERI VEHN3 POS3 EJECT3 INJ3 AGE3
SEX3 SAFE3;
RENAME VEHN3=VEH POS3=POS EJECT3=EJECT INJ3=INJ
AGE3=AGE SEX3=SEX SAFE3=SAFE;
DATA FOUR;
SET ORIGINAL;
KEEP CASENO SEV DATE DAY TIME ACTYPE PDDAM CONFIG
POL LOC ATPOL HR HWYNUM CONTROL KM INTERS LIGHT
WEATH RDTYPE RDCOND RDSURCON RDCAT RDALIGN SITE
NOVEH NOPERK NOPERI VEHN4 POS4 EJECT4 INJ4 AGE4
SEX4 SAFE4;
RENAME VEHN4=VEH POS4=POS EJECT4=EJECT INJ4=INJ
AGE4=AGE SEX4=SEX SAFE4=SAFE;
DATA FIVE;
SET ORIGINAL;
KEEP CASENO SEV DATE DAY TIME ACTYPE PDDAM CONFIG
POL LOC ATPOL HR HWYNUM CONTROL KM INTERS LIGHT
WEATH RDTYPE RDCOND RDSURCON RDCAT RDALIGN SITE
NOVEH NOPERK NOPERI VEHN5 POS5 EJECT5 INJ5 AGE5
SEX5 SAFE5;
RENAME VEHN5=VEH POS5=POS EJECT5=EJECT INJ5=INJ
AGE5=AGE SEX5=SEX SAFE5=SAFE;
DATA COMPILE;
SET ONE TWO THREE FOUR FIVE;
IF VEH=' ' THEN DELETE;
IF VEH='01' THEN VEH='1';
IF VEH='02' THEN VEH='2';
IF VEH='03' THEN VEH='3';
IF VEH='04' THEN VEH='4';
IF VEH='05' THEN VEH='5';
IF VEH='06' THEN VEH='6';
IF VEH='07' THEN VEH='7';
IF VEH='08' THEN VEH='8';
IF VEH='09' THEN VEH='9';
DATA SAVE.INJ;
SET COMPILE;
```

The purpose of this program (file F84D_Mix) is to read the original primary data set and create specific records for each involved vehicle. Additional procedures have been included to introduce a new variable (variable = MIX) describing the detailed mix of vehicles involved in the collision (ie. a passenger car and a light truck, two passenger cars or a single motorcycle). This variable was introduced to facilitate a more straightforward procedure when the database is analyzed.

```
// JOB '0294-24,I=80,T=4M,L=30,','HDALKIE'
// EXEC SAS,REGION=3070K
//WORK DD SPACE=(CYL,(150,50)),UNIT=SYSDA
//READ DD DSN=HDALKIE.MVB.YY84,DISP=SHR
//ALLMIX DD DSN=HDALKIE.V1,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(12,10),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
DATA VEH;
INFILE READ;
INPUT @ 1 CASENO PD4. SEV $5 @ 6 DATE PD4. DAY 10 TIME
11-12 NOVEH 53-54
NUMTRAIL 59-60 @;
VEH='1';
DO I=1 TO NUMTRAIL;
INPUT TYPE $ 1. @;
IF TYPE = 'V' THEN INPUT LIC $ 12. TVEH 2. VPROV $ 2. DAGE
2. DSEX $ 1. DEXP 1. VIOL1 $ 1. VIOL2 $ 1. VIOL3 $ 1. VIOL4 $
1. VYEAR $ 2. VCOLOR 2. RPROV $ 2. NPAS 2. SPEEDL 3. DIR $
1. TCA $ 2. TOWV $ 2. HAZL $ 1. PREACT $ 2. FAC1 $ 2. FAC2 $
2. FAC3 $ 2. EVENT1 $ 2. EVENT $ 2. LOCDAM $ 2. PEDACT $ 2.
```

```
POI $ 2. @;
ELSE INPUT JUNK $ 59. @;
IF TYPE ='V' THEN OUTPUT;
 VEH=VEH+1;
END ;
KEEP CASENO SEV DATE DAY TIME VPROV VIOL1 VIOL2 VIOL3
VIOL4 VEH TYPE LIC TVEH DAGE DSEX DEXP VYEAR VCOLOR
RPROV NPAS SPEEDL DIR TCA TOWV HAZL PREACT FAC1
FAC2 FAC3 EVENT1 EVENT LOCDAM PEDACT POI;
** NEXT LINES OF CODE ARE ADDED TO CREATE "MIX"
VARIABLE**;
PROC SORT; BY CASENO;
DATA SINGLE TWO MULTIPLE; SET VEH; BY CASENO;
IF LAST.CASENO=1 THEN DO;
IF VEH=1 THEN OUTPUT SINGLE; /*SINGLE VEHICLE
ACCIDENTS*/
IF VEH=2 THEN OUTPUT TWO; /*TWO-VEHICLE ACCIDENTS*/
IF VEH>2 THEN OUTPUT MULTIPLE; /*MULTIPLE-VEH
ACCIDENTS*/
END;
DATA TWO; SET TWO;
KEEP CASENO;
DATA MULTIPLE; SET MULTIPLE;
KEEP CASENO;
DATA MMULTIPL;
MERGE MULTIPLE (IN=M) VEH; BY CASENO; IF M; /*ALL RECS
FOR MULTIPLE-VEHICLE ACCIDENTS*/
MIX=55;
DATA SINGLE; SET SINGLE;
IF TVEH='01' THEN MIX=1; /*PASSENGER*/
ELSE IF TVEH='09' THEN MIX=11; /*LGT TRUCK*/
ELSE IF TVEH='10' | TVEH='14' THEN MIX=20; /*MEDIUM
TRUCK*/
ELSE IF TVEH='11' THEN MIX=28; /*HEAVY TRUCK*/
ELSE IF TVEH='2' THEN MIX=35; /*MOTORCYCLE*/
ELSE IF TVEH='3' THEN MIX=41; /*BYCICLE*/
ELSE IF TVEH='24' THEN MIX=46; /*PEDESTRIAN*/
ELSE IF '05'<=TVEH<='08' THEN MIX=50; /*BUS*/
ELSE MIX=53; /*ALL OTHER*/
DATA MTWO;
MERGE TWO (IN=T) VEH; BY CASENO; IF T;
/*ALL RECS FOR TWO-VEHICLE ACCIDENTS*/
IF TVEH='01' THEN PASS=1;
ELSE IF TVEH='09' THEN LTTRUCK=1;
ELSE IF TVEH='10' |TVEH='14' THEN MDTRUCK=1;
ELSE IF TVEH='11' THEN HVTRUCK=1;
ELSE IF TVEH='02' THEN MOTORC=1;
ELSE IF TVEH='03' THEN BIKE=1;
ELSE IF '05'<=TVEH<='08' THEN BUS=1;
ELSE IF TVEH='24' THEN PED=1;
ELSE OTHER=1;
LCASE=LAG(CASENO);
LPASS=LAG(PASS);
LPED=LAG(PED);
LLTTRUCK=LAG(LTTRUCK);
LMDTRUCK=LAG(MDTRUCK);
LHVTRUCK=LAG(HVTRUCK);
LBUS=LAG(BUS);
LBIKE=LAG(BIKE);
LMOTORC=LAG(MOTORC);
LOTHER=LAG(OTHER);
IF CASENO=LCASE THEN DO;
IF PASS=1 | LPASS=1 THEN DO;
IF PASS=1 AND LPASS=1 THEN MIX=2;
IF LTTRUCK=1 | LLTTRUCK=1 THEN MIX=3;
IF MDTRUCK=1 | LMDTRUCK=1 THEN MIX=4;
IF HVTRUCK=1 | LHVTRUCK=1 THEN MIX=5;
IF MOTORC=1 | LMOTORC=1 THEN MIX=6;
IF BIKE=1 | LBIKE=1 THEN MIX=7;
IF PED=1 | LPED=1 THEN MIX=8;
IF BUS=1 | LBUS=1 THEN MIX=9;
IF OTHER=1 | LOTHER=1 THEN MIX=10;
END;
IF LTTRUCK=1 | LLTTRUCK=1 THEN DO;
IF LTTRUCK=1 AND LLTTRUCK=1 THEN MIX=12;
IF MDTRUCK=1 | LMDTRUCK=1 THEN MIX=13;
IF HVTRUCK=1 | LHVTRUCK=1 THEN MIX=14;
IF MOTORC=1 | LMOTORC=1 THEN MIX=15;
IF BIKE=1 | LBIKE=1 THEN MIX=16;
IF PED=1 | LPED=1 THEN MIX=17;
IF BUS=1 | LBUS=1 THEN MIX=18;
IF OTHER=1 | LOTHER=1 THEN MIX=19;
END;
IF MDTRUCK=1 | LMDTRUCK=1 THEN DO;
IF MDTRUCK=1 AND LMDTRUCK=1 THEN MIX=21;
IF HVTRUCK=1 | LHVTRUCK=1 THEN MIX=22;
IF MOTORC=1 | LMOTORC=1 THEN MIX=23;
IF BIKE=1 | LBIKE=1 THEN MIX=24;
IF PED=1 | LPED=1 THEN MIX=25;
IF BUS=1 | LBUS=1 THEN MIX=26;
IF OTHER=1 | LOTHER=1 THEN MIX=27;
END;
IF HVTRUCK=1 | LHVTRUCK=1 THEN DO;
IF HVTRUCK=1 AND LHVTRUCK=1 THEN MIX=29;
IF MOTORC=1 | LMOTORC=1 THEN MIX=30;
IF BIKE=1 | LBIKE=1 THEN MIX=31;
IF PED=1 | LPED=1 THEN MIX=32;
IF BUS=1 | LBUS=1 THEN MIX=33;
IF OTHER=1 | LOTHER=1 THEN MIX=34;
END;
IF MOTORC=1 | LMOTORC=1 THEN DO;
IF MOTORC=1 AND LMOTORC=1 THEN MIX=36;
IF BIKE=1 | LBIKE=1 THEN MIX=37;
IF PED=1 | LPED=1 THEN MIX=38;
IF BUS=1 | LBUS=1 THEN MIX=39;
IF OTHER=1 | LOTHER=1 THEN MIX=40;
END;
IF BIKE=1 | LBIKE=1 THEN DO;
IF BIKE=1 AND LBIKE=1 THEN MIX=42;
IF PED=1 | LPED=1 THEN MIX=43;
IF BUS=1 | LBUS=1 THEN MIX=44;
IF OTHER=1 | LOTHER=1 THEN MIX=45;
END;
IF PED=1 | LPED=1 THEN DO;
IF PED=1 AND LPED=1 THEN MIX=47;
IF BUS=1 | LBUS=1 THEN MIX=48;
IF OTHER=1 | LOTHER=1 THEN MIX=49;
END;
IF BUS=1 | LBUS=1 THEN DO;
IF BUS=1 AND LBUS=1 THEN MIX=51;
IF OTHER=1 | LOTHER=1 THEN MIX=52;
END;
IF OTHER=1 AND LOTHER=1 THEN MIX=54;
END;
DATA ALL;
SET SINGLE MTWO MMULTIPL;
KEEP CASENO--POI MIX;
PROC SORT; BY CASENO;
PROC PRINT DATA=ALL (OBS=100);
TITLE 'ALL SINGLE-, TWO- AND MULTIPLE-VEHICLE
ACCIDENTS';
DATA MIX; SET ALL; BY CASENO;
KEEP CASENO MIX;
IF LAST.CASENO THEN OUTPUT MIX;
DATA ALLMIX.SAVE1;
MERGE ALL (IN=A) MIX; BY CASENO; IF A;
** TESTF83D G=NEW **;
```

The purpose of this program (file = F84E) is to read the data set describing all involved vehicles (generated using file = F84D_MIX) and eliminate all incidents which did not occur prior to 1200 hours. This procedure was completed because vehicle data must be merged with injured person data which was split into two separate data sets (created using files F84B and F84C). This procedure includes only those incidents occurring prior to 1200 hours.

```
// JOB '0294-24,I=80,T=4M,L=30,','HDALKIE'
// EXEC SAS,REGION=1536K
//READ DD DSN=HDALKIE.V1,DISP=SHR
//SAV DD DSN=HDALKIE.V1A,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(10,5),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
DATA ORIGINAL;
SET READ.SAVE1;
IF TIME LE 12 THEN OUTPUT ;
DATA SAV.VEH; SET ORIGINAL;
```

This program (file = F84F) is identical to the previous file listing (file = F84E), however it cosiders those incidents which occurred after 1200 hours.

```
// JOB '0294-24,I=80,T=4M,L=30,','HDALKIE'
// EXEC SAS,REGION=1536K
//READ DD DSN=HDALKIE.V1,DISP=SHR
//SAV DD DSN=HDALKIE.V1B,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(10,5),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
DATA ORIGINAL;
SET READ.SAVE1;
IF TIME GT 12 THEN OUTPUT ;
DATA SAV.VEH; SET ORIGINAL;
```

The purpose of this program (file = F84AA) is to add vehicle data (created using file = F84E) to records describing each injured person (created using file - F84B). (Only those incicents occurring prior to 1200 hours are included.)

```
// JOB '0294-24,I=80,T=4M,L=30,','HDALKIE'
// EXEC SAS,REGION=3072K,OPTIONS='LINESIZE=70'
//READ DD DSN=HDALKIE.V1A,DISP=SHR
//READ1 DD DSN=HDALKIE.I1,DISP=SHR
//SAVE DD DSN=HDALKIE.X4,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(1500,200),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
DATA HAL;
SET READ.VEH;
PROC SORT ; BY CASENO VEH;
DATA HAL1;
SET READ1.INJ;
PROC SORT; BY CASENO VEH;
DATA HAL2;
MERGE HAL HAL1;
BY CASENO VEH;
IF POS=' ' THEN DELETE;
PROC SORT; BY CASENO;
DATA SAVE.FINAL;
SET HAL2;
```

This program (file = F84AB) is identical to the previous file listing (file = F84AA), however it considers those incidents which occurred after 1200 hours.

```
// JOB '0294-24,I=80,T=4M,L=30,','HDALKIE'
// EXEC SAS,REGION=3072K,OPTIONS='LINESIZE=70'
//READ DD DSN=HDALKIE.V1B,DISP=SHR
//READ1 DD DSN=HDALKIE.I2,DISP=SHR
//SAVE DD DSN=HDALKIE.X3,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(1500,200),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
DATA HAL;
SET READ.VEH;
PROC SORT ; BY CASENO VEH;
DATA HAL1;
SET READ1.INJ;
PROC SORT; BY CASENO VEH;
DATA HAL2;
MERGE HAL HAL1;
BY CASENO VEH;
IF POS=' ' THEN DELETE;
PROC SORT; BY CASENO;
DATA SAVE.FINAL;
SET HAL2;
```

This program (file = F84AC) merges the data sets considering incidents occurring prior to (file = F84AA) and following (file = F84AB) 1200 hours.

```
// JOB '0294-24,I=90,T=4M,L=30,','HDALKIE'
// EXEC SAS,OPTIONS='LINESIZE=70',REGION=1536K
//READ DD DSN=HDALKIE.X3,DISP=SHR
//RREAD DD DSN=HDALKIE.X4,DISP=SHR
//SAV DD DSN=HDALKIE.F4,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(5,2),RLSE),UNIT=DISK,VOL=SER=USER23,
// DCB=(RECFM=U)
DATA AAA; SET READ.FINAL;
DATA BBBB; SET RREAD.FINAL;
DATA SAV.HAL; SET AAA BBBB;
DDATE=PUT(DATE,6.);
YY=SUBSTR(DDATE,1,2);
MM=SUBSTR(DDATE,3,2);
DD=SUBSTR(DDATE,5,2);
IF POS='1' THEN DRIVER='1';ELSE DRIVER='2';
```

This program is a sample of the simple analysis routines which can be used to generate ad hoc analyses (file = F84AE).

```
// JOB '0294-24,I=90,T=4M,L=30,','HDALKIE'
// EXEC SAS,OPTIONS='LINESIZE=70',REGION=1536K
//READ DD DSN=HDALKIE.F4,DISP=SHR
DATA A ONE TWO THREE FOUR FIVE SIX;
SET READ.HAL; KEEP AGE TVEH SEX DATE POS POL TIME
DRIVER MM INJ;
DDATE=PUT(DATE,6.);
YY=SUBSTR(DDATE,1,2);
MM=SUBSTR(DDATE,3,2);
DD=SUBSTR(DDATE,5,2);
IF POS='1' THEN DRIVER='1';ELSE DRIVER='2';
IF TVEH='1' THEN OUTPUT ONE;
IF TVEH='2' THEN OUTPUT TWO;
IF TVEH='3' THEN OUTPUT THREE;
IF TVEH='9' THEN OUTPUT FOUR;
IF TVEH='14' THEN OUTPUT FIVE;
IF TVEH='24' THEN OUTPUT SIX;
DATA AUTO; SET ONE;
PROC FREQ;
TABLES DRIVER*SEX*INJ DRIVER*POL*INJ / NOROW NOCOL
NOPERCENT;
PROC FREQ;
TABLES DRIVER*INJ*AGE DRIVER*INJ*MM DRIVER*INJ*TIME /
NOROW NOCOL NOPERCENT LIST;
DATA MC; SET TWO;
PROC FREQ;
TABLES DRIVER*SEX*INJ DRIVER*POL*INJ / NOROW NOCOL
NOPERCENT;
PROC FREQ;
TABLES DRIVER*INJ*AGE DRIVER*INJ*MM DRIVER*INJ*TIME /
NOROW NOCOL NOPERCENT LIST;
DATA BIC; SET THREE;
PROC FREQ;
TABLES DRIVER*SEX*INJ DRIVER*POL*INJ / NOROW NOCOL
NOPERCENT;
PROC FREQ;
TABLES DRIVER*INJ*AGE DRIVER*INJ*MM DRIVER*INJ*TIME /
NOROW NOCOL NOPERCENT LIST;
DATA PED; SET SIX;
PROC FREQ;
TABLES DRIVER*SEX*INJ DRIVER*POL*INJ / NOROW NOCOL
NOPERCENT;
PROC FREQ;
TABLES DRIVER*INJ*AGE DRIVER*INJ*MM DRIVER*INJ*TIME /
NOROW NOCOL NOPERCENT LIST;
```

The following programs save the data sets created from the previous listings to tape to facilitate future research and analysis (files = DTOTCOLL, DTOTVEH).

```
*/HDALKIE JOB '0294-24,I=90,,L=30,','HDALKIE'
/*D6250 MVB/2483 -WR
// EXEC SASV5,REGION=1536K
//READ DD DSN=HDALKIE.F4,DISP=SHR
//SAV DD DSN=HDALKIE.F4,DISP=(NEW,KEEP),LABEL=(18,SL),
// VOL=SER=MVB,UNIT=D6250
DATA READ;
SET READ.HAL;
DATA SAV.FINAL;
SET READ;
PROC PRINT DATA=SAV.FINAL (OBS=20);
/*SAVING FINAL DISK DATASET OF MVB DATA (EA REC A
COLLISION) TO TAPE*/
** DTOTCOLL G=NEW **;
```

```
*/HDALKIE JOB '0294-24,I=90,,L=30,','HDALKIE'
/*D6250 MVB/2483 -WR
// EXEC SASV5,REGION=1536K
//READ DD DSN=HDALKIE.V1,DISP=SHR
//SAV DD DSN=HDALKIE.V1,DISP=(NEW,KEEP),LABEL=(17,SL),
// VOL=SER=MVB,UNIT=D6250
DATA READ;
SET READ.SAVE1;
DATA SAV.FINAL;
SET READ;
PROC PRINT DATA=SAV.FINAL (OBS=20);
/*SAVING DISK DATASET OF MVB DATA (EA REC A VEHICLE)
TO TAPE*/
** DTOTVEH G=NEW **;
```

APPENDIX B: COLLISION INFORMATION SYSTEM: TYPICAL ANALYSIS

As noted previously, one common limitation of police-based collision programmes is related to the failure to develop a comprehensive data-analysis system which complements the exhaustive data collection activities. While this includes the ability to perform basic statistical manipulations of the data, it also includes the ability to analyze information based on spatial characteristics. This spatial analysis would typically involve the graphic display of collision data and would be most beneficial in:

- correlating collision information with traffic volume data;
- determining the frequency of incidents within a geographic area or road section;
- correlating collision information with known roadway parameters and detailed road characteristics; and
- verifying police-reported data elements with data from other sources.

To address this deficiency, the following methodology was developed to provide an analysis capability which considers spatial information:

- construct a digital roads file depicting the applicable road system;
- identify a collision data base in electronic form; and
- use a simple desktop geographic information system to provide a suitable link between the collision data base and the graphic display of the road network.

For the purpose of this research, this methodology was tested and verified using the Provincial Highway System in Manitoba. A digital representation of this road network including control section numbers was created by digitizing an existing hard-copy base map. (If the City of Winnipeg was to be used, it is likely that the electronic roads file developed by Statistics Canada, the Area Master File, would be modified and used.) Second, the police-based collision data was analyzed using the Collision Information System and tabular summaries based on highway control section numbers were generated. Finally, MapInfo Version 2.5 for Windows was used to display collision data spatially. A sample of the results possible using this methodology is provided in the following figure.

Rather than simply being a new way of presenting summary data, use of this methodology can be exceedingly useful in analyzing and understanding basic road safety issues and trends.

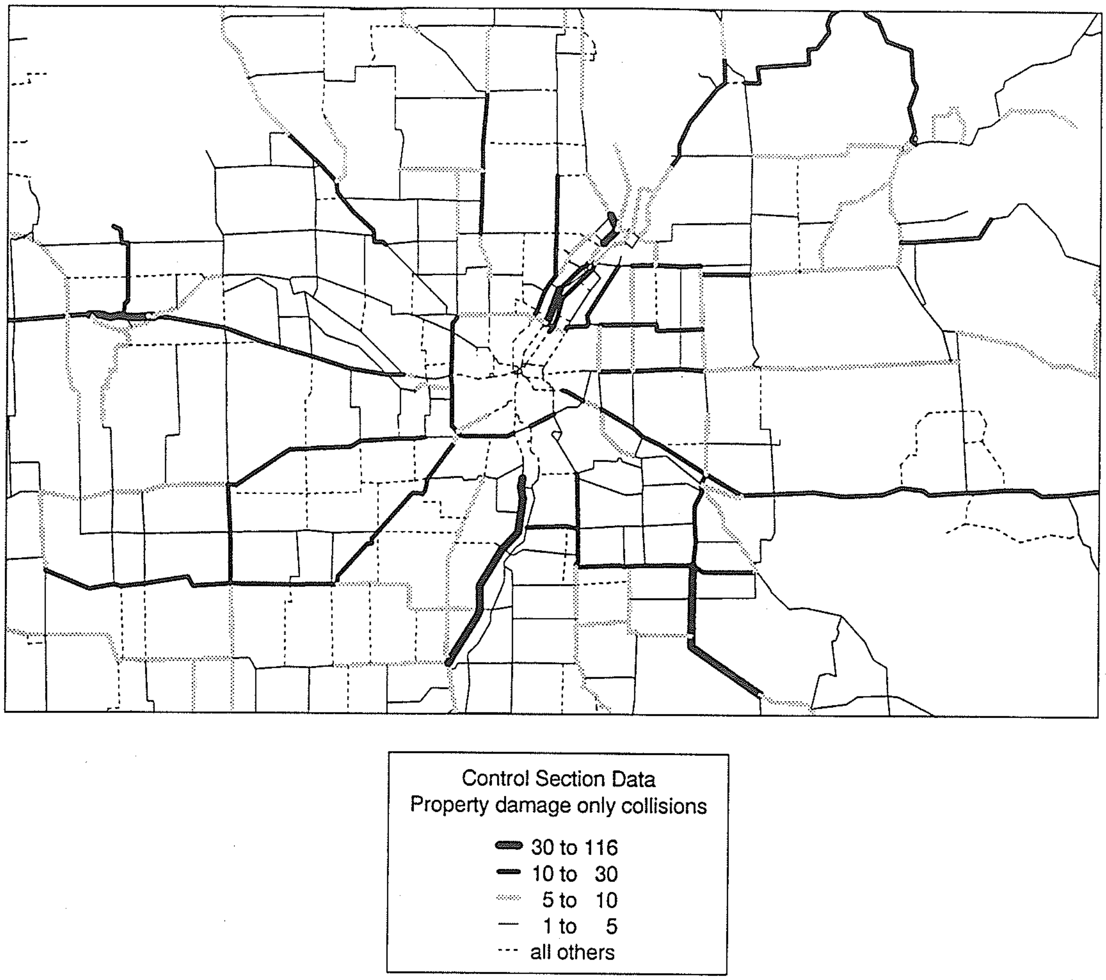

Figure B.1. Graphical illustration of the frequency of collisions (by severity type), on the provincial highway system near the City of Winnipeg.

APPENDIX C: INJURY INFORMATION SYSTEM: ICD9CM, AIS80 CODING CONVENTIONS

Head Injuries

- Single ICD9CM rubrics describing skull fractures (80000-8099 and 8030-8039) may be assigned two ISS/OIC/AIS codes representing 1) the skull fracture, and 2) the anatomic or diffuse lesion.

- If only one substantiated anatomic lesion to the brain is noted and the length of unconsciousness is known, the OIC will consist of the four characters describing the injury as specified int he anatomic lesions section. The AIS will be determined by comparing 1) the AIS which accompanies the specific injury in the anatomic lesion section with 2) the AIS of the comparable injury in the diffuse lesions section. The highest of the two AIS scores will be coded.

- The ICD9CM description of unconsciousness is assigned an AIS severity according to the following table:

ICD9CM Description	AIS Severity
unspecified state of consciousness	-
no loss of consciousness	-
< 1 hour loss of consciousness	2
1-24 hours loss of consciousness	4
> 24 hours loss of consciousness	5
loss of consciousness of unspecified duration	2
unspecified concussion	2

- All ICD9CM descriptions of anatomic lesions are assigned an AIS severity of 3. These lesions are coded conservatively because injuries of higher severity, eg. epidural, subdural, intracerebral, or intracerebellar haematoma (AIS 4); or diffuse brain injury (AIS 5) cannot be identified explicitly and because an injury of such a severity would likely be described by a loss of consciousness > 1 hour (AIS 4 or 5).

- An open fracture of the base of the skull is considered to be more severe than a closed fracture of the same (AIS 4 rather than AIS 3).

Spinal Cord Injuries

- ICD9CM codes specifying fractures of the vertebral column with spinal cord injury (8060-8060) are assigned two ISS/OIC/AIS injury codes representing 1) the fracture of the specified vertebra and 2) the spinal cord injury.

- The AIS of a spinal column injury (8060-8069 and 8390-8399) when associated with hemiplegia (432) or other paralytic syndromes (3440-3449) is reclassified to an AIS score of 5.

- The ICD9CM description for spinal cord injury (including injuries associated with open and closed fractures to the cervical and dorsal vertebra) are assigned an AIS severity according to the following table:

ICD9CM Description	AIS Severity
unspecified spinal cord injury	3
complete lesion	5
anterior cord syndrome	4
central cord syndrome	3
other specified spinal cord injury	4

Chest Injuries

- The AIS of open or closed fractures of the ribs or sternum (8070-8075) when associated with pneumothorax (8600), haemothorax (8604), or pneumohemothorax (8604) is reclassified to an AIS score of 3.

- If a "flail chest" (8074) is associated with open or closed fractures of the ribs (8070-8072) then the code for fractured ribs is deleted and the code for flail chest is used.

Injuries to the Abdomen & Pelvic Contents

- Injuries to the gastrointestinal tract (8630-8639), pelvic organs (8670-8679) and other intra-abdominal organs (8680-8689) with open wound into cavity, is considered to mean a laceration or puncture of the skin surface.

Injuries to the Extremities

- Open and closed fractures of the tibia and fibula are considered as two separate injuries and are assigned two ISS/OIC/AIS codes.

APPENDIX D: INJURY INFORMATION SYSTEM; ICD9CM, AIS80 CONVERSION TABLE

ICD9-CM Code	AIS80 1st Code	AIS80 2nd Code
80000	1HUFS2	
80001	1HUFS2	
80002	1HUFS2	1HWKB2
80003	1HUFS2	1HWKB4
80004	1HUFS2	1HWKB5
80005	1HUFS2	1HWKB5
80006	1HUFS2	1HWKB2
80009	1HUFS2	1HWKB2
80010	1HUFS2	1HUUB3
80011	1HUFS2	1HUUB3
80012	1HUFS2	1HUUB3
80013	1HUFS2	1HUUB4
80014	1HUFS2	1HUUB5
80015	1HUFS2	1HUUB5
80016	1HUFS2	1HUUB3
80019	1HUFS2	1HUUB3
80020	1HUFS2	1HUUB3
80021	1HUFS2	1HUUB3
80022	1HUFS2	1HUUB3
80023	1HUFS2	1HUUB4
80024	1HUFS2	1HUUB5
80025	1HUFS2	1HUUB5
80026	1HUFS2	1HUUB3
80029	1HUFS2	1HUUB3
80030	1HUFS2	1HUUB3
80031	1HUFS2	1HUUB3
80032	1HUFS2	1HUUB3
80033	1HUFS2	1HUUB4
80034	1HUFS2	1HUUB5
80035	1HUFS2	1HUUB5
80036	1HUFS2	1HUUB3
80039	1HUFS2	1HUUB3
80040	1HUFS2	1HUUB3
80041	1HUFS2	1HUUB3
80042	1HUFS2	1HUUB3
80043	1HUFS2	1HUUB4
80044	1HUFS2	1HUUB5
80045	1HUFS2	1HUUB5
80046	1HUFS2	1HUUB3
80049	1HUFS2	1HUUB3
80050	1HUFS4	
80051	1HUFS4	
80052	1HUFS4	1HWKB2
80053	1HUFS4	1HWKB4
80054	1HUFS4	1HWKB5
80055	1HUFS4	1HWKB5
80056	1HUFS4	1HWKB2
80059	1HUFS4	1HUUB3
80060	1HUFS4	1HUUB3
80061	1HUFS4	1HUUB3
80062	1HUFS4	1HUUB3
80063	1HUFS4	1HUUB4
80064	1HUFS4	1HUUB5
80065	1HUFS4	1HUUB5
80066	1HUFS4	1HUUB3
80069	1HUFS4	1HUUB3
80070	1HUFS4	1HUUB3
80071	1HUFS4	1HUUB3
80072	1HUFS4	1HUUB3
80073	1HUFS4	1HUUB4
80074	1HUFS4	1HUUB5
80075	1HUFS4	1HUUB5
80076	1HUFS4	1HUUB3
80079	1HUFS4	1HUUB3
80080	1HUFS4	1HUUB3
80081	1HUFS4	1HUUB3
80082	1HUFS4	1HUUB3
80083	1HUFS4	1HUUB4
80084	1HUFS4	1HUUB5
80085	1HUFS4	1HUUB5
80086	1HUFS4	1HUUB3
80089	1HUFS4	1HUUB3
80090	1HUFS4	1HUUB3
80091	1HUFS4	1HUUB3
80092	1HUFS4	1HUUB3
80093	1HUFS4	1HUUB4
80094	1HUFS4	1HUUB5
80095	1HUFS4	1HWKB5
80096	1HUFS4	1HWKB3
80099	1HUFS4	1HWKB3
80100	1HUFS3	
80101	1HUFS3	
80102	1HUFS3	1HWKB2
80103	1HUFS3	1HWKB4
80104	1HUFS3	1HWKB5
80105	1HUFS3	1HWKB5
80106	1HUFS3	1HWKB2
80109	1HUFS3	1HWKB2
80110	1HUFS3	1HUUB3
80111	1HUFS3	1HUUB3
80112	1HUFS3	1HUUB3
80113	1HUFS3	1HUUB4
80114	1HUFS3	1HUUB5
80115	1HUFS3	1HUUB5
80116	1HUFS3	1HUUB3
80119	1HUFS3	1HUUB3
80120	1HUFS3	1HUUB3
80121	1HUFS3	1HUUB3
80122	1HUFS3	1HUUB3
80123	1HUFS3	1HUUB4
80124	1HUFS3	1HUUB5
80125	1HUFS3	1HUUB5
80126	1HUFS3	1HUUB3
80129	1HUFS3	1HUUB3
80130	1HUFS3	1HUUB3
80131	1HUFS3	1HUUB3
80132	1HUFS3	1HUUB3
80133	1HUFS3	1HUUB4
80134	1HUFS3	1HUUB5
80135	1HUFS3	1HUUB5
80136	1HUFS3	1HUUB3
80139	1HUFS3	1HUUB3
80140	1HUFS3	1HUUB3
80141	1HUFS3	1HUUB3
80142	1HUFS3	1HUUB3
80143	1HUFS3	1HUUB4
80144	1HUFS3	1HUUB5
80145	1HUFS3	1HUUB5
80146	1HUFS3	1HUUB3
80149	1HUFS3	1HUUB3

ICD9-CM Code	AIS80 1st Code	AIS80 2nd Code
80150	1HUFS3	
80151	1HUFS3	
80152	1HUFS3	1HWKB2
80153	1HUFS3	1HWKB4
80154	1HUFS3	1HWKB5
80155	1HUFS3	1HWKB5
80156	1HUFS3	1HWKB2
80159	1HUFS3	1HWKB2
80160	1HUFS3	1HUUB3
80161	1HUFS3	1HUUB3
80162	1HUFS3	1HUUB3
80163	1HUFS3	1HUUB4
80164	1HUFS3	1HUUB5
80165	1HUFS3	1HUUB5
80166	1HUFS3	1HUUB3
80169	1HUFS3	1HUUB3
80170	1HUFS3	1HUUB3
80171	1HUFS3	1HUUB3
80172	1HUFS3	1HUUB3
80173	1HUFS3	1HUUB4
80174	1HUFS3	1HUUB5
80175	1HUFS3	1HUUB5
80176	1HUFS3	1HUUB3
80179	1HUFS3	1HUUB3
80180	1HUFS3	1HUUB3
80181	1HUFS3	1HUUB3
80182	1HUFS3	1HUUB3
80183	1HUFS3	1HUUB4
80184	1HUFS3	1HUUB5
80185	1HUFS3	1HUUB5
80186	1HUFS3	1HUUB3
80189	1HUFS3	1HUUB3
80190	1HUFS3	1HUUB3
80191	1HUFS3	1HUUB3
80192	1HUFS3	1HUUB3
80193	1HUFS3	1HUUB4
80194	1HUFS3	1HUUB5
80195	1HUFS3	1HUUB5
80196	1HUFS3	1HUUB3
80199	1HUFS3	1HUUB3
8020	2FCFS1	
8021	2FCFS1	
80220	2FUFS1	
80221	2FUFS1	
80222	2FUFS2	
80223	2FUFS1	
80224	2FUFS1	
80225	2FUFS2	
80226	2FUFS2	
80227	2FIFS2	
80228	2FIFS2	
80229	2FIFS2	
80230	2FUFS2	
80231	2FUFS2	
80232	2FUFS3	
80233	2FUFS2	
80234	2FUFS2	
80235	2FUFS3	
80236	2FUFS3	
80237	2FUFS2	
80238	2FIFS2	
80239	2FUFS3	
8024	2FUFS2	
8025	2FUFS3	
8026	2FUFS3	
8027	2FUFS3	
8028	2FUFS2	
8029	2FUFS2	
80300	1HUFS2	
80301	1HUFS2	
80302	1HUFS2	1HWKB2
80303	1HUFS2	1HWKB4
80304	1HUFS2	1HWKB5
80305	1HUFS2	1HWKB5
80306	1HUFS2	1HWKB2
80309	1HUFS2	1HWKB2
80310	1HUFS2	1HUUB3
80311	1HUFS2	1HUUB3
80312	1HUFS2	1HUUB3
80313	1HUFS2	1HUUB4
80314	1HUFS2	1HUUB5
80315	1HUFS2	1HUUB5
80316	1HUFS2	1HUUB3
80319	1HUFS2	1HUUB3
80320	1HUFS2	1HUUB3
80321	1HUFS2	1HUUB3
80322	1HUFS2	1HUUB3
80323	1HUFS2	1HUUB4
80324	1HUFS2	1HUUB5
80325	1HUFS2	1HUUB5
80326	1HUFS2	1HUUB3
80329	1HUFS2	1HUUB3
80330	1HUFS2	1HUUB3
80331	1HUFS2	1HUUB3
80332	1HUFS2	1HUUB3
80333	1HUFS2	1HUUB4
80334	1HUFS2	1HUUB5
80335	1HUFS2	1HUUB5
80336	1HUFS2	1HUUB3
80339	1HUFS2	1HUUB3
80340	1HUFS2	1HUUB3
80341	1HUFS2	1HUUB3
80342	1HUFS2	1HUUB3
80343	1HUFS2	1HUUB4
80344	1HUFS2	1HUUB5
80345	1HUFS2	1HUUB5
80346	1HUFS2	1HUUB3
80349	1HUFS2	1HUUB3
80350	1HUFS4	1HUUB3
80351	1HUFS4	1HUUB3
80352	1HUFS4	1HUUB3
80353	1HUFS4	1HUUB4
80354	1HUFS4	1HUUB5
80355	1HUFS4	1HUUB5
80356	1HUFS4	1HUUB3
80359	1HUFS4	1HUUB3
80360	1HUFS4	1HUUB3
80361	1HUFS4	1HUUB3
80362	1HUFS4	1HUUB3
80363	1HUFS4	1HUUB4

ICD9-CM Code	AIS80 1st Code	AIS80 2nd Code
80364	1HUFS4	1HUUB5
80365	1HUFS4	1HUUB5
80366	1HUFS4	1HUUB3
80369	1HUFS4	1HUUB3
80370	1HUFS4	1HUUB3
80371	1HUFS4	1HUUB3
80372	1HUFS4	1HUUB3
80373	1HUFS4	1HUUB4
80374	1HUFS4	1HUUB5
80375	1HUFS4	1HUUB5
80376	1HUFS4	1HUUB3
80379	1HUFS4	1HUUB3
80380	1HUFS4	1HUUB3
80381	1HUFS4	1HUUB3
80382	1HUFS4	1HUUB3
80383	1HUFS4	1HUUB4
80384	1HUFS4	1HUUB5
80385	1HUFS4	1HUUB5
80386	1HUFS4	1HUUB3
80389	1HUFS4	1HUUB3
80390	1HUFS4	1HUUB3
80391	1HUFS4	1HUUB3
80392	1HUFS4	1HUUB3
80393	1HUFS4	1HUUB4
80394	1HUFS4	1HUUB5
80395	1HUFS4	1HUUB5
80396	1HUFS4	1HUUB3
80399	1HUFS4	1HUUB3
80400	1HUFS2	
80401	1HUFS2	
80402	1HUFS2	1HWKB2
80403	1HUFS2	1HWKB4
80404	1HUFS2	1HWKB5
80405	1HUFS2	1HWKB5
80406	1HUFS2	1HWKB2
80409	1HUFS2	1HWKB2
80410	1HUFS2	1HUUB3
80411	1HUFS2	1HUUB3
80412	1HUFS2	1HUUB3
80413	1HUFS2	1HUUB4
80414	1HUFS2	1HUUB5
80415	1HUFS2	1HUUB5
80416	1HUFS2	1HUUB3
80419	1HUFS2	1HUUB3
80420	1HUFS2	1HUUB3
80421	1HUFS2	1HUUB3
80422	1HUFS2	1HUUB3
80423	1HUFS2	1HUUB4
80424	1HUFS2	1HUUB5
80425	1HUFS2	1HUUB5
80426	1HUFS2	1HUUB3
80429	1HUFS2	1HUUB3
80430	1HUFS2	1HUUB3
80431	1HUFS2	1HUUB3
80432	1HUFS2	1HUUB3
80433	1HUFS2	1HUUB4
80434	1HUFS2	1HUUB5
80435	1HUFS2	1HUUB5
80436	1HUFS2	1HUUB3
80439	1HUFS2	1HUUB3

ICD9-CM Code	AIS80 1st Code	AIS80 2nd Code
80440	1HUFS2	1HUUB3
80441	1HUFS2	1HUUB3
80442	1HUFS2	1HUUB3
80443	1HUFS2	1HUUB4
80444	1HUFS2	1HUUB5
80445	1HUFS2	1HUUB5
80446	1HUFS2	1HUUB3
80449	1HUFS2	1HUUB3
80450	1HUFS2	1HUUB3
80451	1HUFS2	1HUUB3
80452	1HUFS2	1HUUB3
80453	1HUFS2	1HUUB4
80454	1HUFS2	1HUUB5
80455	1HUFS2	1HUUB5
80456	1HUFS2	1HUUB3
80459	1HUFS2	1HUUB3
80460	1HUFS2	1HUUB3
80461	1HUFS2	1HUUB3
80462	1HUFS2	1HUUB3
80463	1HUFS2	1HUUB4
80464	1HUFS2	1HUUB5
80465	1HUFS2	1HUUB5
80466	1HUFS2	1HUUB3
80469	1HUFS2	1HUUB3
80470	1HUFS2	1HUUB3
80471	1HUFS2	1HUUB3
80472	1HUFS2	1HUUB3
80473	1HUFS2	1HUUB4
80474	1HUFS2	1HUUB5
80475	1HUFS2	1HUUB5
80476	1HUFS2	1HUUB3
80479	1HUFS2	1HUUB3
80480	1HUFS2	1HUUB3
80481	1HUFS2	1HUUB3
80482	1HUFS2	1HUUB3
80483	1HUFS2	1HUUB4
80484	1HUFS2	1HUUB5
80485	1HUFS2	1HUUB5
80486	1HUFS2	1HUUB3
80489	1HUFS2	1HUUB3
80490	1HUFS2	1HUUB3
80491	1HUFS2	1HUUB3
80492	1HUFS2	1HUUB3
80493	1HUFS2	1HUUB4
80494	1HUFS2	1HUUB5
80495	1HUFS2	1HUUB5
80496	1HUFS2	1HUUB3
80499	1HUFS2	1HUUB3
80500	1NPFS2	
80501	1NPFS2	
80502	1NPFS2	
80503	1NPFS2	
80504	1NPFS2	
80505	1NPFS2	
80506	1NPFS2	
80507	1NPFS2	
80508	1NPFS2	
80510	1NPFS2	
80511	1NPFS2	
80512	1NPFS2	

ICD9-CM Code	AIS80 1st Code	AIS80 2nd Code
80513	1NPFS2	
80514	1NPFS2	
80515	1NPFS2	
80516	1NPFS2	
80517	1NPFS2	
80518	1NPFS2	
8052	3BSFS2	
8053	3BSFS2	
8054	4BIFS2	
8055	4BIFS2	
8056	5PPFS2	
8057	5PPFS3	
8058	9UUFS2	
8059	9UUFS2	
80600	1BSFS2	1NPUC3
80601	1BSFS2	1NPUC5
80602	1BSFS2	1NPUC4
80603	1BSFS2	1NPUC3
80604	1BSFS2	1NPUC4
80605	1BSFS2	1NPUC3
80606	1BSFS2	1NPUC5
80607	1BSFS2	1NPUC4
80608	1BSFS2	1NPUC3
80609	1BSFS2	1NPUC4
80610	1BSFS2	1NPUC3
80611	1BSFS2	1NPUC5
80612	1BSFS2	1NPUC4
80613	1BSFS2	1NPUC3
80614	1BSFS2	1NPUC4
80615	1BSFS2	1NPUC3
80616	1BSFS2	1NPUC5
80617	1BSFS2	1NPUC4
80618	1BSFS2	1NPUC3
80619	1BSFS2	1NPUC4
80620	3BSFS2	1NPUC3
80621	3BSFS2	1NPUC5
80622	3BSFS2	1NPUC4
80623	3BSFS2	1NPUC3
80624	3BSFS2	1NPUC4
80625	3BSFS2	1NPUC3
80626	3BSFS2	1NPUC5
80627	3BSFS2	1NPUC4
80628	3BSFS2	1NPUC3
80629	3BSFS2	1NPUC4
80630	3BSFS2	1NPUC3
80631	3BSFS2	1NPUC5.
80632	3BSFS2	1NPUC4
80633	3BSFS2	1NPUC3
80634	3BSFS2	1NPUC4
80635	3BSFS2	1NPUC3
80636	3BSFS2	1NPUC5
80637	3BSFS2	1NPUC4
80638	3BSFS2	1NPUC3
80639	3BSFS2	1NPUC4
8064	4BIFS2	
8065	4BIFS2	
80660	5PPFS2	4BIUC3
80661	5PPFS2	4BIUC5
80662	5PPFS2	4BIUC5
80669	5PPFS2	4BIUC4

ICD9-CM Code	AIS80 1st Code	AIS80 2nd Code
80670	5PPFS3	4BIUC3
80671	5PPFS3	4BIUC5
80672	5PPFS3	4BIUC5
80679	5PPFS3	4BIUC4
8068	5PPFS3	4BIUC3
8069	5PPFS3	4BIUC3
80700	3CUFS1	
80701	3CUFS1	
80702	3CUFS1	
80703	3CUFS1	
80704	3CUFS1	
80705	3CUFS2	
80706	3CUFS2	
80707	3CUFS2	
80708	3CUFS2	
80709	3CUFS2	
80710	3CUFS2	
80711	3CUFS2	
80712	3CUFS2	
80713	3CUFS2	
80714	3CUFS2	
80715	3CUFS2	
80716	3CUFS2	
80717	3CUFS2	
80718	3CUFS2	
80719	3CUFS2	
8072	3CCFS2	
8073	3CCFS2	
8074	3CUFS2	
8075	1NAFR4	
8076	1NAFR4	
8080	5PPFS2	
8081	5PPFS3	
8082	5PAFS2	
8083	5PAFS3	
80841	5PUFS2	
80842	5PUFS2	
80843	5PUFS4	
80849	5PUFS2	
80851	5PUFS3	
80852	5PUFS3	
80853	5PUFS4	
80859	5PUFS3	
8088	5PUFS2	
8089	5PUFS3	
8090	5PUFS2	
8091	5PUFS3	
81000	5SUFS2	
81001	5SUFS2	
81002	5SUFS2	
81003	5SUFS2	
81010	5SUFS2	
81011	5SUFS2	
81012	5SUFS2	
81013	5SUFS2	
81100	5SUFS2	
81101	5SUFS2	
81102	5SUFS2	
81103	5SUFS2	
81109	5SUFS2	

ICD9-CM Code	AIS80 Code	ICD9-CM Code	AIS80 Code	ICD9-CM Code	AIS80 Code
81110	5SUFS2	81344	5RUFS2	82001	5TUFS3
81111	5SUFS2	81350	5RUFS3	82002	5TUFS3
81112	5SUFS2	81351	5RUFS3	82003	5TUFS3
81113	5SUFS2	81352	5RUFS3	82009	5TUFS3
81119	5SUFS2	81353	5RUFS3	82010	5TUFS3
81200	5AUFS2	81354	5RUFS3	82011	5TUFS3
81201	5AUFS2	81380	5RUFS2	82012	5TUFS3
81202	5AUFS2	81381	5RUFS2	82013	5TUFS3
81203	5AUFS2	81382	5RUFS2	82019	5TUFS3
81209	5AUFS2	81383	5RUFS2	82020	5TUFS3
81210	5AUFS3	81390	5RUFS3	82021	5TUFS3
81211	5AUFS3	81391	5RUFS3	82022	5TUFS3
81212	5AUFS3	81392	5RUFS3	82030	5TUFS3
81213	5AUFS3	81393	5RUFS3	82031	5TUFS3
81219	5AUFS3	81400	5WUFS2	82032	5TUFS3
81220	5AUFS2	81401	5WUFS2	8208	5TUFS3
81221	5AUFS2	81402	5WUFS2	8209	5TUFS3
81230	5AUFS3	81403	5WUFS2	82100	5TUFS3
81231	5AUFS3	81404	5WUFS2	82101	5TUFS3
81240	5AUFS2	81405	5WUFS2	82110	5TUFS3
81241	5AUFS2	81406	5WUFS2	82111	5TUFS3
81242	5AUFS2	81407	5WUFS2	82120	5TUFS3
81243	5AUFS2	81408	5WUFS2	82121	5TUFS3
81244	5AUFS2	81409	5WUFS2	82122	5TUFS3
81249	5AUFS2	81410	5WUFS3	82123	5TUFS3
81250	5AUFS3	81411	5WUFS3	82129	5TUFS3
81251	5AUFS3	81412	5WUFS3	82130	5TUFS3
81252	5AUFS3	81413	5WUFS3	82131	5TUFS3
81253	5AUFS3	81414	5WUFS3	82132	5TUFS3
81254	5AUFS3	81415	5WUFS3	82133	5TUFS3
81259	5AUFS3	81416	5WUFS3	82139	5TUFS3
81300	5RUFS2	81417	5WUFS3	8220	5KUFS2
81301	5RUFS2	81418	5WUFS3	8221	5KUFS2
81302	5RUFS2	81419	5WUFS3	82300	5LUFS2
81303	5EUZJ3	81500	5WUFS2	82301	5LUFS2
81304	5RUFS2	81501	5WUFS2	82302	5LUFS2
81305	5RUFS2	81502	5WUFS2	82310	5LUFS3
81306	5RUFS2	81503	5WUFS2	82311	5LUFS3
81307	5RUFS2	81504	5WUFS2	82312	5LUFS3
81308	5RUFS3	81509	5WUFS2	82320	5LUFS2
81310	5RUFS3	81510	5WUFS2	82321	5LUFS2
81311	5RUFS3	81511	5WUFS2	82322	5LUFS2
81312	5RUFS3	81512	5WUFS2	82330	5LUFS3
81313	5EUZJ3	81513	5WUFS2	82331	5LUFS3
81314	5RUFS3	81514	5WUFS2	82332	5LUFS3
81315	5RUFS3	81519	5WUFS2	82380	5LUFS2
81316	5RUFS3	81600	5WUFS1	82381	5LUFS2
81317	5RUFS3	81601	5WUFS1	82382	5LUFS2
81318	5RUFS3	81602	5WUFS1	82390	5LUFS3
81320	5RUFS2	81603	5WUFS1	82391	5LUFS3
81321	5RUFS2	81610	5WUFS1	82392	5LUFS3
81322	5RUFS2	81611	5WUFS1	8240	5QUFS2
81323	5RUFS2	81612	5WUFS1	8241	5QUFS3
81330	5RUFS2	81613	5WUFS1	8242	5QUFS2
81331	5RUFS3	8170	5WUFS2	8243	5QUFS3
81332	5RUFS3	8171	5WUFS2	8244	5QUFS3
81333	5RUFS3	8180	5XUFS2	8245	5QUFS3
81340	5RUFS2	8181	5XUFS2	8246	5QUFS3
81341	5RUFS2	8190	5XUFS2	8247	5QUFS3
81342	5RUFS2	8191	5XUFS2	8248	5QUFS2
81343	5RUFS2	82000	5TUFS3	8249	5QUFS3

ICD9-CM Code	AIS80 Code	ICD9-CM Code	AIS80 Code	ICD9-CM Code	AIS80 Code
8250	5QUFS2	83314	5WUDJ2	83910	1NPDV2
8251	5QUFS2	83315	5WUDJ2	83911	1NPDV2
82520	5QUFS2	83319	5WUDJ3	83912	1NPDV2
82521	5QUFS2	83400	5WUDJ1	83913	1NPDV2
82522	5QUFS2	83401	5WUDJ1	83914	1NPDV2
82523	5QUFS2	83402	5WUDJ1	83915	1NPDV2
82524	5QUFS2	83410	5WUDJ1	83916	1NPDV2
82525	5QUFS2	83411	5WUDJ1	83917	1NPDV2
82529	5QUFS2	83412	5WUDJ1	83918	1NPDV2
82530	5QUFS2	83500	5PUDJ3	83920	4BIDV2
82531	5QUFS2	83501	5PUDJ3	83921	3BSDV2
82532	5QUFS2	83502	5PUDJ3	83930	4BIDV2
82533	5QUFS2	83503	5PUDJ3	83931	3BSDV2
82534	5QUFS2	83510	5PUDJ3	83940	9UUDV2
82535	5QUFS2	83511	5PUDJ3	83941	5PPDJ2
82539	5QUFS2	83512	5PUDJ3	83942	5PPDJ2
8260	5QUFS1	83513	5PUDJ3	83949	9UUDV2
8261	5QUFS1	8360	5KUDJ3	83950	9UUDV2
8271	5YUFS2	8361	5KUDJ3	83951	5PPDJ2
8270	5YUFS3	8362	5KUDJ3	83952	5PPDJ2
8280	9UUFS3	8363	5KUDJ3	83959	9UUDV2
8281	9UUFS3	8364	5KUDJ3	83961	5SUDJ2
8290	9UUFS1	83650	5KUDJ3	83969	5PUDJ2
8291	9UUFS1	83651	5KUDJ3	83971	5SUDJ2
8300	2FUDJ2	83652	5KUDJ3	83979	5PUDJ2
8301	2FUDJ2	83653	5KUDJ3	8398	9UUDU2
83100	5SUDJ3	83654	5KUDJ3	8399	9UUDU2
83101	5SUDJ3	83659	5KUDJ3	8400	5SUSJ1
83102	5SUDJ3	83660	5KUDJ3	8401	5SUSJ1
83103	5SUDJ3	83661	5KUDJ3	8402	5SUSJ1
83104	5SUDJ2	83662	5KUDJ3	8403	5SUSJ1
83109	5SUDJ2	83663	5KUDJ3	8404	5SUSJ1
83110	5SUDJ3	83664	5KUDJ3	8405	5SUSJ1
83111	5SUDJ3	83669	5KUDJ3	8406	5SUSJ1
83112	5SUDJ3	8370	5QUDJ3	8408	5SUSJ1
83113	5SUDJ3	8371	5QUDJ3	8409	5SUSJ1
83114	5SUDJ2	83800	5QUDJ2	8410	5 USJ1
83119	5SUDJ2	83801	5QUDJ3	8411	5 USJ1
83200	5EUDJ2	83802	5QUDJ2	8412	5 USJ1
83201	5EUDJ2	83803	5QUDJ2	8413	5 USJ1
83202	5EUDJ2	83804	5QUDJ2	8418	5EUSJ1
83203	5EUDJ2	83805	5QUDJ1	8419	5EUSJ1
83204	5EUDJ2	83806	5QUDJ1	84200	5WUSJ1
83209	5EUDJ2	83809	5QUDJ2	84201	5WUSJ1
83210	5EUDJ2	83810	5QUDJ2	84202	5WUSJ1
83211	5EUDJ2	83811	5QUDJ3	84209	5WUSJ1
83212	5EUDJ2	83812	5QUDJ2	84210	5WUSJ1
83213	5EUDJ2	83813	5QUDJ2	84211	5WUSJ1
83214	5EUDJ2	83814	5QUDJ2	84212	5WUSJ1
83219	5EUDJ2	83815	5QUDJ1	84213	5WUSJ1
83300	5WUDJ3	83816	5QUDJ1	84219	5WUSJ1
83301	5WUDJ3	83819	5QUDJ2	8430	5PUSJ1
83302	5WUDJ3	83900	1NPDV2	8431	5PUSJ1
83303	5WUDJ2	83901	1NPDV2	8438	5PUSJ1
83304	5WUDJ2	83902	1NPDV2	8439	5PUSJ1
83305	5WUDJ2	83903	1NPDV2	8440	5KUSJ2
83309	5WUDJ3	83904	1NPDV2	8441	5KUSJ2
83310	5WUDJ3	83905	1NPDV2	8442	5KUSJ2
83311	5WUDJ3	83906	1NPDV2	8443	5KUSJ2
83312	5WUDJ3	83907	1NPDV2	8448	5KUSJ2
83313	5WUDJ2	83908	1NPDV2	8449	5KUSJ2

ICD9-CM Code	AIS80 Code
84500	5QUSJ1
84501	5QUSJ1
84502	5QUSJ1
84503	5QUSJ1
84509	5QUSJ1
84510	5QUSJ1
84511	5QUSJ1
84512	5QUSJ1
84513	5QUSJ1
84519	5QUSJ1
8460	4BITM1
8461	4BITM1
8462	4BITM1
8463	4BITM1
8468	4BITM1
8469	4BITM1
8470	1NPTM1
8471	3BSTM1
8472	4BITM1
8473	4BITM1
8474	4BITM1
8479	9BUTM1
8480	1FUTM1
8481	1FUTM1
8482	1NUTM1
8483	3CUTM1
84840	3CCTM1
84841	3CCTM1
84842	3CCTM1
84849	3CCTM1
8485	5PUTM1
8488	9UUTM1
8489	9UUTM1
8500	1HWKB2
8501	1HWKB2
8502	1HWKB4
8503	1HWKB5
8504	1HWKB5
8505	1HWKB2
8509	1HWKB2
85100	1HUCB3
85101	1HUCB3
85102	1HUCB3
85103	1HUCB4
85104	1HUCB5
85105	1HUCB5
85106	1HUCB3
85109	1HUCB3
85110	1HUCB3
85111	1HUCB3
85112	1HUCB3
85113	1HUCB4
85114	1HUCB5
85115	1HUCB5
85116	1HUCB3
85119	1HUCB3
85120	1HULB4
85121	1HULB4
85122	1HULB4
85123	1HULB4
85124	1HULB5

ICD9-CM Code	AIS80 Code
85125	1HULB5
85126	1HULB4
85129	1HULB4
85130	1HULB4
85131	1HULB4
85132	1HULB4
85133	1HULB4
85134	1HULB5
85135	1HULB5
85136	1HULB4
85139	1HULB4
85140	1HICB5
85141	1HICB5
85142	1HICB5
85143	1HICB5
85144	1HICB5
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85146	1HICB5
85149	1HICB5
85150	1HICB5
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85153	1HICB5
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85159	1HICB5
85160	1HILB5
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85162	1HILB5
85163	1HILB5
85164	1HILB5
85165	1HILB5
85166	1HILB5
85169	1HILB5
85170	1HILB5
85171	1HILB5
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85173	1HILB5
85174	1HILB5
85175	1HILB5
85176	1HILB5
85179	1HILB5
85180	1HUUB4
85181	1HUUB4
85182	1HUUB4
85183	1HUUB4
85184	1HUUB5
85185	1HUUB5
85186	1HUUB4
85189	1HUUB4
85190	1HUUB4
85191	1HUUB4
85192	1HUUB4
85193	1HUUB4
85194	1HUUB5
85195	1HUUB5
85196	1HUUB4
85199	1HUUB4
85200	1HUUB3
85201	1HUUB3

ICD9-CM Code	AIS80 Code
85202	1HUUB3
85203	1HUUB4
85204	1HUUB5
85205	1HUUB5
85206	1HUUB3
85209	1HUUB3
85210	1HUUB3
85211	1HUUB3
85212	1HUUB3
85213	1HUUB4
85214	1HUUB5
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85216	1HUUB3
85219	1HUUB3
85220	1HUUB3
85221	1HUUB3
85222	1HUUB3
85223	1HUUB4
85224	1HUUB5
85225	1HUUB5
85226	1HUUB3
85229	1HUUB3
85230	1HUUB3
85231	1HUUB3
85232	1HUUB3
85233	1HUUB4
85344	1HUUB5
85235	1HUUB5
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85242	1HUUB3
85243	1HUUB4
85244	1HUUB5
85245	1HUUB5
85246	1HUUB3
85249	1HUUB3
85250	1HUUB3
85251	1HUUB3
85252	1HUUB3
85253	1HUUB4
85254	1HUUB5
85255	1HUUB5
85256	1HUUB3
85259	1HUUB3
85300	1HUUB3
85301	1HUUB3
85302	1HUUB3
85303	1HUUB4
85304	1HUUB5
85305	1HUUB5
85306	1HUUB3
85309	1HUUB3
85310	1HUUB3
85311	1HUUB3
85312	1HUUB3
85313	1HUUB4
85314	1HUUB5
85315	1HUUB5
85316	1HUUB3

ICD9-CM Code	AIS80 Code
85319	1HUUB3
85400	1HUUB3
85401	1HUUB3
85402	1HUUB3
85403	1HUUB4
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85406	1HUUB3
85409	1HUUB3
85410	1HUUB3
85411	1HUUB3
85412	1HUUB3
85413	1HUUB4
85414	1HUUB5
85415	1HUUB5
85416	1HUUB3
85419	1HUUB3
8600	9P_HT9
8601	9P_HT9
8602	9P_HT9
8603	9P_HT9
8604	9P_HT9
8605	9P_HT9
86100	3CCUH3
86101	3CCCH3
86102	3CCLH4
86103	3CCLH
86110	3CCUH3
86111	3CCCH3
86112	3CCLH4
86113	3CCLH
86120	3CUUP3
86121	3CUCP3
86122	3CULP3
86130	3CUUP3
86131	3CUCP3
86132	3CULP3
8620	3MSUR3
8621	3MSUR3
86221	3CCUR5
86222	1NAUD5
86229	3CUUU9
86231	3CCUR5
86232	1NAUD5
86239	3CUUU9
8628	3CUUU9
8629	3CUUU9
8630	4MSUD3
8631	4MSUD3
86320	4MIUD4
86321	4MSUD4
86329	4MSUD4
86330	4MIUD4
86331	4MSUD4
86339	4MSUD4
86340	4MIUD4
86341	4MIUD4
86342	4MIUD4
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86354	4MIUD4
86355	4MIUD4
86356	4MIUD4
86359	4MIUD4
86380	4MIUD4
86381	4MSUD4
86382	4MSUD4
86383	4MSUD4
86384	4MSUD4
86385	4MSUD4
86389	4MIUD4
86390	4MIUD4
86391	4MSUD4
86392	4MSUD4
86393	4MSUD4
86394	4MSUD4
86395	4MSUD4
86399	4MSUD4
86400	4MRUL3
86401	4MRCL3
86402	4MRLL4
86403	4MRLL4
86404	4MRLL5
86409	4MRUL3
86410	4MRCL3
86411	4MRLL3
86412	4MRLL4
86413	4MRLL4
86414	4MRLL5
86419	4MRUL3
86500	4MLUQ3
86501	4MLUQ3
86502	4MLUQ3
86503	4MLLQ3
86504	4MLRQ4
86509	4MLUQ3
86510	4MLUQ3
86511	4MLUQ3
86512	4MLUQ3
86513	4MLLQ3
86514	4MLRQ4
86519	4MLUQ3
86600	4MUUK3
86601	4MUCK3
86602	4MULK4
86603	4MURK5
86610	4MUUK3
86611	4MUCK3
86612	4MULK4
86613	4MURK5
8670	4MIUG3
8671	4MIUG3
8672	4MIUG2
8673	4MIUG2
8674	4MIUG3
8675	4MIUG3
8676	4MIUG3
8677	4MIUG3
8678	4MIUG3
8679	4MIUG3
86800	4MUUU3
86801	4MUUT4
86802	4MSUD4
86803	4MIUW4
86804	4MIUU3
86809	4MUUU3
86810	4MUUU3
86811	4MUUT4
86812	4MSUD4
86813	4MIUW4
86814	4MIUU3
86819	4MUUU3
8690	4MUUU9
8691	4MUUU9
8700	2FULO1
8701	2FULO1
8702	2FULO1
8703	2FULO1
8704	2FUUO1
8708	2FUUO1
8709	2FUUO1
8710	2FULO1
8711	2FUUO2
8712	2FUUO2
8713	2FUVO3
8714	2FUUO1
8715	2FUUO2
8716	2FUUO2
8717	2FUUO2
8719	2FUUU1
87200	6HUUE1
87201	6HUUE1
87202	1HUOE1
87210	6HUUE1
87211	6HUUE1
87212	1HUOE1
87261	1HUOE2
87262	1HUOE2
87263	1HUOE2
87264	1HUOE2
87269	1HUOE2
87271	1HUOE2
87272	1HUOE2
87273	1HUOE2
87274	1HUOE2
87279	1HUOE2
8728	6HUUE1
8729	6HUUE1
8730	6HUUI1
8731	6HUUI1
87320	6FCCI1
87321	2FCCS1
87322	2FCCS1
87323	6FCCI1
87329	6FCCI1
87330	6FCCI1

ICD9-CM Code	AIS80 Code	ICD9-CM Code	AIS80 Code	ICD9-CM Code	AIS80 Code
87331	6FCCI1	88100	6RUUI1	8921	6QUUI1
87332	6FCCI1	88101	6EUUI1	8922	5QUUM2
87333	6FCCI1	88102	6WUUI1	8930	6QUUI1
87339	6FCCI1	88110	6RUUI1	8931	6QUUI1
87340	6FUUI1	88111	6EUUI1	8932	5QUUM2
87341	6FUUI1	88112	6WUUI1	8940	6YUUI1
87342	6FUUI1	88120	5RUUM2	8941	6YUUI1
87343	6FIUI1	88121	5EUUM2	8942	6YUUI2
87344	6FUUI1	88122	5WUUM2	8950	5QUMW2
87349	6FUUI1	8820	5WUUI1	8951	5QUMW2
87350	6FUUI1	8821	5WUUI1	8960	5QUMW3
87351	6FUUI1	8822	5WUUM2	8961	5QUMW3
87352	6FUUI1	8830	5WUUI1	8962	5QUMW3
87353	6FIUI1	8831	5WUUI1	8963	5QUMW3
87354	6FUUI1	8832	5WUUM2	8970	5LUMW3
87359	6FUUI1	8840	6XUUI1	8971	5LUMW3
87360	2FIUD1	8841	6XUUI1	8972	5TUMW4
87361	2FIAD1	8842	5XUUM2	8973	5TUMW4
87362	2FIUD1	8850	5WUMW2	8974	5YUMW3
87363	2FIFS1	8851	5WUMW2	8975	5YUMW3
87364	2FIUD1	8860	5WUMW2	90000	1NUUA4
87365	2FIUD1	8861	5WUMW2	90001	1NUUA4
87369	2FIUD1	8870	5RUMW3	90002	1NUUA4
87370	2FIUD1	8871	5RUMW3	90003	1NUUA4
87371	2FIUD1	8872	5RUMW3	9001	1NUUA4
87372	2FIUD1	8873	5RUMW3	90081	1NUUA4
87373	2FIFS1	8874	5RUMW3	90082	1NUUA4
87374	2FIFS1	8875	5RUMW3	90089	1NUUA3
87375	2FIFS1	8876	5RUMW3	9009	1NUUA3
87379	2FIUD1	8877	5RUMW3	9010	3CCUA5
8738	2FIUD1	8748	6NUUI1	9011	3CCUA5
8739	2FIUD1	8749	6NUUI1	9012	3CCUA5
87400	1NAUR4	8750	6CUUI1	9013	3CCUA5
87401	1NAUR4	8751	6CUUI1	90140	3CCUA5
87402	1NAUR4	8760	6BUUI1	90141	3CCUA5
87410	1NAUR4	8761	6BUUI1	90142	3CCUA5
87411	1NAUR4	8770	6PPUI1	90181	3CCUA4
87412	1NAUR4	8771	6PPUI1	90182	3CCUA4
8742	1NAUT2	8780	4MIUG1	90183	3CCUA4
8743	1NAUT2	8781	4MIUG1	90189	3CCUA4
8744	1NAUR1	8782	4MIUG1	9020	4MUUA5
8745	1NAUR1	8783	4MIUG1	90210	4MUUA5
8796	6SUUI1	8784	4MIUG1	90211	4MUUA5
8797	6SUUI1	8785	4MIUG1	90219	4MUUA5
8798	6SUUI1	8786	4MIUG1	90220	4MUUA4
8799	6SUUI1	8787	4MIUG1	90221	4MUUA5
88000	6SUUI1	8788	4MIUG1	90222	4MUUA5
88001	6SUUI1	8789	4MIUG1	90223	4MUUA4
88002	6SUUI1	8790	6CUUI1	90224	4MUUA4
88003	6AUUI1	8791	6CUUI1	90225	4MUUA5
88009	6XUUI1	8792	6CUUI1	90226	4MUUA4
88010	6SUUI1	8793	6CUUI1	90227	4MUUA4
88011	6SUUI1	8794	6CUUI1	90229	4MUUA4
88012	6SUUI1	8795	6CUUI1	90231	4MUUA4
88013	6AUUI1	8900	6YUUI1	90232	4MUUA5
88019	6XUUI1	8901	6YUUI1	90233	4MUUA5
88020	5SUUM2	8902	5YUUM2	90234	4MUUA4
88021	5SUUM2	8910	6LUUI1	90239	4MUUA4
88022	5SUUM2	8911	6LUUI1	90240	4MUUA5
88023	5AUUM2	8912	5LUUM2	90241	4MUUA5
88029	5XUUM2	8920	6QUUI1	90242	4MUUA5

ICD9-CM Code	AIS80 Code
90249	4MUUA5
90250	4MUUA5
90251	4MUUA5
90252	4MUUA5
90253	4MUUA5
90254	4MUUA5
90255	4MUUA4
90256	4MUUA4
90259	4MUUA4
90281	4MUUA4
90282	4MUUA4
90287	4MUUA4
90289	4MUUA4
90300	5XUUA3
90301	5XUUA3
90302	5XUUA3
9031	5XUUA3
9032	5XUUA3
9033	5XUUA3
9034	5XUUA2
9035	5XUUA2
9038	5XUUA3
9039	5XUUA2
9040	5YUUA3
9041	5YUUA3
9042	5YUUA3
9043	5YUUA3
9044	5YUUA3
90440	5YUUA3
90441	5YUUA3
90442	5YUUA3
9045	5YUUA3
90450	5YUUA3
90451	5YUUA3
90452	5YUUA3
90453	5YUUA3
90454	5YUUA3
9046	5YUUA1
9047	5YUUA2
9048	5YUUA2
9049	5YUUA2
9100	1FUAI1
9101	1FUAI1
9108	1FUAU1
9109	1FUAU1
9110	3MUAI1
9111	3MUAI1
9118	3MUAI1
9119	3MUAI1
912	5SMUI1
9120	5SMUI1
9121	5SMUI1
9128	5SMUI1
9129	5SMUI1
9130	5XMUI1
9131	5XMUI1
9138	5XMUI1
9139	5XMUI1
9140	5WMUI1
9141	5WMUI1
9148	5WMUI1
9149	5WMUI1
9150	5WMUI1
9151	5WMUI1
9158	5WMUI1
9159	5WMUI1
9160	5YMUI1
9161	5YMUI1
9168	5YMUI1
9169	5YMUI1
9170	5QMUI1
9171	5QMUI1
9178	5QMUI1
9179	5QMUI1
9180	2FUAU1
9181	2FUAU1
9182	2FUAU1
9189	2FUAU1
9190	6UUUI1
9191	6UUUI1
9198	6UUUI1
9199	6UUUI1
920	6FUCI1
9210	2FUUO1
9211	2FUCO1
9212	2FUCO1
9213	2FUCO1
9219	2FUUO1
9220	6CUCI1
9221	6CUCI1
9222	6MUCI1
9223	6BUCI1
9224	4MUCI1
9228	6MUCI1
9229	6MUCI1
92300	6SUCI1
92301	6SUCI1
92302	6SUCI1
92303	6AUCI1
92309	6XUCI1
92310	6RUCI1
92311	6EUCI1
92320	6WUCI1
92321	6WUCI1
9233	6WUCI1
9238	6XUCI1
9239	6XUCI1
92400	6TUCI1
92401	6PUCI1
92410	6LUCI1
92411	6KUCI1
92420	6QUCI1
92421	6QUCI1
9243	6QUCI1
9244	6YUCI1
9245	6YUCI1
9248	6YUCI1
9249	6YUCI1
925	6FUNW2
9260	4MUNW2
92611	6BUNW3
92612	6PUNW3
92619	6CUNW2
9268	6MUNW3
9269	6MUNW2
92700	5SUNW3
92701	5SUNW3
92702	5SUNW3
92703	5AUNW3
92709	5AUNW3
92710	5RUNW3
92711	5EUNW3
92720	5WUNW3
92721	5WUNW3
9273	5WUNW3
9278	5XUNW3
9279	5XUNW3
92800	5TUNW3
92801	5PUNW3
92810	5LUNW3
92811	5KUNW3
92820	5QUNW3
92821	5QUNW3
9283	5QUNW2
9288	5YUNW3
9289	5YUNW2
9290	5UUNW2
9299	5UUNW2
95200	1NPUN3
95201	1NPUN5
95202	1NPUN4
95203	1NPUN3
95204	1NPUN4
95205	1NPUN3
95206	1NPUN5
95207	1NPUN4
95208	1NPUN3
95209	1NPUN4
95210	3BSUN3
95211	3BSUN5
95212	3BSUN4
95213	3BSUN3
95214	3BSUN4
95215	3BSUN3
95216	3BSUN5
95217	3BSUN4
95218	3BSUN3
95219	3BSUN4
9522	4BIUN3
9523	4BIUN3
9524	4BIUN3
9528	4BIUN3
9529	4BIUN3
9530	4BIUN3
9531	4BIUN3
9532	4BIUN3
9533	4BIUN3
9534	4BIUN3
9535	4BIUN3
9538	4BIUN3
9539	9BUUN3
9540	9UUUN2
9541	9UUUN2

ICD9-CM Code	AIS80 Code	ICD9-CM Code	AIS80 Code	ICD9-CM Code	AIS80 Code
9548	9UUUN2				
9549	9UUUN2				
9550	5UUUN2				
9551	5UUUN2				
9552	5RUUN2				
9553	5RUUN2				
9554	5UUUN2				
9555	5AUUN2				
9556	5WUUN2				
9557	5XUUN2				
9558	9UUN22				
9559	9UUN22				
9560	5YUUN2				
9561	5YUUN2				
9562	5YUUN2				
9563	5YUUN2				
9564	5YUUN2				
9565	5YUUN2				
9568	5YUUN2				
9569	5YUUN2				
9570	1HUUN1				
9571	9UUUN7				
9578	9UUUN7				
9579	9UUUN7				
9590	9FUUU7				
9591	9CUUU7				
9592	9SUUU7				
9593	9EUUU7				
9594	9WUUU7				
9595	9WUUU7				
9596	9YUUU7				
9597	9YUUU7				
9598	9UUUU7				
9599	9UUUU7				

APPENDIX E: INJURY INFORMATION SYSTEM, SAMPLE PROGRAM LISTINGS

The purpose of this program (file = T2DH4) is to transfer data obtained from the Manitoba Health Services Commission in a standard magnetic tape format onto the University of Manitoba mainframe computer system. This particular listing considers data describing 1985/1986 hospital admissions.

```
//HEALTH JOB '0294-24,,,T=10,L=5,I=10','HDALKIE'
/*ROUTE PRINT REMOTE3
/*D6250 BIN# MIN407 SER# MH4201
// EXEC PGM=IEBGENER
//SYSIN DD DUMMY
//SYSPRINT DD SYSOUT=A
//SYSUT1 DD DSN=A44APRD.I.XCH.E44895.S86,DISP=OLD,
// VOL=SER=MH4201,DCB=DEN=4,LABEL=(1,SL),UNIT=D6250
//SYSUT2 DD DSN=HDALKIE.MED86,UNIT=DISK,
// SPACE=(TRK,(80,5),RLSE),
// DCB=(RECFM=FB,LRECL=850,BLKSIZE=5950),
// DISP=(NEW,CATLG),VOL=SER=WEEK01
READ_TAPES.T2DH5
```

This program (file = SORT_ALL_DATA.D_DUP_NODUP) is used to combine records contained in five data sets (MED 82, MED83, MED84, MED85 and MED86) which had been created using file = T2DH4 and other similar programs for other years. Once all data variables are read, a routine has been incorporated to identify persons hospitalized only once during the five-year period and persons who were hospitalized more than once during this period. Two output data sets are created: one containing non-duplicate admissions (UNIQUEC) and one containing duplicate admissions (DUPSC).

```
//TOLL JOB '0294-24,I=90,,L=30,','HDALKIE'
// EXEC SASV5,REGION=1536K
//READ1 DD DSN=HDALKIE.MED82,DISP=SHR
//READ2 DD DSN=HDALKIE.MED83,DISP=SHR
//READ3 DD DSN=HDALKIE.MED84,DISP=SHR
//READ4 DD DSN=HDALKIE.MED85,DISP=SHR
//READ5 DD DSN=HDALKIE.MED86,DISP=SHR
//SSAVE DD DSN=HDALKIE.DUPSC,DISP=(NEW,CATLG,DELETE),
// SPACE=(TRK,(90,5),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
//SAVE DD
DSN=HDALKIE.UNIQUEC,DISP=(NEW,CATLG,DELETE),
// SPACE=(TRK,(90,5),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
DATA MEDX;
INFILE READ1;
INPUT TRN 1-3 HOSP 4-7 ADMIT $ 24-29 SEP 30-35 REG $ 36-41
REC $ 42-50 SEX $ 86 BIRTH 87-92 PAY 95 AD 102 DIAG1 $
109-113 DIAG2 $ 114-118 DIAG3 $ 119-123 DIAG4 $ 124-128
DIAG5 $ 129-133 DIAG6 $ 134-138 DIAG7 $ 139-143 DIAG8 $
144-148 DIAG9 $ 149-153 DIAG10 $ 154-158 DIAG11 $ 159-163
DIAG12 $ 164-168 DIAG13 $ 169-173 DIAG14 $ 174-178 DIAG15 $
179-183 DIAG16 $ 184-188 TRANSF 195-198 TOPO $ 249-263
MORPHO $ 264-278 PREDAY $ 279 ORTRPS $ 280 TRANST
578-581 OUTC 577 AGE 600-601 DAYS 610-613;
DATA MEDX1;
INFILE READ2;
INPUT TRN 1-3 HOSP 4-7 ADMIT $ 24-29 SEP 30-35 REG $ 36-41
REC $ 42-50 SEX $ 86 BIRTH 87-92 PAY 95 AD 102 DIAG1 $
109-113 DIAG2 $ 114-118
DIAG3 $ 119-123 DIAG4 $ 124-128 DIAG5 $ 129-133 DIAG6 $
134-138 DIAG7 $ 139-143
DIAG8 $ 144-148 DIAG9 $ 149-153 DIAG10 $ 154-158 DIAG11 $
159-163 DIAG12 $ 164-168 DIAG13 $ 169-173 DIAG14 $ 174-178
DIAG15 $ 179-183 DIAG16 $ 184-188 TRANSF 195-198 TOPO $
249-263 MORPHO $ 264-278 PREDAY $ 279 ORTRPS $ 280
TRANST 578-581 OUTC 577 AGE 600-601 DAYS 610-613;
DATA MEDX2;
INFILE READ3;
INPUT TRN 1-3 HOSP 4-7 ADMIT $ 24-29 SEP 30-35 REG $ 36-41
REC $ 42-50 SEX $ 86 BIRTH 87-92 PAY 95 AD 102 DIAG1 $
109-113 DIAG2 $ 114-118
DIAG3 $ 119-123 DIAG4 $ 124-128 DIAG5 $ 129-133 DIAG6 $
134-138 DIAG7 $ 139-143
DIAG8 $ 144-148 DIAG9 $ 149-153 DIAG10 $ 154-158 DIAG11 $
159-163 DIAG12 $ 164-168 DIAG13 $ 169-173 DIAG14 $ 174-178
DIAG15 $ 179-183 DIAG16 $ 184-188 TRANSF 195-198 TOPO $
249-263 MORPHO $ 264-278 PREDAY $ 279 ORTRPS $ 280
TRANST 578-581 OUTC 577 AGE 600-601 DAYS 610-613;
DATA MEDX3;
INFILE READ4;
INPUT TRN 1-3 HOSP 4-7 ADMIT $ 24-29 SEP 30-35 REG $ 36-41
REC $ 42-50 SEX $ 86 BIRTH 87-92 PAY 95 AD 102 DIAG1 $
109-113 DIAG2 $ 114-118
DIAG3 $ 119-123 DIAG4 $ 124-128 DIAG5 $ 129-133 DIAG6 $
134-138 DIAG7 $ 139-143
DIAG8 $ 144-148 DIAG9 $ 149-153 DIAG10 $ 154-158 DIAG11 $
159-163 DIAG12 $ 164-168 DIAG13 $ 169-173 DIAG14 $ 174-178
DIAG15 $ 179-183 DIAG16 $ 184-188 TRANSF 195-198 TOPO $
249-263 MORPHO $ 264-278 PREDAY $ 279 ORTRPS $ 280
TRANST 578-581 OUTC 577 AGE 600-601 DAYS 610-613;
DATA MEDX4;
INFILE READ5;
INPUT TRN 1-3 HOSP 4-7 ADMIT $ 24-29 SEP 30-35 REG $ 36-41
REC $ 42-50 SEX $ 86 BIRTH 87-92 PAY 95 AD 102 DIAG1 $
109-113 DIAG2 $ 114-118
DIAG3 $ 119-123 DIAG4 $ 124-128 DIAG5 $ 129-133 DIAG6 $
134-138 DIAG7 $ 139-143
DIAG8 $ 144-148 DIAG9 $ 149-153 DIAG10 $ 154-158 DIAG11 $
159-163 DIAG12 $ 164-168 DIAG13 $ 169-173 DIAG14 $ 174-178
DIAG15 $ 179-183 DIAG16 $ 184-188 TRANSF 195-198 TOPO $
249-263 MORPHO $ 264-278 PREDAY $ 279 ORTRPS $ 280
TRANST 578-581 OUTC 577 AGE 600-601 DAYS 610-613;
DATA OUTPUT ;
SET MEDX MEDX1 MEDX2 MEDX3 MEDX4;
KEY=REG || BIRTH;
PROC SORT DATA=OUTPUT;
BY KEY ADMIT SEP;
DATA SAVE.FINAL;
SET OUTPUT;
BY KEY;
IF ^(FIRST.KEY AND LAST.KEY) THEN DELETE;
DATA SSAVE.FINAL;
SET OUTPUT;
BY KEY;
IF ^(FIRST.KEY AND LAST.KEY) THEN OUTPUT;
```

This program (file SORT_DUP_DATA.DUPDUPA) considers all duplciate admissions and eliminates the "double counting" of the same injury sustained by persons admitted to one hospital and then transferred to a second hospital due to the same incident. The resultant data set (DUPSC) is used in further anlyses.

```
SORT_DUP_DATA.DUPDUPA
//TOLL JOB '0294-24,I=30,,L=30,','HDALKIE'
// EXEC SASV5,REGION=1536K,OPTIONS='LINESIZE=70'
//READ DD DSN=HDALKIE.DUPSC,DISP=SHR
//SAVE DD
DSN=HDALKIE.DUPSC.SORTED,DISP=(NEW,CATLG,DELETE),
// SPACE=(TRK,(10,2),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
DATA FIX; /* ALL DUPLICATE RECORDS */
SET READ.FINAL;
DATA LAST ; /* FIRST OBSERVATION OF VARIABLE */
SET FIX; BY KEY; /* KEY */
IF FIRST.KEY THEN OUTPUT;
ODAYS=DAYS;
OHOSP=HOSP;
OADMIT=ADMIT;
OSEP=SEP;
DATA LAST1; /* SECOND AND SUBSEQUENT */
SET FIX; BY KEY; /* OBSERVATIONS OF KEY */
IF FIRST.KEY THEN DELETE;
DATA LAST2; /* ALL SECOND OBS OF KEY */
SET LAST1; BY KEY;
IF FIRST.KEY THEN OUTPUT;
DATA LAST3; /* THIRD AND SUBSEQUENT */
SET LAST1 ; BY KEY; /* OBSERVATIONS OF KEY */
IF FIRST.KEY THEN DELETE;
DATA LAST3B; /* SET DATSET WITH FIRST OBS AND DATASET
*/
SET LAST3 LAST1; /* WITH 3RD AND SUBSQ OBS, DELETING
DUPS */
PROC SORT; BY KEY; PROC PRINT;
DATA LAST4;
SET LAST3B; BY KEY;
IF ^(FIRST.KEY AND LAST.KEY) THEN DELETE;
PDAYS=DAYS;
DATA LAST5; /*SECOND OBSERV */
SET LAST4 LAST; BY KEY; /*OF INCID OCCU */
IF ^(FIRST.KEY AND LAST.KEY) THEN OUTPUT; /* ONCE */
DATA INFO1; /* MERGE DUPLCATE RECORDS OF SAME
INCIDENT */
SET LAST5; /* INTO SINGLE RECORD CONTAING INFORMATION
*/
NDIAG1 = DIAG1; /* FROM EACH RECORD. */
NDIAG2 = DIAG2;
NDIAG3 = DIAG3;
NDIAG4 = DIAG4;
NDIAG5 = DIAG5;
NDIAG6 = DIAG6;
NDIAG7 = DIAG7;
NDIAG8 = DIAG8;
NDIAG9 = DIAG9;
PROC SORT OUT = HAL;
BY KEY ADMIT SEP;
DATA INFO2;
SET LAST5;
PROC SORT OUT = HAL1;
BY KEY DESCENDING ADMIT DESCENDING SEP;
DATA CONCAT;
MERGE HAL HAL1; BY KEY;
BETWEEN=ADMIT-OSEP;
DAYS=ODAYS+PDAYS;
DATA FINAL1;
SET CONCAT; BY KEY;
IF FIRST.KEY THEN OUTPUT;
DATA FINAL2;
SET CONCAT;BY KEY;
IF FIRST.KEY AND BETWEEN < 60 AND OPSEP NE ADMIT THEN
OUTPUT;
DATA FINAL99;
ARRAY D(16) $5 DIAG1 DIAG2 DIAG3 DIAG4 DIAG5 DIAG6 DIAG7
DIAG8 DIAG9 DIAG10 DIAG11 DIAG12 DIAG13 DIAG14 DIAG15
DIAG16;
ARRAY CONV(16) $1 CV1-CV16;
SET LAST4 ; BY KEY;
IF ^(FIRST.KEY AND LAST.KEY) THEN DELETE;
DO I=1 TO 16;
CV = SUBSTR(D(I),1,1);
IF CV='V' THEN DELETE;
END;
DATA SAVE.FINAL;
SET FINAL1;
DAYS=PDAYS+ODAYS;
DATA FINAL91;
ARRAY D(16) $5 DIAG1 DIAG2 DIAG3 DIAG4 DIAG5 DIAG6 DIAG7
DIAG8 DIAG9 DIAG10 DIAG11 DIAG12 DIAG13 DIAG14 DIAG15
DIAG16;
ARRAY CONV(16) $1 CV1-CV16;
SET LAST3; BY KEY;
IF ^(FIRST.KEY AND LAST.KEY) THEN DELETE;
DO I=1 TO 16;
CV = SUBSTR(D(I),1,1);
IF CV='V' THEN DELETE;
END;
```

The following files read the non-duplicate records and assign an appropriate AIS80 code (including the five-digit OIC code) to each ICD9CM code. In addition, routines are included to calculate the maximum AIS80 injury code for each body region and calculate the Injury Severity Code (ISS) for each person. Three specific files are submitted as one job to complete this procedure. The first file (file = ASSIGN_OIC_AIS_ CODES.NODUPJCLA for non-duplicate records dataset or file = ASSIGN_OIC_AIS_CODES.DUPSJCLA for the sorted duplicate records dataset) contains the appropriate job control language. The second file is the ICD9CM to AIS80 conversion table described in Appendix C (file ASSIGN_OIC_AIS_ CODES.SCALE2), and the third file performs the above-noted procedures (file = ASSIGN_OIC_AIS_CODES. SCALE2).

```
ASSIGN_OIC_AIS_CODES.NODUPJCLA
//TOLL JOB '0294-24,I=80,T=2M,L=30,','HDALKIE'
// EXEC SASV5,REGION=1536K,OPTIONS='LINESIZE=70'
//READ DD DSN=HDALKIE.UNIQUEC,DISP=SHR
//SAVE DD
DSN=HDALKIE.UNIQUE.SCALED,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(2,1),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
ASSIGN_OIC_AIS_CODES.DUPJCLA
//TOLL JOB '0294-24,I=80,T=2M,L=30,','HDALKIE'
// EXEC SASV5,REGION=1536K
//READ DD DSN=HDALKIE.DUPS.SORTED,DISP=SHR
//SAVE DD
DSN=HDALKIE.DUPSC.SCALED,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(2,1),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
ASSIGN_OIC_AIS_CODES.SCALE2
DATA ONE;
SET READ.FINAL;
ARRAY D(16) $5 DIAG1 DIAG2 DIAG3 DIAG4 DIAG5 DIAG6 DIAG7
DIAG8 DIAG9 DIAG10 DIAG11 DIAG12 DIAG13 DIAG14 DIAG15
DIAG16;
ARRAY A(16) $6 A1-A16; /* DEFINES FIRST AISOIC CODE FOR
EACH ECODE */
ARRAY B(16) $6 B1-B16; /* DEFINES SECOND AISOIC CODE
WHABLE */\
ARRAY C(32) $6 A1-A16 B1-B16; /* ALL AISOIC CODES FOR
EACM CODE */
ARRAY M(6) $1 M1-M6; /* MAXIMUM AIS FOR EACH BODY
REGION */
ARRAY OMAX(6) 2 FIRST SECOND THIRD FOURTH FIFTH
SIXTH;
ARRAY ISSREG(6) $1 HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL;
M1 = '0'; /* MAXIMUM AIS FOR BODY REGION 1 (HEAD) */
M2 = '0'; /* MAXIMUM AIS FOR BODY REGION 2 (FACE AND
NECK) */
M3 = '0'; /* MAXIMUM AIS FOR BODY REGION 3*/
M4 = '0'; /* MAXIMUM AIS FOR BODY REGION 4*/
M5 = '0'; /* MAXIMUM AIS FOR BODY REGION 5*/
M6 = '0'; /* MAXIMUM AIS FOR BODY REGION 6*/
MAX='0';
TEST='0';
FIRST='0';
SECOND='0';
THIRD='0';
FOURTH='0';
FIFTH='0';
SIXTH='0';
DO I=1 TO 16; /* ASSIGNS AISOIC VALUE TO ICD9CM CODE */
TEMPC = PUT(D(I),$SCALE.);
A(I) = SUBSTR(TEMPC, 1,6);
B(I) = SUBSTR(TEMPC, 8,6);
IF SUBSTR(TEMPC,1,3)='MVA' THEN TYPE=TEMPC;
END;
DO I=1 TO 32; /* DETERMINES MAXIMUM AIS FOR EACH BODY
REGION */
IF C(I) NOT = '0N/A 0' AND C(I) NOT = ' '
AND SUBSTR(C(I),1,1) NOT = '9'
AND SUBSTR( C(I),1,3) NOT = 'MVA' THEN DO;
REGION = INPUT(SUBSTR(C(I),1,1), 1.);
AIS = SUBSTR( C(I),6,1);
IF AIS > M(REGION) THEN M(REGION) = AIS;
END;
END;
DO I=1 TO 6;
ISSREG(I) = M(I);
END ;
DO J=1 TO 6;
DO I=1 TO 6; /* DETERMINES GREATEST AIS FOR BODY
REGION (J) */
MAX=M(I);
IF OMAX(J) < MAX THEN OMAX(J)=MAX ;
END;
DO I=1 TO 6; /* REDEFINES GREATEST AIS VALUE FOUND IN
PREVIOUS */
TEST=M(I); /* LOOP TO A MINIMAL VALUE SO THAT THE NEXT
GREATEST */
IF TEST=OMAX(J) THEN GO TO BB; /*VALUE MAY BE
DETERMINED */
GO TO MM;
BB: M(I)='.1';
GO TO OUT;
MM: END;
OUT:;
END;
ISS=OMAX(1)**2+OMAX(2)**2+OMAX(3)**2;
DATA SAVE.RAW;
SET ONE;
```

This program (file = INJURY_DATASETS.READFILE) produces a data set where each record represents a specific injury sustained by some injured person. Due to data processing limitations, this file must be modified to separately consider each road-user type as defined by the ICD9CM coding conventions.

```
INJURY_DATASETS.READFILE
//TOLL JOB '0294-24,I=90,,L=30,','HDALKIE'
// EXEC SASV5,REGION=3072K,OPTIONS='LINESIZE=70'
//READ DD DSN=HDALKIE.UNIQUE.SCALED,DISP=SHR
//RREAD DD DSN=HDALKIE.DUPSC.SCALED,DISP=SHR
//SSAVE DD DSN=HDALKIE.I9,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(5,5),RLSE),UNIT=DISK,VOL=SER=WORK02,
// DCB=(RECFM=U)
DATA WON; SET READ.RAW;
PERSON=SUBSTR(TYPE,6,1) ;
IF PERSON='9' THEN OUTPUT;
DATA WONA; SET RREAD.RAW;
PERSON=SUBSTR(TYPE,6,1) ;
IF PERSON='9' THEN OUTPUT;
DATA A; SET WON WONA;
YR=SUBSTR(ADMIT,1,2);
MONTH=SUBSTR(ADMIT,3,2);
INJURY=A1;OUTPUT;
INJURY=A2;OUTPUT;
INJURY=A3;OUTPUT;
INJURY=A4;OUTPUT;
INJURY=A5;OUTPUT;
INJURY=A6;OUTPUT;
INJURY=A7;OUTPUT;
INJURY=A8;OUTPUT;
INJURY=A9;OUTPUT;
INJURY=A10;OUTPUT;
INJURY=A11;OUTPUT;
INJURY=A12;OUTPUT;
INJURY=A13;OUTPUT;
INJURY=A14;OUTPUT;
INJURY=A15;OUTPUT;
INJURY=A16;OUTPUT;
INJURY=B1;OUTPUT;
INJURY=B2;OUTPUT;
INJURY=B3;OUTPUT;
INJURY=B4;OUTPUT;
INJURY=B5;OUTPUT;
INJURY=B6;OUTPUT;
INJURY=B7;OUTPUT;
```

```
INJURY=B8;OUTPUT;
INJURY=B9;OUTPUT;
INJURY=B10;OUTPUT;
INJURY=B11;OUTPUT;
INJURY=B12;OUTPUT;
INJURY=B13;OUTPUT;
INJURY=B14;OUTPUT;
INJURY=B15;OUTPUT;
INJURY=B16;OUTPUT;
KEEP MONTH YR INJURY HOSP ADMIT SEX OUTC AGE DAYS
KEY ISS FIRST SECOND THIRD FOURTH FIFTH CHEST
ABDOMEN EXTERNAL EXTREM FACE HEAD PERSON ;
DATA B; SET A;
TT=SUBSTR(INJURY,2,1);
REGION=SUBSTR(INJURY,2,1);
LESION=SUBSTR(INJURY,4,1);
ORGAN=SUBSTR(INJURY,5,1);
TU=SUBSTR(INJURY,4,2);
SEV=SUBSTR(INJURY,6,1);
RISS=SUBSTR(INJURY,1,1);
IF RISS='M' OR RISS='9' THEN DELETE;
IF INJURY='0N/A 0' OR INJURY=' ' THEN DELETE;
DATA SSAVE.FINAL; SET B;
INJURY_DATASETS.COMBINE
```

This program (file = DATASETS.COMBINE) reads all datasets created using the previously listed program and merges the information to a single dataset. Since original data included data from the end of 1981 and the beginning of 1986 only those persons injured in 1982, 1983, 1984 and 1985 are included in this data set.

```
//LAWS JOB '0294-24,I=90,,L=30,','HDALKIE'
// EXEC SASV5,REGION=1536K,OPTIONS='LINESIZE=70'
//SFILE DD DSN=HDALKIE.I0,DISP=SHR
//SFILF DD DSN=HDALKIE.II1,DISP=SHR
//SFILG DD DSN=HDALKIE.II2,DISP=SHR
//SFILH DD DSN=HDALKIE.I3,DISP=SHR
//SFILI DD DSN=HDALKIE.I4,DISP=SHR
//SFILJ DD DSN=HDALKIE.I5,DISP=SHR
//SFILK DD DSN=HDALKIE.I6,DISP=SHR
//SFILL DD DSN=HDALKIE.I7,DISP=SHR
//SFILM DD DSN=HDALKIE.I8,DISP=SHR
//SFILN DD DSN=HDALKIE.I9,DISP=SHR
//FILEA DD DSN=HDALKIE.COMB,DISP=(NEW,CATLG,DELETE),
// SPACE=(CYL,(1,1),RLSE),UNIT=DISK,VOL=SER=WEEK01,
// DCB=(RECFM=U)
DATA ONE; SET SFILE.FINAL;
DATA TWO; SET SFILF.FINAL;
DATA THR; SET SFILG.FINAL;
DATA FOU; SET SFILH.FINAL;
DATA FIV; SET SFILI.FINAL;
DATA SIX; SET SFILJ.FINAL;
DATA SEV; SET SFILK.FINAL;
DATA EIG; SET SFILL.FINAL;
DATA NIN; SET SFILM.FINAL;
DATA TEN; SET SFILN.FINAL;
DATA TEST; SET ONE TWO THR FOU FIV SIX SEV EIG NIN TEN;
IF YR='82' OR YR='83' OR YR='84' OR YR='85' THEN OUTPUT;
DATA FILEA.FINAL; SET TEST;
```

This program (file = INJURY_DATASETS.INJ1) uses the data set created representing injuries sustained by persons involved in motor vehicle collisions (1982-1985) and completes basic summary analysis of the data. Tables are produced which describe the distribution of injuries sustained by each road-user type (by body region and severity).

```
//HDALKIE JOB '0294-24,I=90,,L=30,','HDALKIE'
/*D6250 MVB/2483
// EXEC SASV5,REGION=1536K
//READ DD
DSN=HDALKIE.COMB,DISP=OLD,VOL=SER=MVB,LABEL=(16,SL),
// UNIT=D6250
PROC FORMAT;
PROC FORMAT;
VALUE $ISSC
'1'='NO SCORE'
'2'='ISS 1-8'
'3'='ISS 9-15'
'4'='ISS 16-24'
'5'='ISS 25-40'
'6'='ISS > 40';
VALUE $PERSON '0'='MV DRIVER'
'1'='MV PASS'
'2'='MC DRIVER'
'3'='MC PASS'
'4'='BUS OCC'
'6'='BICYCLIST'
'7'='PEDESTRIAN'
'8','9'='OTHER AND UNSPEC';
DATA READ;
SET READ.FINAL;
IF PERSON='0' AND AGE < 16 THEN DELETE;
IF PERSON='2' AND AGE < 16 THEN DELETE;
IF PERSON='0' | PERSON ='1' THEN TVEH=1; /*PASS DRIVER
OR OCC*/
IF PERSON='2' | PERSON ='3' THEN TVEH=2; /*MC DRIVER OR
PASSENGER*/
IF PERSON='4' THEN TVEH=3; /*BUS OCCUPANT*/
IF PERSON='6' THEN TVEH=4; /*BICYCLIST*/
IF PERSON='7' THEN TVEH=5; /*PEDESTRIAN*/
IF PERSON='8' | PERSON='9' THEN TVEH=6; /*OTHER AND
UNSPECIFIED*/
IF YR=82 OR YR=83 THEN LEGIS=1;
IF YR=84 OR YR=85 THEN LEGIS=2;
IF ISS =0 THEN ISSC='1';
IF ISS >0 AND ISS <=8 THEN ISSC='2';
IF ISS >8 AND ISS <=15 THEN ISSC='3';
IF ISS >15 AND ISS <=24 THEN ISSC='4';
IF ISS >24 AND ISS <=40 THEN ISSC='5';
IF ISS >40 THEN ISSC='6';
PROC SORT; BY KEY;
DATA MVDR MVPASS MCDR MCPASS BUSPASS BIKE PED
OTHER; SET READ; BY KEY;
IF FIRST.KEY;
IF PERSON='0' THEN OUTPUT MVDR;
IF PERSON='1' THEN OUTPUT MVPASS;
IF PERSON='2' THEN OUTPUT MCDR;
IF PERSON='3' THEN OUTPUT MCPASS;
IF PERSON='4' THEN OUTPUT BUSPASS;
IF PERSON='6' THEN OUTPUT BIKE;
IF PERSON='7' THEN OUTPUT PED;
IF PERSON='8' | PERSON='9' THEN OUTPUT OTHER;
```

```
DATA MVDR; SET MVDR;
PROC SORT; BY YR;
PROC FREQ; BY YR;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
PROC SORT; BY LEGIS;
PROC FREQ;
TABLES RISS*LEGIS REGION*LEGIS ISSC*LEGIS /NOROW
NOPERCENT NOCOL;
DATA MVPASS; SET MVPASS;
PROC SORT; BY YR;
PROC FREQ; BY YR;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
PROC SORT; BY LEGIS;
PROC FREQ; BY LEGIS;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
DATA MCDR; SET MCDR;
PROC SORT; BY YR;
PROC FREQ; BY YR;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
PROC SORT; BY LEGIS;
PROC FREQ; BY LEGIS;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
DATA MCPASS; SET MCPASS;
PROC SORT; BY YR;
PROC FREQ; BY YR;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
PROC SORT; BY LEGIS;
PROC FREQ; BY LEGIS;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
DATA BUSPASS; SET BUSPASS;
PROC SORT; BY YR;
PROC FREQ; BY YR;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
PROC SORT; BY LEGIS;
PROC FREQ; BY LEGIS;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
DATA BIKE; SET BIKE;
PROC SORT; BY YR;
PROC FREQ; BY YR;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
PROC SORT; BY LEGIS;
PROC FREQ; BY LEGIS;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
DATA PED; SET PED;
PROC SORT; BY YR;
PROC FREQ; BY YR;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
PROC SORT; BY LEGIS;
PROC FREQ; BY LEGIS;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
DATA OTHER; SET OTHER;
PROC SORT; BY YR;
PROC FREQ; BY YR;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
PROC SORT; BY LEGIS;
PROC FREQ; BY LEGIS;
TABLES HEAD FACE CHEST ABDOMEN EXTREM
EXTERNAL/NOROW NOCOL NOPERCENT;
```

This program (file = INJURY_DATASETS.INJ2) is similar to the previous file listing (file = INJURY_DATASETS.INJ1), however the tables produced describe the number of persons included in the database rather than the number of injuries.

```
INJURY_DATASETS.INJ2
//HDALKIE JOB '0294-24,I=90,,L=30,','HDALKIE'
/*D6250 MVB/2483
// EXEC SASV5,REGION=1536K
//READ DD
DSN=HDALKIE.COMB,DISP=OLD,VOL=SER=MVB,LABEL=(16,SL),
// UNIT=D6250
PROC FORMAT;
VALUE ISSC
1='NO SCORE'
2='ISS 1-8'
3='ISS 9-15'
4='ISS 16-24'
5='ISS 25-40'
6='ISS >40';
VALUE $PERSON '0'='MV DRIVER'
'1'='MV PASS'
'2'='MC DRIVER'
'3'='MC PASS'
'4'='BUS OCC'
'6'='BICYCLIST'
'7'='PEDESTRIAN'
'8','9'='OTHER AND UNSPEC';
DATA READ;
SET READ.FINAL;
IF PERSON='0' | PERSON ='1' THEN TVEH=1; /*PASS DRIVER
OR OCC*/
IF PERSON='2' | PERSON ='3' THEN TVEH=2; /*MC DRIVER OR
PASSENGER*/
IF PERSON='4' THEN TVEH=3; /*BUS OCCUPANT*/
IF PERSON='6' THEN TVEH=4; /*BICYCLIST*/
IF PERSON='7' THEN TVEH=5; /*PEDESTRIAN*/
IF PERSON='8' | PERSON='9' THEN TVEH=6; /*OTHER AND
UNSPECIFIED*/
IF YR=82 OR YR=83 THEN LEGIS=1;
IF YR=84 OR YR=85 THEN LEGIS=2;
IF ISS =0 THEN ISSC=1;
IF ISS >0 AND ISS <=8 THEN ISSC=2;
IF ISS >8 AND ISS <=15 THEN ISSC=3;
IF ISS >15 AND ISS <=24 THEN ISSC=4;
IF ISS >24 AND ISS <=40 THEN ISSC=5;
IF ISS >40 THEN ISSC=6;
PROC SORT; BY KEY;
DATA READ; SET READ; BY KEY;
IF FIRST.KEY;
PROC SORT; BY PERSON;
PROC FREQ;
TABLES ISSC*LEGIS /NOPERCENT CHISQ;
FORMAT PERSON $PERSON. ISSC ISSC.;
PROC SORT; BY PERSON;
PROC MEANS; BY PERSON;
VAR ISS;
FORMAT ISSC ISSC.;
```

The following programs (files = INJURY_ANALYSIS.GENERAL INJ2B) are typical analytical procedures which can be completed to analyse and characterize the database.

```
INJURY_ANALYSIS.GENERAL
//PODS JOB '0294-24,I=90,,L=30,','HDALKIE'
// EXEC SASV5,REGION=1536K,OPTIONS='LINESIZE=70'
//SFILE DD DSN=HDALKIE.COMB,DISP=SHR
DATA TEST;SET SFILE.FINAL;
IF PERSON='4' OR PERSON='5' THEN DELETE;
IF YR='82' OR YR='83' THEN LEG='BEFORE';
IF YR='84' OR YR='85' THEN LEG='AFTER';
PROC SORT; BY KEY;
DATA TEST1; SET TEST; IF SEV > 1 THEN OUTPUT;
DATA TEST2; SET TEST1; BY KEY; IF FIRST.KEY THEN
OUTPUT;
PROC SORT; BY PERSON;
PROC FREQ; BY PERSON;
TABLES MONTH*YR ISS*YR DAYS*YR / NOROW NOPERCENT
NOCOL;
DATA BEFORE; SET TEST2;
IF LEG='BEFORE' THEN OUTPUT;
PROC FREQ; BY PERSON; TABLES HEAD*YR FACE*YR
CHEST*YR
ABDOMEN*YR EXTREM*YR EXTERNAL*YR / NOCOL
NOPERCENT NOROW;
DATA BEFINJ; SET TEST1;
IF LEG='BEFORE' THEN OUTPUT;
PROC FREQ; BY PERSON; TABLE ISS DAYS ;
PROC FREQ; BY PERSON; TABLES SEV*RISS SEV*REGION
/ NOROW NOPERCENT NOCOL;
DATA AFTER; SET TEST2;
IF LEG='AFTER' THEN OUTPUT;
PROC FREQ; BY PERSON; TABLES HEAD*YR FACE*YR
CHEST*YR
ABDOMEN*YR EXTREM*YR EXTERNAL*YR / NOCOL
NOPERCENT NOROW;
DATA AFTINJ; SET TEST1;
IF LEG='AFTER' THEN OUTPUT;
PROC FREQ; BY PERSON; TABLE ISS DAYS ;
PROC FREQ; BY PERSON; TABLES SEV*RISS SEV*REGION
/ NOROW NOPERCENT NOCOL;
```

```
INJURY_ANALYSIS.GEN
//PODS JOB '0294-24,I=90,,L=30,','HDALKIE'
// EXEC SASV5,REGION=1536K,OPTIONS='LINESIZE=70'
//SFILE DD DSN=HDALKIE.COMB,DISP=SHR
DATA TEST;SET SFILE.FINAL;
DATA TEST1; SET TEST; IF SEV > 1 THEN OUTPUT;
DATA TEST2; SET TEST1; IF PERSON = '0' THEN OUTPUT;
PROC SORT; BY YR; PROC FREQ; BY YR;
TABLES RISS*SEV / NOCOL NOPERCENT NOROW;
INJ1B
//HDALKIE JOB '0294-24,I=90,,L=30,','HDALKIE'
// EXEC SASV5,REGION=1536K
//READ DD DSN=HDALKIE.COMB,DISP=SHR
PROC FORMAT;
VALUE $ISSC
'1'='NO SCORE'
'2'='ISS 1-8'
'3'='ISS 9-15'
'4'='ISS 16-24'
'5'='ISS 25-40'
'6'='ISS > 40';
VALUE $PERSON '0'='MV DRIVER'
'1'='MV PASS'
'2'='MC DRIVER'
'3'='MC PASS'
'4'='BUS OCC'
'6'='BICYCLIST'
'7'='PEDESTRIAN'
'8','9'='OTHER AND UNSPEC';
DATA READ;
SET READ.FINAL;
IF PERSON='0' AND AGE < 16 THEN DELETE;
IF PERSON='2' AND AGE < 16 THEN DELETE;
NCHEST=CHEST*1; NFACE=FACE*1; NABDOMEN=ABDOMEN*1;
NEXTREM=EXTREM*1; NEXTERNL=EXTERNAL*1;
IF PERSON='0' | PERSON ='1' THEN TVEH=1; /*PASS DRIVER
OR OCC*/
IF PERSON='2' | PERSON ='3' THEN TVEH=2; /*MC DRIVER OR
PASSENGER*/
IF PERSON='4' THEN TVEH=3; /*BUS OCCUPANT*/
IF PERSON='6' THEN TVEH=4; /*BICYCLIST*/
IF PERSON='7' THEN TVEH=5; /*PEDESTRIAN*/
IF PERSON='8' | PERSON='9' THEN TVEH=6; /*OTHER AND
UNSPECIFIED*/
IF YR=82 OR YR=83 THEN LEGIS=1;
IF YR=84 OR YR=85 THEN LEGIS=2;
IF ISS =0 THEN ISSC='1';
IF ISS >0 AND ISS <=8 THEN ISSC='2';
IF ISS >8 AND ISS <=15 THEN ISSC ='3';
IF ISS >15 AND ISS <=24 THEN ISSC ='4';
IF ISS >24 AND ISS <=40 THEN ISSC ='5';
IF ISS >40 THEN ISSC ='6';
DATA ALL; SET READ;
IND=KEY || ADMIT;
PROC SORT ; BY IND;
DATA ALL1;SET ALL; BY IND;
IF FIRST.IND THEN OUTPUT;
DATA PERSON; SET ALL1;
PROC SORT; BY PERSON;
PROC MEANS; BY PERSON;
PROC SORT; BY IND;
PROC MEANS; BY IND;
VAR NCHEST NFACE NEXTREM NEXTERNL NABDOMEN;
VAR ISS FIRST DAYS AGE;
PROC FREQ;BY PERSON; TABLES ISSC HOSP OUTC;
PROC SORT; BY HOSP;
PROC MEANS; BY HOSP; VAR ISS;
PROC SORT; BY PERSON;
DATA PERSON; SET ALL1; IF SEX='M' THEN OUTPUT;
PROC SORT; BY PERSON;
PROC MEANS; BY PERSON;
VAR ISS FIRST DAYS AGE;
PROC FREQ;BY PERSON; TABLES ISSC HOSP OUTC;
PROC SORT; BY HOSP;
PROC MEANS; BY HOSP; VAR ISS;
PROC SORT; BY PERSON;
DATA PERSON; SET ALL1; IF SEX='F' THEN OUTPUT;
PROC SORT; BY PERSON;
PROC MEANS; BY PERSON;
VAR ISS FIRST DAYS AGE;
PROC FREQ;BY PERSON; TABLES ISSC HOSP OUTC;
PROC SORT; BY HOSP;
PROC MEANS; BY HOSP; VAR ISS;
PROC SORT; BY PERSON;
DATA PERSON; SET ALL1; IF LEGIS=1 THEN OUTPUT;
PROC SORT; BY PERSON;
PROC MEANS; BY PERSON;
VAR ISS FIRST DAYS AGE;
PROC FREQ;BY PERSON; TABLES ISSC HOSP OUTC;
PROC SORT; BY HOSP;
PROC MEANS; BY HOSP; VAR ISS;
PROC SORT; BY PERSON;
DATA PERSON; SET ALL1; IF LEGIS=2 THEN OUTPUT;
PROC SORT; BY PERSON;
PROC MEANS; BY PERSON;
VAR ISS FIRST DAYS AGE;
PROC FREQ;BY PERSON; TABLES ISSC HOSP OUTC;
PROC SORT; BY HOSP;
PROC MEANS; BY HOSP; VAR ISS;
PROC SORT; BY PERSON;
```

```
INJ2B
//HDALKIE JOB '0294-24,I=90,,L=30,','HDALKIE'
/*D6250 MVB/2483
// EXEC SASV5,REGION=1536K
//READ DD
DSN=HDALKIE.COMB,DISP=OLD,UNIT=D6250,VOL=SER=MVB,
```

```
// LABEL=(16,SL)
PROC FORMAT;
VALUE $ISSC
'1'='NO SCORE'
'2'='ISS 1-8'
'3'='ISS 9-15'
'4'='ISS 16-24'
'5'='ISS 25-40'
'6'='ISS > 40';
VALUE $PERSON '0'='MV DRIVER'
'1'='MV PASS'
'2'='MC DRIVER'
'3'='MC PASS'
'4'='BUS OCC'
'6'='BICYCLIST'
'7'='PEDESTRIAN'
'8','9'='OTHER AND UNSPEC';
DATA READ;
SET READ.FINAL;
IF PERSON='0' AND AGE < 16 THEN DELETE;
IF PERSON='2' AND AGE < 16 THEN DELETE;
NCHEST=CHEST*1; NFACE=FACE*1; NABDOMEN=ABDOMEN*1;
NEXTREM=EXTREM*1; NEXTERNL=EXTERNAL*1;
NHEAD=HEAD*1;
IF PERSON='0' | PERSON ='1' THEN TVEH=1; /*PASS DRIVER
OR OCC*/
IF PERSON='2' | PERSON ='3' THEN TVEH=2; /*MC DRIVER OR
PASSENGER*/
IF PERSON='4' THEN TVEH=3; /*BUS OCCUPANT*/
IF PERSON='6' THEN TVEH=4; /*BICYCLIST*/
IF PERSON='7' THEN TVEH=5; /*PEDESTRIAN*/
IF PERSON='8' | PERSON='9' THEN TVEH=6; /*OTHER AND
UNSPECIFIED*/
IF YR=82 OR YR=83 THEN LEGIS=1;
IF YR=84 OR YR=85 THEN LEGIS=2;
IF ISS =0 THEN ISSC='1';
IF ISS >0 AND ISS <=8 THEN ISSC='2';
IF ISS >8 AND ISS <=15 THEN ISSC ='3';
IF ISS >15 AND ISS <=24 THEN ISSC ='4';
IF ISS >24 AND ISS <=40 THEN ISSC ='5';
IF ISS >40 THEN ISSC ='6';
DATA ALL; SET READ;
IND=KEY || ADMIT;
PROC SORT ; BY IND;
DATA ALL1;SET ALL; BY IND;
IF FIRST.IND THEN OUTPUT;
DATA PERSON; SET ALL1;
PROC SORT; BY PERSON;
PROC MEANS; BY PERSON;
VAR NCHEST NFACE NEXTREM NEXTERNL NABDOMEN
NHEAD;
** INJ2B G=NEW **;
```

APPENDIX F: INJURY INFORMATION SYSTEM; SUMMARY DATA

	Motor Vehicle Drivers	Motor Vehicle Passengers	Motorcycle Drivers	Motorcycle Passengers	Pedestrians	Bicyclists	Other
Persons	1536	1440	519	92	843	151	469
Males	1049	697	496	50	483	106	289
(%)	68	48	96	54	57	70	62
Females	487	743	23	42	360	45	180
(%)	32	52	04	46	43	30	38
Mean ISS	7.29±.21	6.81±.21	8.46±.45	9.45±.92	9.08±.34	6.93±.44	6.39±.33
Mean MAIS	2.16±.03	2.12±.03	2.39±.05	2.48±.03	2.49±.11	2.30±.07	2.11±.04
Mean Days	1.77±.63	1.58±.70	1.53±.86	18.31±.96	14.89±3.48	11.29±1.94	7.89±.76
Mean Age	34.38±.45	29.92±.54	24.93±.38	19.33±.95	28.20±.85	18.88±1.24	32.22±.81
ISS 1-8 (persons)	981	956	302	43	424	93	327
(%)	64	66	58	47	50	62	70
ISS 9-15 (persons)	398	363	156	35	318	46	112
(%)	26	25	30	38	38	30	24
ISS 16-24 (persons)	99	75	33	6	51	7	11
(%)	06	05	06	07	06	05	02
ISS 25-40 (persons)	44	36	20	7	41	5	17
(%)	3	3	4	8	5	3	4
ISS > 40 (persons)	14	10	8	1		0	2
(%)	1	1	2	1	0	0	0

Table F.1. Summary characteristics of the Injury Information System derived from primary information from the Manitoba Health Service Commission (1982-1986). The Mean ISS is defined as the Mean Injury Severity Score, the Mean MAIS is the Mean Maximum Abbreviated Injury Score, while the Mean Days represents the mean number of days an injured person is treated in hospital. The various ISS groupings describe the number and percentage of persons within each ISS category.

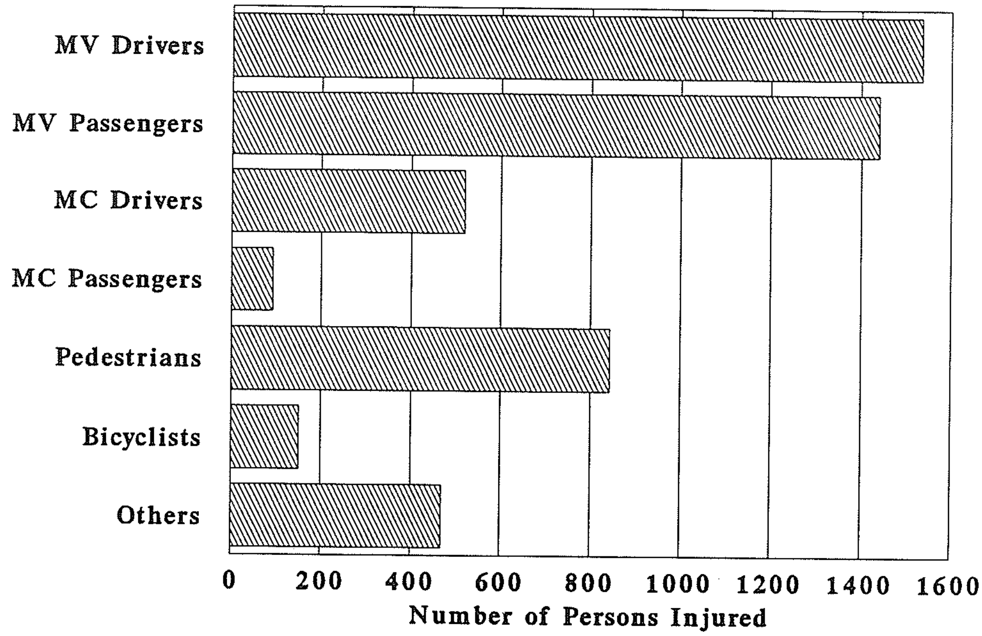


Figure F.1. Graphical representation of data presented in Table F.1 describing the number of persons contained in the Injury Information System.

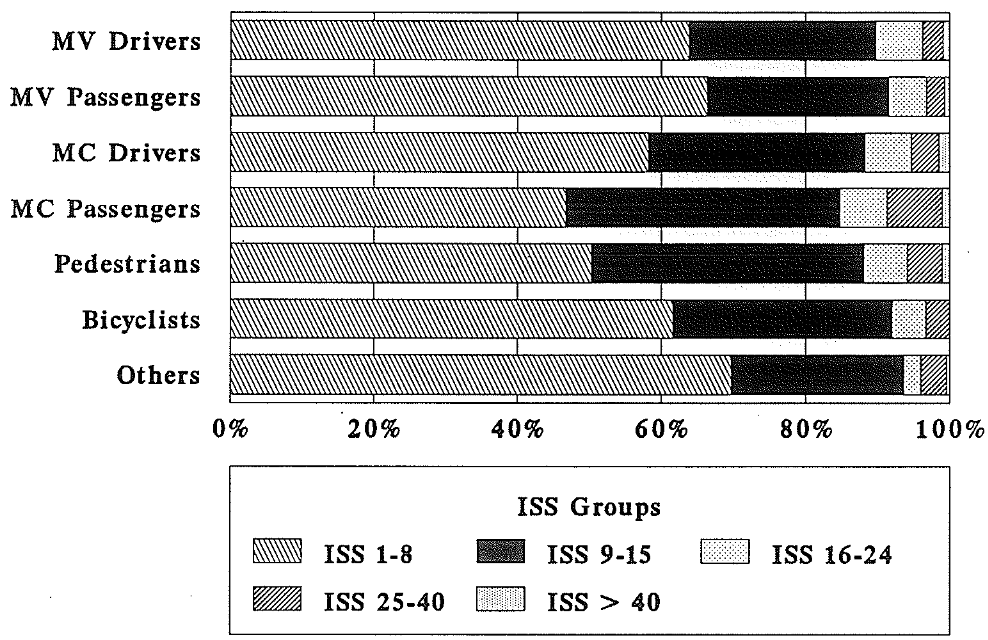


Figure F.2. Graphical representation of data presented in Table F.1 describing the severity of persons injured according to the calculated Injury Severity Score (ISS) contained in the Injury Information System.

APPENDIX G: INJURY INFORMATION SYSTEM; DESCRIPTIVE DATA

Body region	Injury severity	Motor vehicle drivers				Motor vehicle passengers			
		1982	1983	1984	1985	1982	1983	1984	1985
Head	AIS1	20	37	26	24	21	23	23	15
	AIS2	98	86	72	68	83	75	59	72
	AIS3	55	57	57	41	38	39	46	37
	AIS4	10	8	5	9	3	9	4	4
	AIS5	5	5	5	4	9	8	2	3
	> AIS1	168	156	139	122	133	131	111	116
Face	AIS1	28	33	24	29	26	27	24	15
	AIS2	17	23	11	8	12	13	9	12
	AIS3	4	2	3	1	1	1	0	2
	> AIS1	21	25	14	9	13	14	9	14
Chest	AIS1	52	29	32	29	26	22	20	32
	AIS2	20	25	24	32	17	19	17	19
	AIS3	16	22	10	20	10	14	16	10
	AIS4	0	0	0	0	0	0	0	0
	AIS5	0	0	2	0	0	2	0	1
	> AIS1	36	47	36	52	27	35	33	30
Abdomen	AIS1	0	3	6	0	1	4	2	0
	AIS2	9	8	19	6	18	12	11	3
	AIS3	24	24	16	17	13	25	10	17
	AIS4	12	9	11	12	4	4	14	6
	AIS5	1	2	2	1	2	2	0	1
	> AIS1	46	43	48	36	37	43	35	27
Extremities	AIS1	17	15	20	14	18	21	16	20
	AIS2	91	90	67	78	81	90	75	83
	AIS3	29	27	31	30	38	48	33	29
	AIS4	2	2	3	0	2	0	1	1
	> AIS1	122	119	101	108	121	138	109	113
External	AIS1	185	187	193	163	163	167	156	151
	AIS2	0	1	0	0	0	0	0	1
	> AIS1	0	1	0	0	0	0	0	1

Table G.1. The number of motor vehicle drivers and passengers sustaining injuries to specific body regions by maximum injury severity as described using the Collision Information System derived from primary information from the Manitoba Health Services Commission (1982-1986).

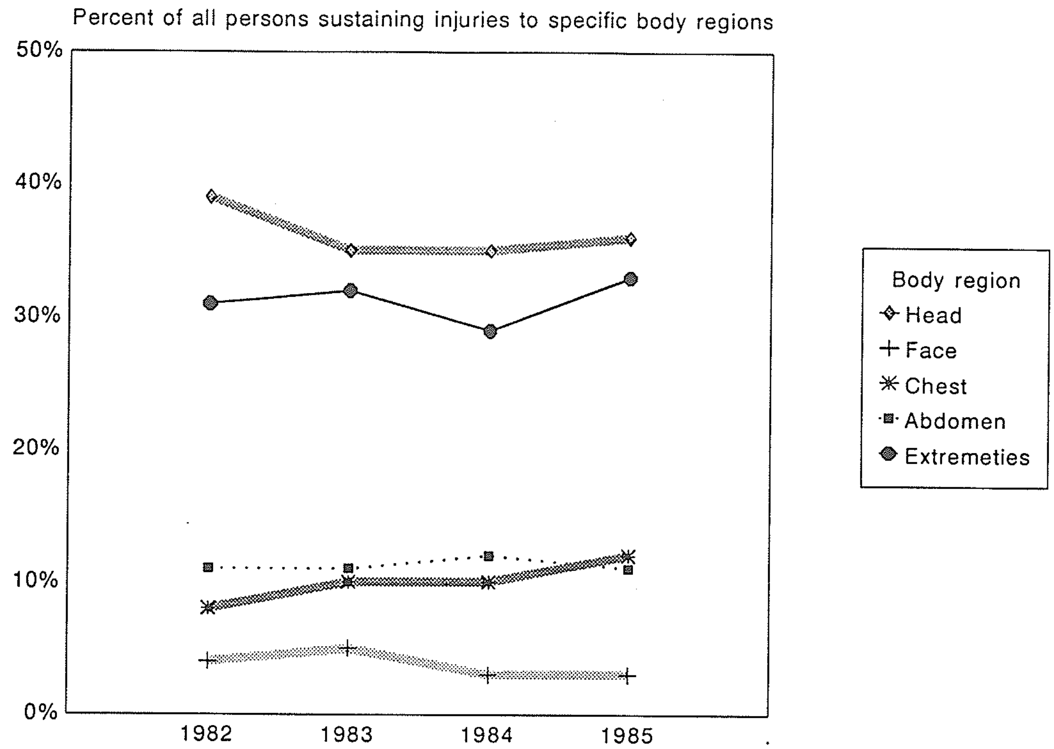


Figure G.1. Change in the percentage of motor vehicle drivers sustaining injuries (AIS≥2) to specific body regions as described using the Collision Information System derived from primary information from the Manitoba Health Services Commission (1982-1986).

Body region	Injury severity	Motorcycle drivers				Motorcycle passengers			
		1982	1983	1984	1985	1982	1983	1984	1985
Head	AIS1	2	3	4	1	1	2	0	0
	AIS2	29	30	8	12	5	2	2	1
	AIS3	13	18	6	9	3	3	2	3
	AIS4	5	7	2	1	1	0	0	1
	AIS5	4	2	4	3	1	2	1	0
	> AIS1	51	57	20	25	10	7	5	5
Face	AIS1	5	14	7	7	1	1	0	1
	AIS2	3	6	3	3	1	7	1	1
	AIS3	2	0	0	2	0	0	0	0
	> AIS1	5	6	3	5	1	7	1	1
Chest	AIS1	5	8	2	6	2	4	1	0
	AIS2	9	2	2	3	0	1	2	0
	AIS3	3	2	3	1	0	2	0	1
	AIS4	0	0	0	0	0	0	0	0
	AIS5	1	1	0	0	0	0	0	0
	> AIS1	13	5	5	4	0	3	2	1
Abdomen	AIS1	0	1	1	1	0	1	0	0
	AIS2	1	1	3	6	0	0	0	1
	AIS3	5	10	4	5	1	2	1	1
	AIS4	4	1	2	6	1	2	0	1
	AIS5	0	2	0	1	0	1	0	0
	> AIS1	10	14	9	18	2	5	1	3
Extremities	AIS1	7	6	8	9	1	4	0	0
	AIS2	45	65	35	48	10	8	3	6
	AIS3	26	20	21	35	7	5	3	8
	AIS4	0	0	0	1	0	1	0	0
	> AIS1	71	85	56	84	17	14	6	14
External	AIS1	45	55	32	34	12	8	5	7
	AIS2	0	0	1	1	0	0	0	0
	> AIS1	0	0	1	1	0	0	0	0

Table G.2. The number of motorcycle drivers and passengers sustaining injuries to specific body regions by maximum injury severity as described using the Collision Information System derived from primary information from the Manitoba Health Services Commission (1982-1986).

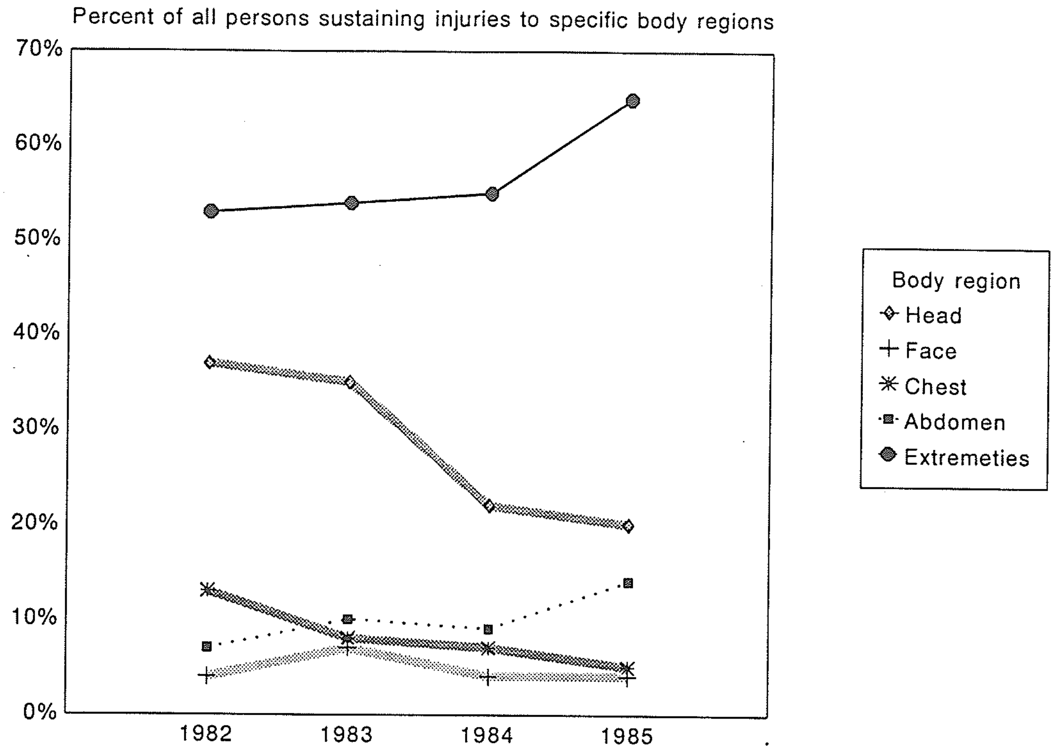


Figure G.2. Change in the percentage of motorcycle riders sustaining injuries (AIS≥2) to specific body regions as described using the Collision Information System derived from primary information from the Manitoba Health Services Commission (1982-1986).

Body region	Injury severity	Bicyclists				Pedestrians			
		1982	1983	1984	1985	1982	1983	1984	1985
Head	AIS1	0	2	4	1	6	5	6	3
	AIS2	5	5	9	8	46	24	31	28
	AIS3	6	5	9	10	16	26	25	27
	AIS4	0	1	1	0	6	6	6	4
	AIS5	0	1	1	2	6	9	4	3
	> AIS1	11	12	20	20	74	65	66	62
Face	AIS1	2	5	5	3	11	9	8	8
	AIS2	0	1	0	2	2	1	3	3
	AIS3	0	0	0	0	0	1	1	0
	> AIS1	0	1	0	2	2	2	4	3
Chest	AIS1	1	2	2	1	12	11	9	13
	AIS2	0	2	0	0	3	5	3	7
	AIS3	0	0	0	0	6	8	9	4
	AIS4	0	0	0	0	0	0	1	0
	AIS5	0	0	0	0	0	0	0	0
	> AIS1	0	2	0	0	9	13	13	11
Abdomen	AIS1	0	0	0	0	1	1	0	1
	AIS2	0	0	1	1	2	0	1	4
	AIS3	2	1	1	0	19	15	11	8
	AIS4	1	0	0	1	6	5	1	3
	AIS5	3	0	0	0	3	3	0	0
	> AIS1	6	1	2	2	30	23	13	15
Extremities	AIS1	1	0	2	0	14	6	5	5
	AIS2	9	13	14	3	86	86	81	77
	AIS3	5	3	5	7	59	57	53	58
	AIS4	1	0	0	5	0	2	1	2
	> AIS1	15	16	19	15	145	145	135	137
External	AIS1	14	12	13	17	98	73	66	66
	AIS2	0	0	0	0	0	0	0	0
	> AIS1	0	0	0	0	0	0	0	0

Table G.3. The number of bicyclists and pedestrians sustaining injuries to specific body regions by maximum injury severity as described using the Collision Information System derived from primary information from the Manitoba Health Services Commission (1982-1986).

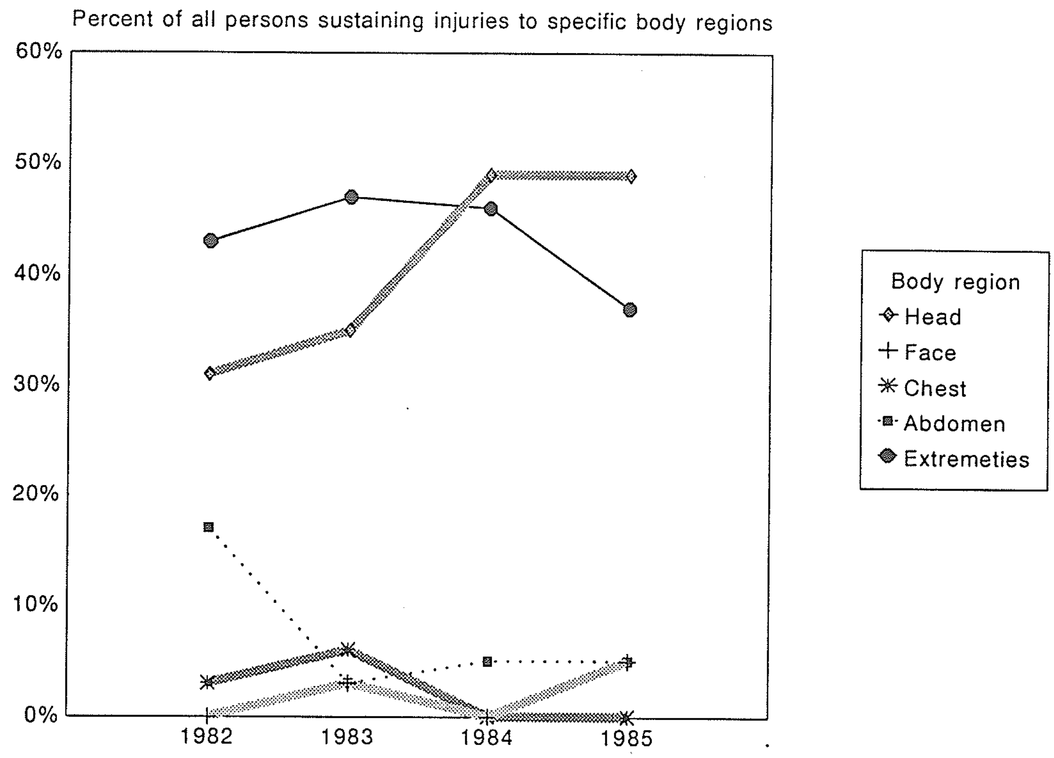


Figure G.3. Change in the percentage of bicyclists sustaining injuries (AIS≥2) to specific body regions as described using the Collision Information System derived from primary information from the Manitoba Health Services Commission (1982-1986).

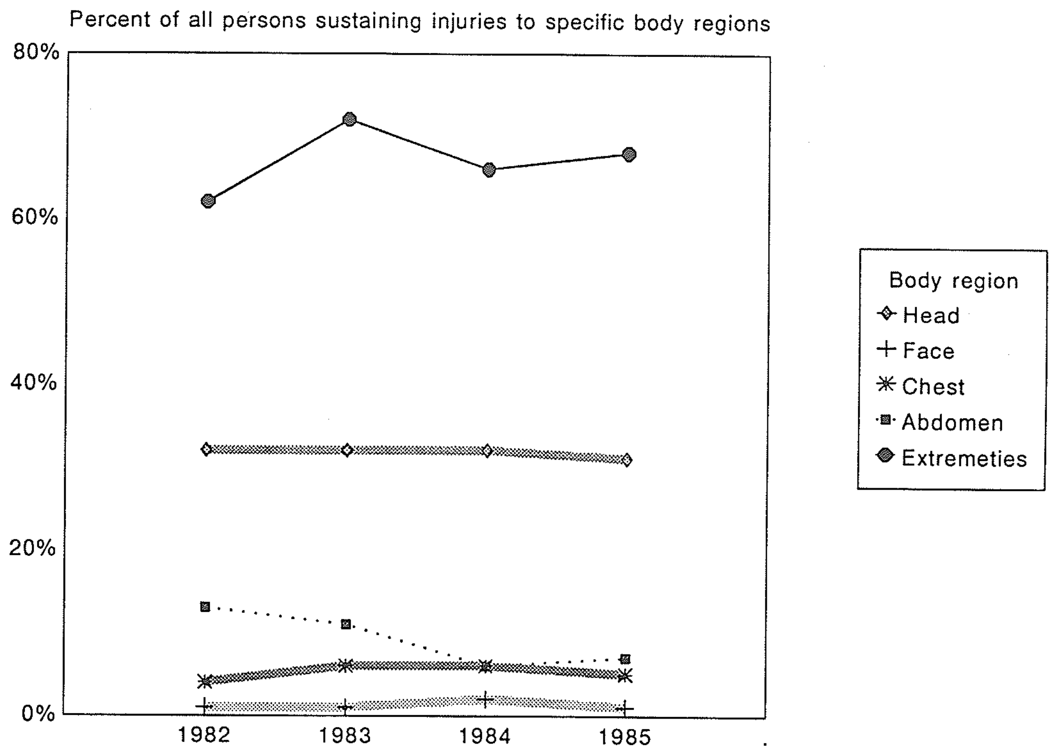


Figure G.4. Change in the percentage of <u>pedestrians</u> sustaining injuries (AIS≥2) to specific body regions as described using the Collision Information System derived from primary information from the Manitoba Health Services Commission (1982-1986).

Injury location	Motor vehicle drivers				Motor vehicle passengers			
	1982	1983	1984	1985	1982	1983	1984	1985
Head	176	147	142	124	138	147	112	116
Face	26	29	17	11	15	18	12	16
Neck	22	28	17	15	15	22	12	17
Shoulder	37	34	20	39	19	28	23	46
Upper extremeties	49	50	33	39	36	44	4	28
Chest	36	38	37	55	13	36	34	29
Back	28	41	33	20	38	32	24	13
Abdomen	53	47	39	34	23	43	40	29
Pelvis	35	27	31	29	45	41	30	35
Lower extremeties	64	57	67	57	63	82	61	36

Table G.4. The number of injuries (AIS≥2) sustained annually by motor vehicle drivers and passengers to specific body regions as described using the Injury Information System derived from primary data from the Manitoba Health Services Commission (1982-1986).

Injury location	1982-1983		1983-1984		% change
	Number	% of total	Number	% of total	
Head	323	32%	266	31%	-18%
Face	55	5%	28	3%	-49%
Neck	50	5%	32	4%	-36%
Shoulder	71	7%	59	7%	-17%
Upper extremeties	99	10%	72	8%	-27%
Chest	74	7%	92	11%	24%
Back	69	7%	53	6%	-23%
Abdomen	100	10%	73	8%	-27%
Pelvis	62	6%	60	7%	-3%
Lower extremeties	121	12%	124	14%	2%
Total	1024	100%	859	100%	-16%

Table G.5. The number and distribution of injuries (AIS≥2) sustained by motor vehicle drivers during 1982-1983 compared to 1984-1985 as described using the Injury Information System derived from primary data from the Manitoba Health Services Commission (1982-1986).

Injury location	1982-1983		1983-1984		% change
	Number	% of total	Number	% of total	
Head	285	32%	228	32%	-20%
Face	33	4%	28	4%	-15%
Neck	37	4%	29	4%	-22%
Shoulder	47	5%	69	10%	47%
Upper extremeties	80	9%	32	4%	-60%
Chest	49	5%	63	9%	29%
Back	70	8%	37	5%	na
Abdomen	66	7%	69	10%	5%
Pelvis	86	10%	65	9%	-24%
Lower extremeties	145	16%	97	14%	-33%
Total	898	100%	717	100%	-20%

Table G.6. The number and distribution of injuries (AIS≥2) sustained by motor vehicle passengers during 1982-1983 compared to 1984-1985 as described using the Injury Information System derived from primary data from the Manitoba Health Services Commission (1982-1986).

Injury location	1982-1983		1983-1984		% change
	Number	% of total	Number	% of total	
Head	608	32%	494	31%	-19%
Face	88	5%	56	4%	-36%
Neck	87	5%	61	4%	-30%
Shoulder	118	6%	128	8%	8%
Upper extremeties	179	9%	104	7%	-42%
Chest	123	6%	155	10%	26%
Back	139	7%	90	6%	-35%
Abdomen	166	9%	142	9%	-14%
Pelvis	148	8%	125	8%	-16%
Lower extremeties	266	14%	221	14%	-17%
Total	1922	100%	1576	100%	-18%

Table G.7. The number and distribution of injuries (AIS≥2) sustained by motor vehicle occupants during 1982-1983 compared to 1984-1985 as described using the Injury Information System derived from primary data from the Manitoba Health Services Commission (1982-1986).

Injury location	Motorcycle drivers				Motorcycle passengers			
	1982	1983	1984	1985	1982	1983	1984	1985
Head	65	66	22	29	12	8	7	5
Face	7	7	4	5	1	8	2	2
Neck	6	5	1	2	1	1	0	0
Shoulder	15	20	13	15	3	3	1	1
Upper extremeties	12	37	16	33	5	4	1	4
Chest	7	2	5	6	0	3	1	2
Back	10	7	6	12	0	0	1	1
Abdomen	10	13	9	19	2	9	1	7
Pelvis	9	10	7	10	1	3	0	8
Lower extremeties	72	61	43	65	17	9	8	14

Table G.8. The number of injuries (AIS≥2) sustained annually by motorcycle drivers and passengers to specific body regions as described using the Injury Information System derived from primary data from the Manitoba Health Services Commission (1982-1986).

Injury location	1982-1983		1983-1984		% change
	Number	% of total	Number	% of total	
Head	131	30%	51	16%	-61%
Face	14	3%	9	3%	-36%
Neck	11	2%	3	1%	-73%
Shoulder	35	8%	28	9%	-20%
Upper extremeties	49	11%	49	15%	0%
Chest	9	2%	11	3%	22%
Back	17	4%	18	6%	6%
Abdomen	23	5%	28	9%	22%
Pelvis	19	4%	17	5%	-11%
Lower extremeties	133	30%	108	34%	-19%
Total	441	100%	322	100%	-27%

Table G.9. The number and distribution of injuries (AIS≥2) sustained by motorcycle drivers during 1982-1983 compared to 1984-1985 as described using the Injury Information System derived from primary data from the Manitoba Health Services Commission (1982-1986).

Injury location	1982-1983		1983-1984		% change
	Number	% of total	Number	% of total	
Head	20	22%	12	18%	-40%
Face	9	10%	4	6%	-56%
Neck	2	2%	0	0%	-100%
Shoulder	6	7%	2	3%	-67%
Upper extremeties	9	10%	5	8%	-44%
Chest	3	3%	3	5%	0%
Back	0	0%	2	3%	na
Abdomen	11	12%	8	12%	-27%
Pelvis	4	4%	8	12%	100%
Lower extremeties	26	29%	22	33%	-15%
Total	90	100%	66	100%	-27%

Table G.10. The number and distribution of injuries (AIS≥2) sustained by motorcycle passengers during 1982-1983 compared to 1984-1985 as described using the Injury Information System derived from primary data from the Manitoba Health Services Commission (1982-1986).

Injury location	1982-1983		1983-1984		% change
	Number	% of total	Number	% of total	
Head	151	28%	63	16%	-58%
Face	23	4%	13	3%	-43%
Neck	13	2%	3	1%	-77%
Shoulder	41	8%	30	8%	-27%
Upper extremeties	58	11%	54	14%	-7%
Chest	12	2%	14	4%	17%
Back	17	3%	20	5%	18%
Abdomen	34	6%	36	9%	6%
Pelvis	23	4%	25	6%	9%
Lower extremeties	159	30%	130	34%	-18%
Total	531	100%	388	100%	-27%

Table G.11. The number and distribution of injuries (AIS≥2) sustained by motorcycle riders during 1982-1983 compared to 1984-1985 as described using the Injury Information System derived from primary data from the Manitoba Health Services Commission (1982-1986).

APPENDIX H: IN-DEPTH COLLISION INFORMATION SYSTEM: SAMPLE FORMS

MOTORCYCLE DAMAGE FORM

1. Licence Number ___________ 2. Make ___________ 3. Model ___________ 4. Year ___________

5. Engine Displacement ________________ 5.1 Odometer ___________

6. Motorcycle Type (street OEM, dirt, enduro, chopper, other) ___________ 7. Colour ___________

8. Equipment (y/n) crash bars ___________ windshield ___________

   luggage rack ___________ fairing/shield ___________

9. Headlight on ___________

10. Availability/Type of Left Rear View Mirror _______ 11. Availability/Type of Right Rear View mirror _______

12. Size of Headlamp ___________ 13. Type of Headlamp ___________

14. Any modifications? (frame, gas tank, seat, sissy bar, triple clamp, muffler/exhaust system, extended front forks, luggage box, accessories, suspension ... specify)

____

____

15. Make of Front Tire ___________ 16. Tire Wear Pattern ___________

17. Extent of Tire Wear ___________ 18. Tire Pressure ___________

19. Tire Pattern (sketch)

20. Make of Rear Tire ___________ 21. Tire Wear Pattern ___________

22. Extent of Tire Wear ___________ 23. Tire Pressure ___________

24. Tire Pattern (sketch)

25. Describe Tire Damage ______________________________

____

26. Type of Wheel ______________ 27. Type of Propulsion System ______________

28. Document Damage (consider crash bars, windshield, fairing, luggage rack, seat, sissy bars, front fender, rear fender, footpegs, handle bars, engine crank-case/cylinders, exhaust pipes, front brake lever, clutch lever, throttle assembly, rear brake pedal, transmission, gear shift lever, tires and wheels, turns signals and lights, mirrors, gas tank, frame, triple clamp, oil tank and battery.)

____

____

____

____

____

____

____

____

____

29. Location of Most Severe Impact ______________ 30. Wheel Base if Shortened ____________________

31. Lateral Deformation of Wheel Base (sketch)

32. Overall Pre-crash Condition _________________ 33. Overall Post-Crash Condition ________________

OTHER

HELMET FORM

1. Helmet For (rider/passenger) ________________

2. Helmet Manufacturer ________________ 3. Date of Manufacture ________________

4. DOT Qualification Label ________________ 5. ANSI Standard Label ________________

6. CSA Approved Label ________________

7. Snell Qualification ________________ Year __________ No. __________

8. Helmet Weight __________ 9. Helmet Colour __________ 10. Type of Coverage __________

11. Condition of Helmet Prior to Accident __________

12. Retention System Fastened Prior to Accident __________

13. Helmet Remain on During the Accident __________

14. Type of Retention System d-rings ________ snaps and d-rings ________

    snaps ________ quick release ________

    Other ________________________________

15. If Retention System Failed, What Type of Failure

    Pulled through d-rings _____ webbing failure _____

    quick release let go _____ shell failure at rivet _____

    unsnapped _____ broke rivet _____

    Other (specify) ________________________________

16. Helmet Fit ________________ 17. Shell Material ________________

18. Any Impacts ____

19. Primary Impact Type (normal or tangential) __________

20. Struck Object Material (pavement, soil, metal, glass, wood) ________________________

21. Geometry of Struck Object (flat, blunt edge, sharp edge) ________________________

22. Severity of Impact (minimal, moderate, severe) ________________________

23. Liner Damage __________ 24. Type of shell damage (abrasion, puncture, crack, multiple) ________

25. Secondary Impact type (normal or tangential) ____________

26. Struck Object Material (pavement, soil, metal, glass, wood) ____________

27. Geometry of Struck Object (flat, blunt edge, sharp edge) ____________

28. Severity of Impact (minimal, moderate, severe) ____________

29. Liner Damage ____________ 30. Type of shell damage (abrasion, puncture, crack, multiple) ____________

31. Visor Available ____________ Visor in Use ____________

32. Visor Damage ____________ 33. Helmet Relationship to Injuries (preliminary) ____________

MOTORCYCLE DRIVER INTERVIEW FORM

1. Date of Birth _____ dd _____ mm _____ yy   2. Height ___________   3. Weight _________

4. Marital Status ___________   5. Sex ___________

6. Hand Preference ___________   7. Number of Children _________

8. Level of Education Completed: Some High School _____ Some Post Secondary School _____

High School _____ Post Secondary _____

9. Type of Driver's Licence ____

10. Type of Motorcycle Driver Training   None, self taught _____

Friends, family _____

Formal motorcycle course _____   Which One? ___________

Year Completed _________

11. Age First Began to Operate a Street Motorcycle ___________

12. Age First Began to Operate an Off-Road or Dirt Bike ___________

13. Age First Licensed to Operate a Motorcycle ___________

14. Age First Owned a Motorcycle ___________

15. Number of Motorcycles Presently Owned ___________

16. Number of Motorcycles Ever Owned ___________

17. Engine Displacement of First Motorcycle ___________

18. Engine Displacement of Motorcycle Operated in 1983 ___________

19. Engine Displacement of Motorcycle Operated in 1984 ___________

20. Engine Displacement of Motorcycle Presently Operating ___________

21. Total Street Motorcycle Riding Experience   Years/months _________

Miles/kms _________

22. Number of Days Per Week that Motorcycles are Ridden ___________

23. Any Change in Amount of Motorcycle Driving Over the Last 2 Years? _________ If so, Why? ________

____

24. Own a Car? ____________

25. Primary Use of the Motorcycle ____________

26. Use of Motorcycle vs Other Means of Transportation ________ %

27. Percent of Time a Passenger is Carried ________ %

28. Percent of Time Riding is Done After Dark ________ %

29. Percent of Time Riding is Done in an Urban Area ________ %

30. Was a Motorcycle Helmet Worn ____________

31. If Yes, What Percent of Time ________ %

Why Sometime and Not Others? ________________

32. If Not, Why Not ____

33. Type of Helmet Presently Worn ____________

34. Any Other Protective Equipment Worn More than 80% of the Time? __________ If Yes, Specify ________

____

35. What is Your Opinion of the Provincial Government's Motorcycle Helmet Legislation? ________________

____

____

____

36. Amount of Riding Experience on Accident Involving Motorcycle ____________

37. Number of Times Driver Travelled Involved Roadway ____________

38. Purpose of Intended Trip ____________

39. Length of Intended Trip ____________

40. Length of Time Riding Motorcycle Just Before Accident ____________

41. Distance from Place of Residence to Scene of the Accident ____________

42. Was Helmet Worn? ____________

43. Was Helmet Retained ____________

44. Eye Correction Used ____________

45. Any Alcohol Consumed Prior to the Accident (specify) ______

46. Any Drugs or Medication Involved (specify) ______

47. Accident Narrative ______

48. Motorcycle in Lane # __________ of __________ Through Lanes

49. Motorcycle Position in lane Prior to Accident ____________ 50. Estimated Speed ____________________

51. Motorcycle Control Operations Before Accident
None __________ Braking __________
Downshifting __________ Other __________
Upshifting/Accelerating ____________

52. Any Evasive Manoeuvres? Accelerating __________ Steering __________

53. Were Brakes Applied? Front or Rear __________ Partial or Full __________

54. Total Braking Distance ____________ 55. Passenger Interference ____________

56. Motorcycle Laid Down? Yes No
Left Right

57. Laid Down Intentionally? Yes No
____

58. Total Distance Motorcycle Slid ____________ 59. Total Distance Driver Slid ____________

60. Driver Airborne? ____________ Distance ____________

61. Driver Remain with Motorcycle? ____________ 62. Headlight On or Off? ____________

63. Evasive Action by Other Vehicle ____

64. Driver Position at Time of Impact
Normal Seated __________ Standing on Footrests __________
Head Down __________ Dismounting/Bailing Out __________

65. Injuries

____

____

____

____

____

____

____

66. If Treated, Where Treated ______________________________

67. Upper Torso Coverage ____________ 68. Did Coverage Prevent or Reduce Injury ______

69. Lower Extremities Coverage ____________ 70. Did Coverage Prevent or Reduce Injury ______

71. Foot Coverage ____________ 72. Did Coverage Prevent or Reduce Injury ______

73. Gloves Worn ____________ 74. Did Coverage Prevent or Reduce Injury ______

75. Helmet Worn ____________

76. Reason for Not Wearing Helmet ______________________________

If Doctor's Certificate, Which Doctor ______________________________

77. Loss of Any Work Days ________

78. Did the Use of a Motorcycle Helmet Affect Your Ability to Avoid or To React to the Collision in Any Way?

____

____

____

____

APPENDIX I: IN-DEPTH COLLISION INVESTIGATION SYSTEM; TYPICAL DOCUMENTATION

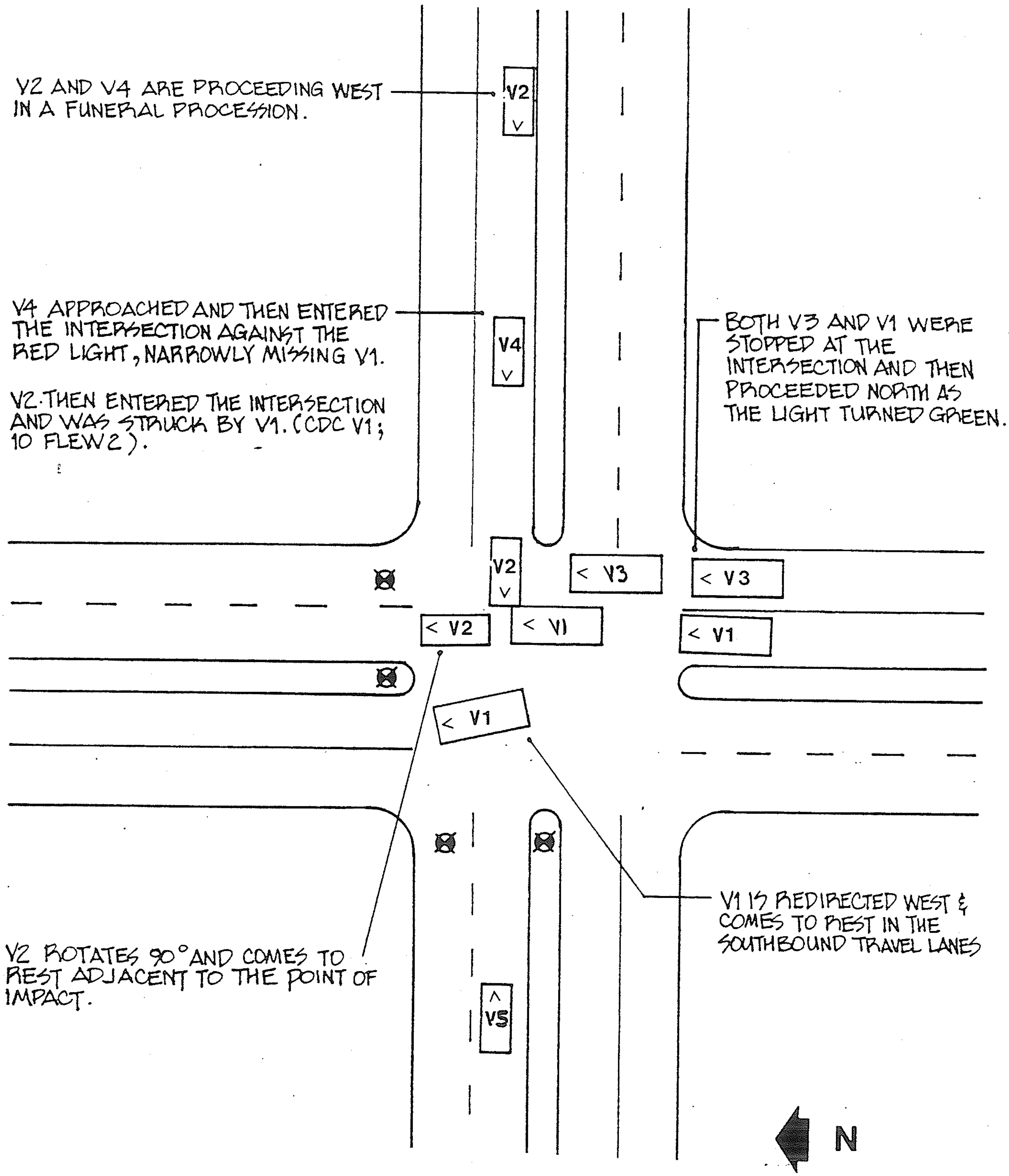
This two-vehicle collision occurred at approximately 1500 hours at the intersection of two urban arterials. The primary two-way, four-lane, median-divided roadway is orientated in a north/south direction. The secondary roadway is also a two-way, four-lane roadway. The concrete road surface of both roads was worn and dry at the time of the collision. Visibility was excellent under clear skies. The intersection is regulated by simple traffic control signals.

V1, a 1972 Chevrolet dump truck, operated by a 27-year-old male, was northbound. V2, a 1977 Volkswagen four-door passenger car, operated by a 55-year-old female, was westbound. The driver of V2 was accompanied by a 79-year-old female seated in the right front passenger seat, and a 76-year-old female seated in the right rear seating position. The two front-seat occupants were utilizing the passive two-point restraint system developed by Volkswagen to be installed with knee bolsters under the front dash area. No knee bolsters were provided in V2. The rear occupant of V2 was using the normal two-point lap belt provided for her seating position.

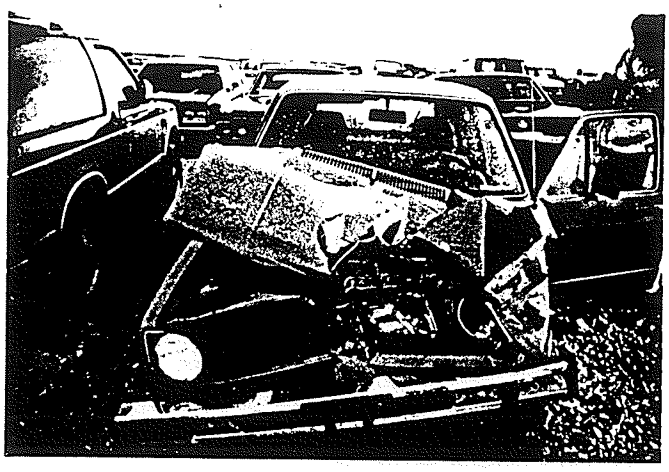
V1, travelling in a funeral procession, proceeded through a red light and was struck by the right front corner of V2 which had entered the intersection (CDC V1,10LFEW2). It is probable that after the impact, V1 was redirected into the southbound travel lanes while V2 rotated approximately 90° and came to rest adjacent to the point of impact (POI).

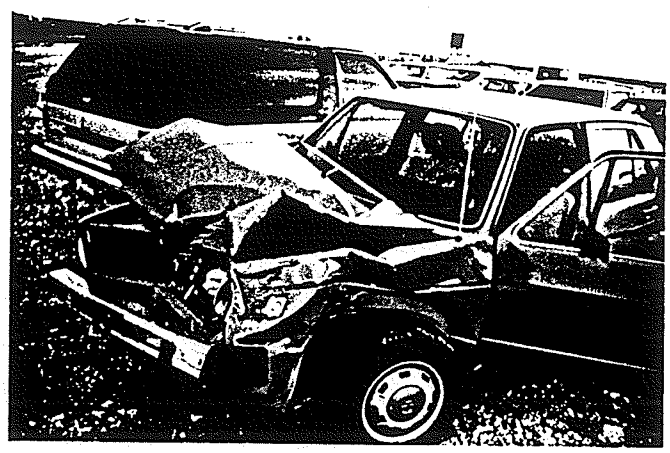
During the crash phase, the moderately-obese right-front passenger moved left and forward, loading the two-point passive restraint system and causing the seat belt webbing to move up along the passenger's left side to the torso area and down along her right shoulder and arm. There is no evidence to suggest that her lower extremities struck the lower dash area. This occupant sustained critical chest (MAIS 4) and abdominal (MAIS 4) injuries and was pronounced dead in hospital approximately 28 hours following the incident. Her ability to tolerate the injuries sustained during the crash event was compromised by the deceased's advanced age and pre-collision medical conditions. The remaining occupants of V2 sustained only minor (MAIS 1) injuries while the driver of V1 was not injured.

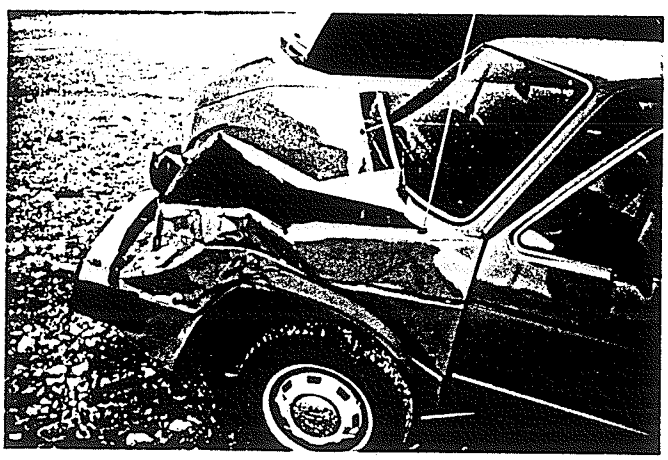
Scene Diagram: UOM 530

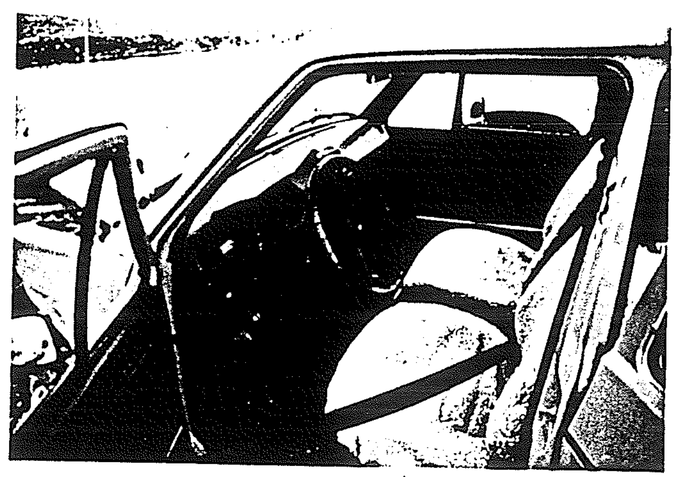


Representative Photographs: UOM 530









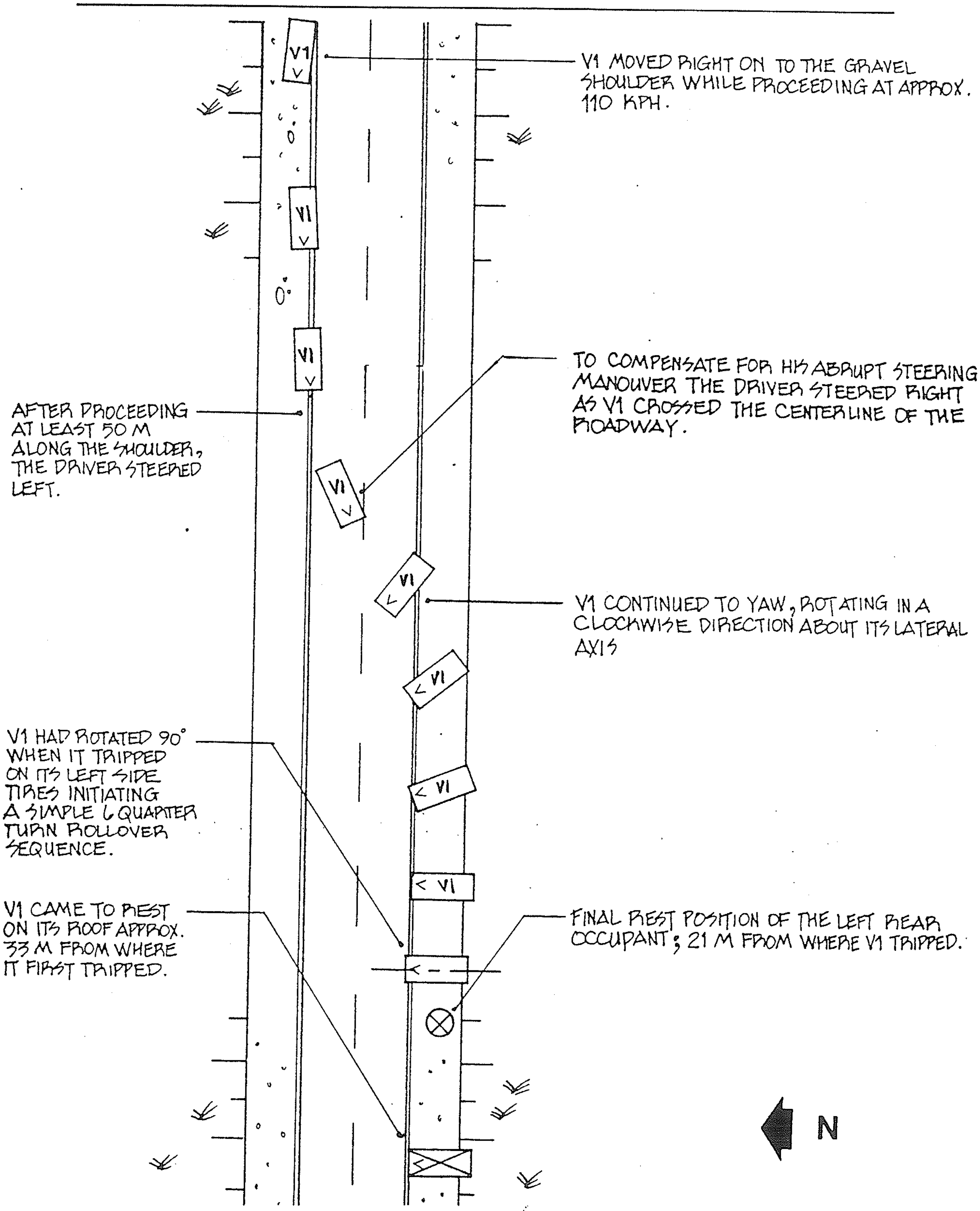
This single-vehicle, roll-over collision occurred at approximately 0500 hours on a two-lane, two-way, undivided, rural roadway. The asphalt road surface was in good condition and dry. A painted solid white line delineates the road surface and the well-maintained gravel shoulder. At the time of the incident, visibility was good under clear skies. The collision occurred at dawn.

V1, a 1979 Chevrolet four-door passenger car, operated by a 21-year-old male, was westbound. The driver was accompanied by a 23-year-old male seated in the right front passenger seat; a 38-year-old male seated in the left rear passenger seat and a 21-year-old male seated in the right rear seating position. Although both front seat occupants were utilizing the available three-point seat belts, the rear-seat occupants were unrestrained. All passengers in V1 were asleep immediately prior to the collision event. V1 was equipped with three all-season radial tires and a bias-ply snow tire on the right rear.

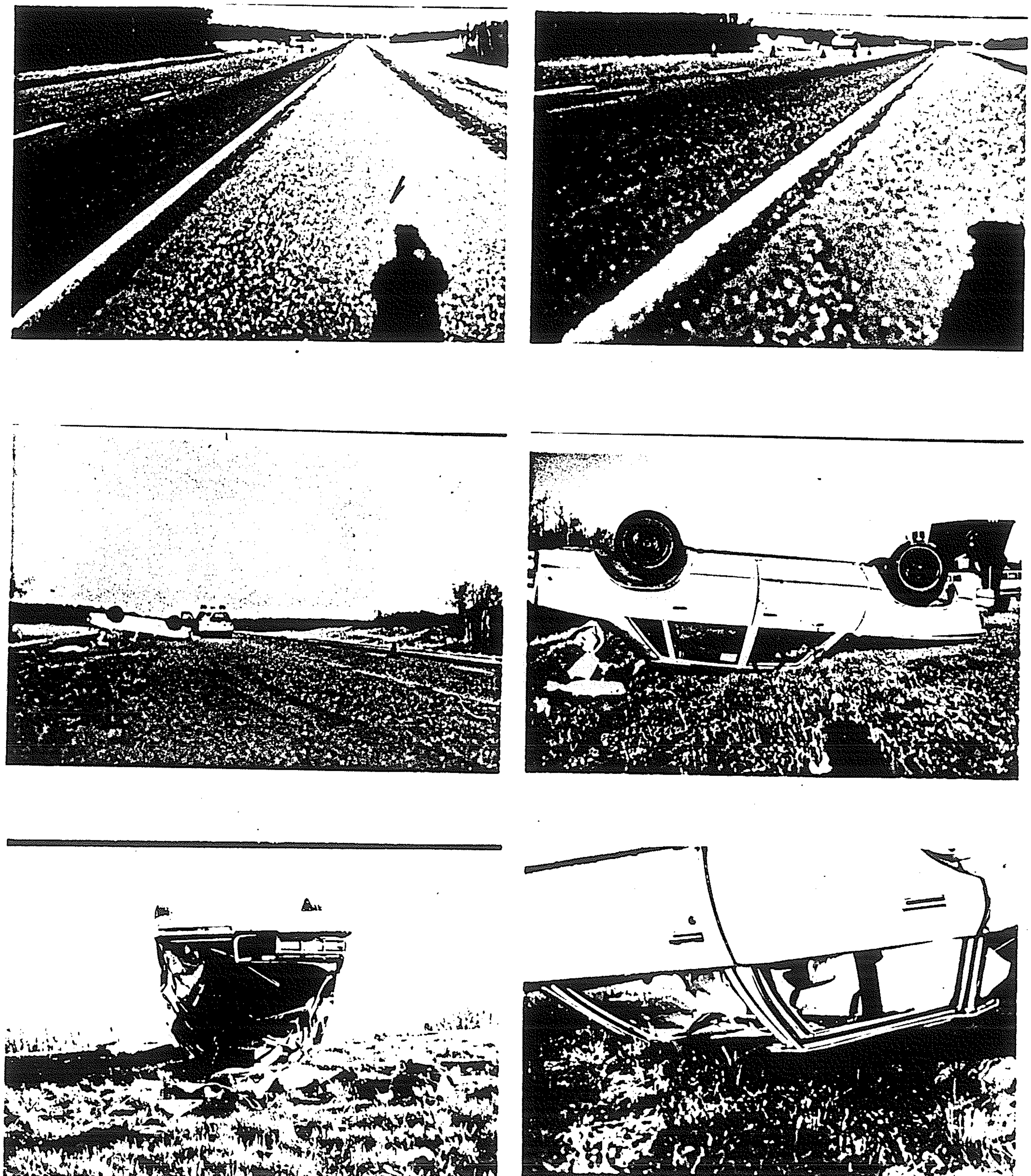
The collision event was initiated as the driver negotiated a slight curve in the road and then allowed his vehicle to move right and onto the north shoulder area. V1 continued along the north shoulder for approximately 50 m before the driver abruptly steered left and returned to the road surface. Characteristic yaw marks observed along the south shoulder area indicated that V1 was proceeding at approximately 110 kph. As V1 moved across the center line, the driver steered right causing V1 to begin to yaw and rotate in a clockwise direction about its lateral axis. V1 moved approximately 35 m west along the gravel shoulder and it had rotated 90° to its original direction of travel when it tripped on its left side tires. A simple six-quarter-turn roll-over was completed by V1 before it came to rest on its roof approximately 23 m from where the roll-over began.

During the roll-over, the left-rear passenger was completely ejected from V1 and came to rest approximately 11 m east of the final position of V1. All other occupants remained fully in the occupant compartment. The ejected occupant sustained critical face (MAIS 5), chest (MAIS 5) and abdominal (MAIS 5) injuries and was pronounced dead at the scene of the collision. All other occupants sustained only minor (MAIS 1) abrasions, lacerations or contusions.

Scene Diagram: UOM 548



Representative Photographs: UOM 548



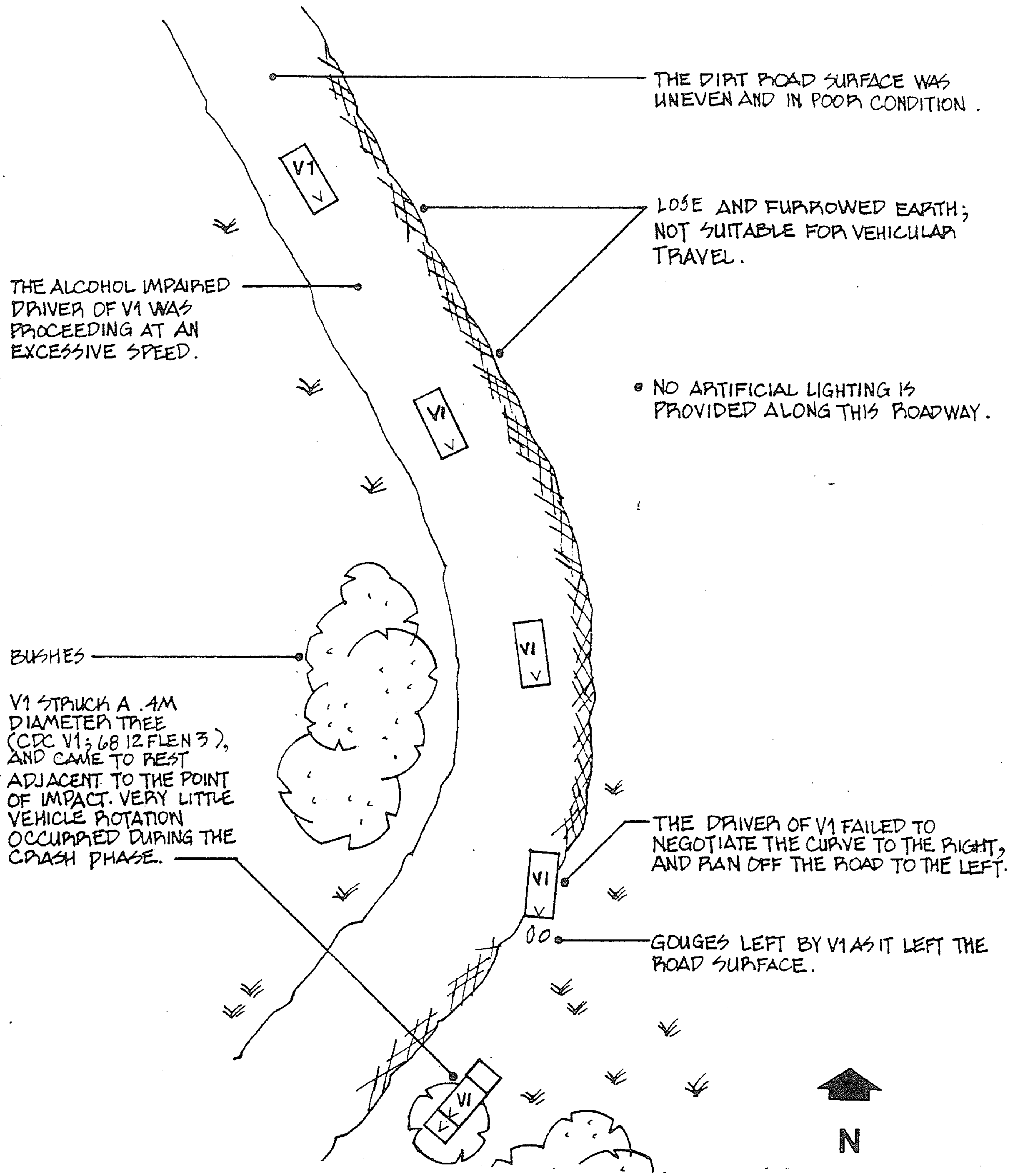
This single-vehicle, fixed-object collision occurred at approximately 0200 hours on a two-lane, two-way, rural, dirt road. The road surface was dry and in poor condition prior to the collision. Visibility was normal under night driving conditions. No artificial illumination was provided on this municipal road.

V1, a 1971 Chevrolet four-door passenger car, operated by an alcohol-impaired, unlicensed 15-year-old male, was westbound. The driver was accompanied by five passengers; a 17-year-old male seated in the center-front position, a 16-year-old male seated in the right-front position, a 16-year-old male in the left rear, a 15-year-old male in the center rear and a 17-year-old male in the right-rear passenger seat. The only occupant using the available restraint system was the center-rear occupant. This occupant was utilizing the simple two-point lap belt provided for this seating position.

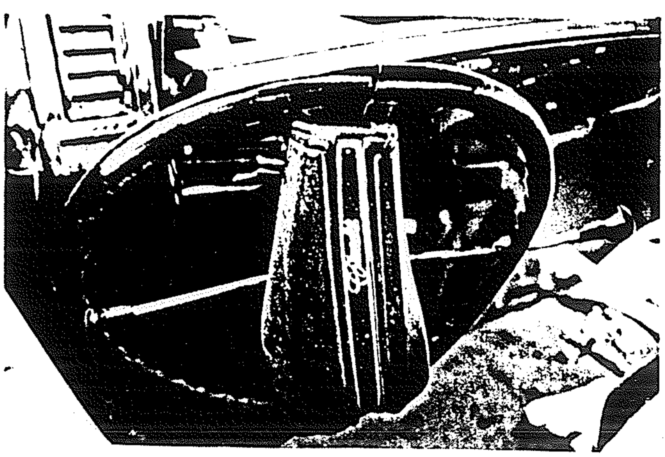
A post-collision vehicle inspection noted that the brakes on V1 were in poor condition and provided uneven stopping power; three tires were radial, while the fourth was a bias tire; two tires were nearly bald, while the right front shock absorber was absent. The incident occurred as the driver of V1 failed to negotiate a curve to the right and moved left off the road surface onto a grassy area. V1 then struck a tree (38 cm in diameter) located 1.8 m east of the road (CDC V1,12FLEN3). During the crash phase of the collision, all occupants of V1 moved forward. The driver contacted the steering assembly and lower dash area; the front-seat passengers loaded the front dash area and the rear-seat occupants loaded the back of the front seat. Due to the loading by the rear-seat occupants, the front-seat back, originally held into place at the driver side by the seat belt, failed and moved forward.

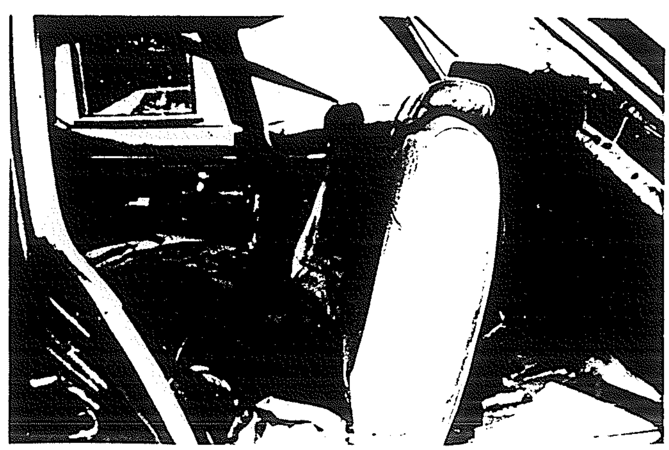
All the unrestrained passengers sustained minor injuries and abrasions (MAIS 1) and exited the vehicle unassisted following the impact. The left-rear passenger also sustained a minor chest (MAIS 2) injury in addition to superficial injuries. It is probable that, during the crash phase, the center-rear occupant, restrained by a two-point lap belt, moved forward and loaded the restraint system. At this time, the occupant may have moved down into the soft bench-type rear seats allowing the lap belt to move up into the abdominal area. As a result of the seat-belt loading, the occupant sustained critical abdominal (MAIS 5) and chest (MAIS 2) injuries.

Scene Diagram: UOM 603



Representative Photographs: UOM 603





This two-vehicle, rear-end collision occurred at approximately 1600 hours at the intersection of two rural roads. The primary east-west roadway is comprised of an asphalt road surface and gravel shoulders. The secondary roadway is a minor gravel provincial road. The intersection is controlled by a stop sign for north and southbound traffic. Immediately prior to the collision, the road surface was in good condition and dry. Visibility was good under clear skies.

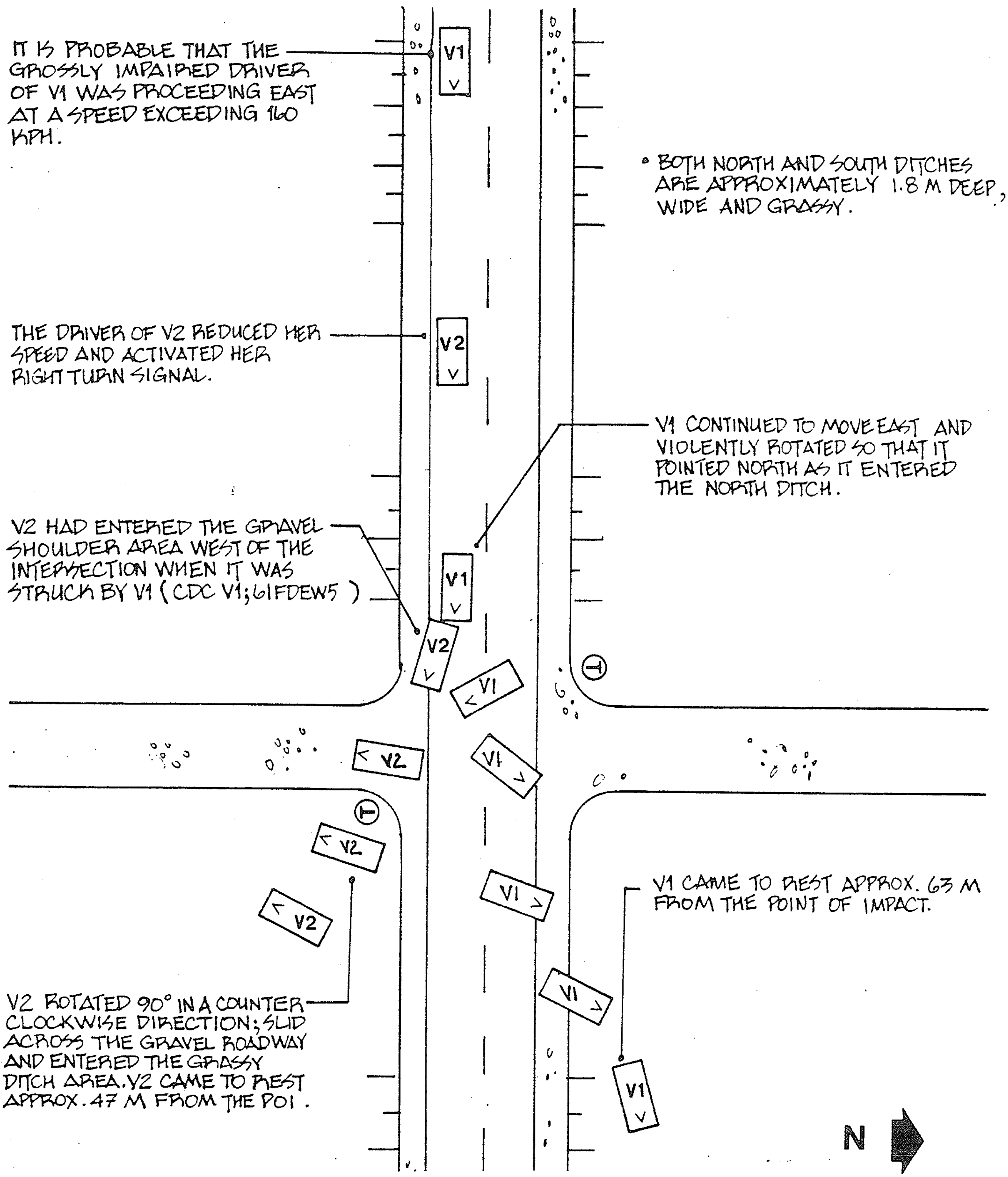
V1, a 1983 Plymouth two-door passenger car, operated by a grossly-impaired 19-year-old male, was eastbound. The driver was accompanied by a 15-year-old female seated in the right-front seat and an 18-year-old male lying down in the rear. Although the driver and the rear-seat occupant were unrestrained, the right-front passenger was using the available three-point lap- and shoulder-restraint system. V2, a 1979 Chrysler two-door passenger car, operated by a restrained 61-year-old female, was also eastbound on the primary roadway. The driver was accompanied by a 16-year-old female seated in the right-front passenger seat.

It is highly probable that V1 was travelling in excess of 160 kph when the driver failed to recognized that the vehicle in front of him had reduced its speed to turn right. V2 was travelling at approximately 15-20 kph when struck in the rear by V1. There was no scene evidence to suggest that either vehicle braked or attempted a steering manoeuvre immediately prior to the collision. Following the impact V1 moved east, entered the north grassy ditch area and came to rest approximately 65 m from the point of impact. V2 also moved east and entered the south, grassy ditch area and came to rest approximately 65 m from the point of impact. V2 also moved east and entered the south, grassy ditch area before coming to rest approximately 49 m from the POI.

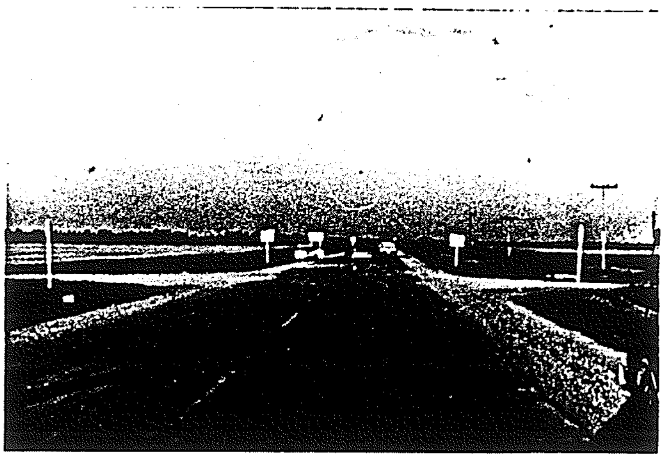
During the collision, the occupants of V1 moved forward. The unrestrained driver severely loaded the steering assembly and front dash area while the restrained right-front-seat occupant loaded the occupant restraint system leaving witness marks on the belt webbing. The right-front occupant also contacted the dash area which had moved rearwards intruding into the occupant compartment. The rear-seat passenger moved forward against the back of the front seats. Although there was significant intrusion into the front-seat-occupant compartment due to rearward displacement of the dash and front hood, it is possible that the severity of the injuries sustained by the front-seat occupant was increased due to loading of the front-seat back by the unrestrained rear-seat passenger.

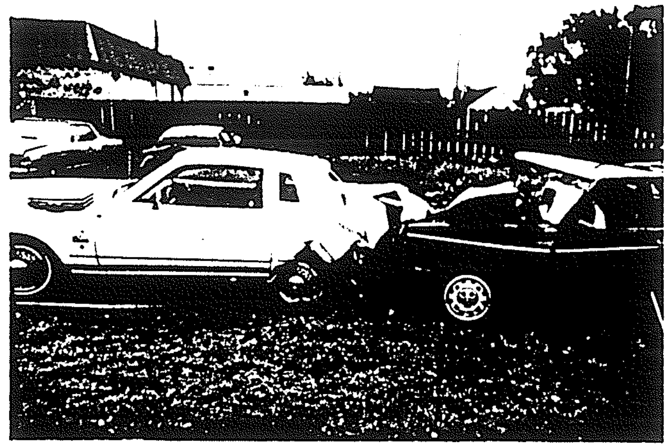
The driver of V1 sustained critical chest (MAIS 5), head (MAIS 3) and extremity (MAIS 3) injuries and was pronounced dead at the scene of the collision. The right-front passenger sustained injuries to her abdomen (MAIS 4), head (MAIS 2), face (MAIS 2) and extremity (MAIS 2) and eventually recovered. The right-rear passenger of V1 and the restrained occupants of V2 sustained undetermined minor injuries.

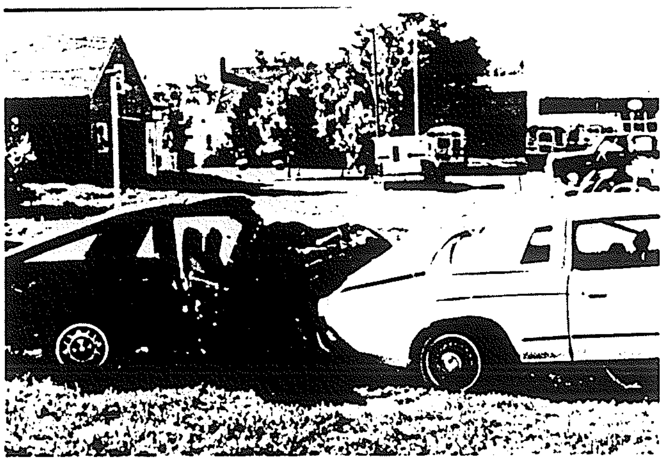
Scene Diagram: UOM 647

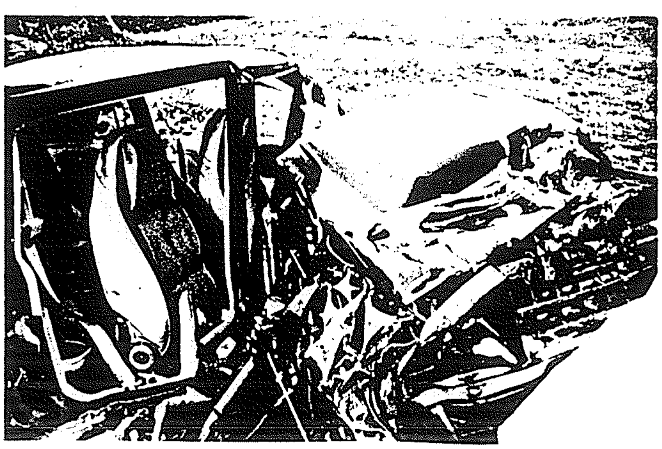


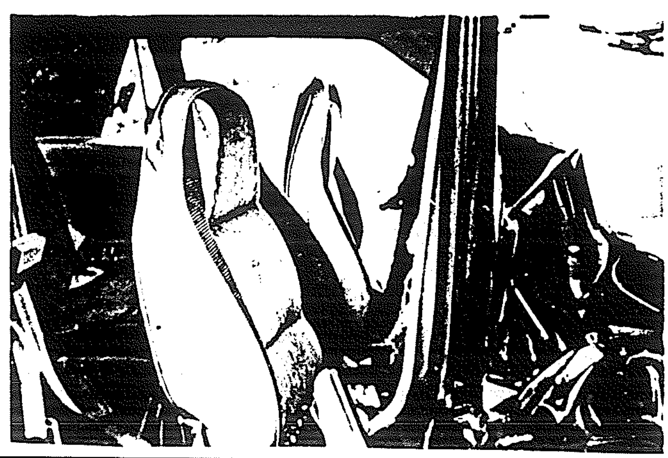
Representative Photographs: UOM 647

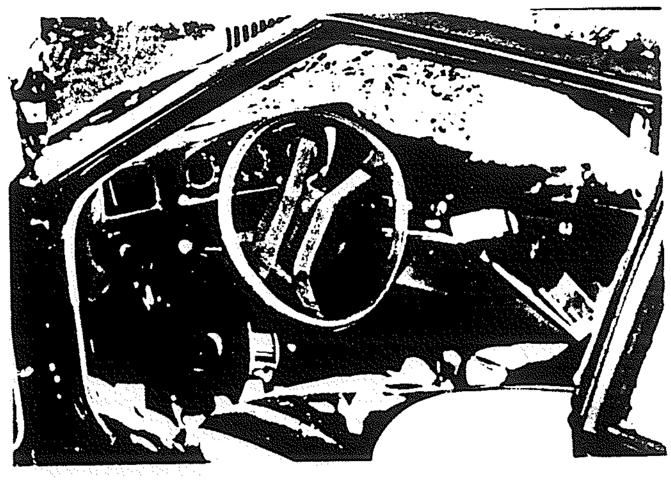


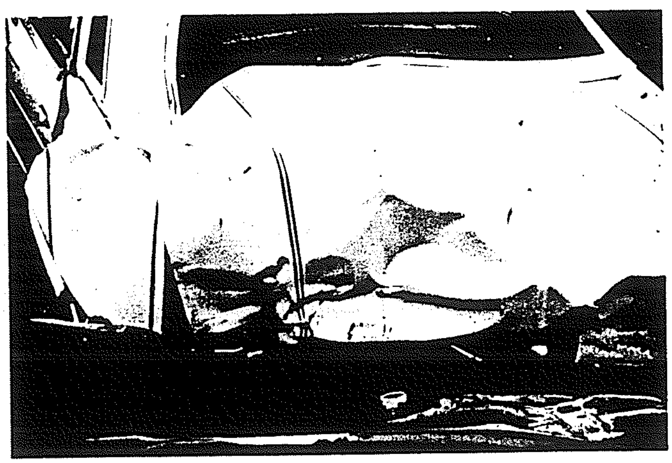












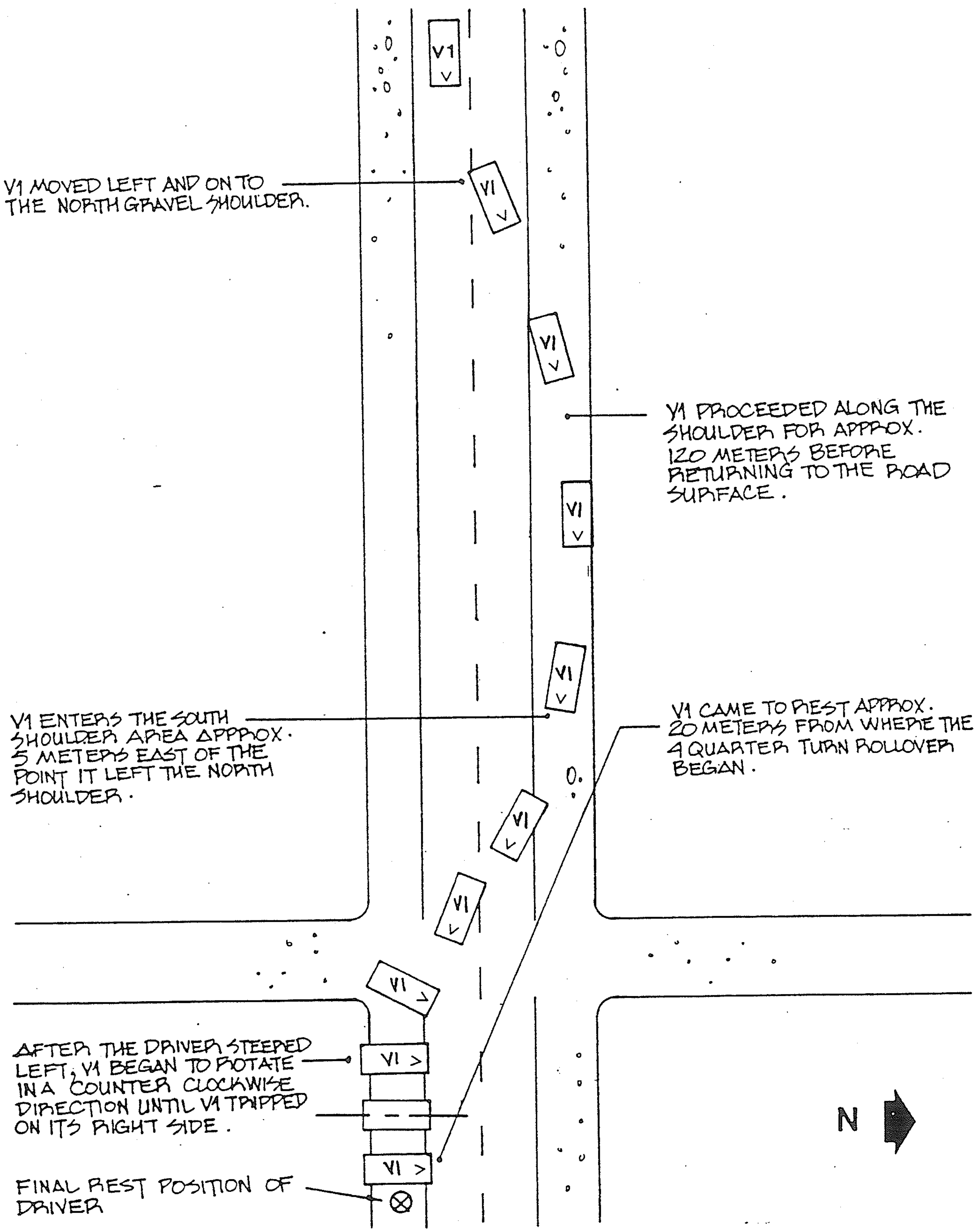
This single-vehicle, roll-over collision occurred at approximately 1500 hours on a two-lane, two-way, undivided rural roadway. The asphalt road surface was in good condition and dry. A significant pavement edge drop-off existed between the road surface and the gravel shoulders. Visibility was unrestricted.

V1, a 1977 Dodge van, operated by a 73-year-old female, was eastbound. The driver was accompanied by a 43-year-old female seated in the right-front passenger seat. Between the two front seats was a cat secured in a box. Both occupants were using the available two-point lap belts provided for their seating positions, however, it is highly probable that the obese driver was wearing her lap belt loosely.

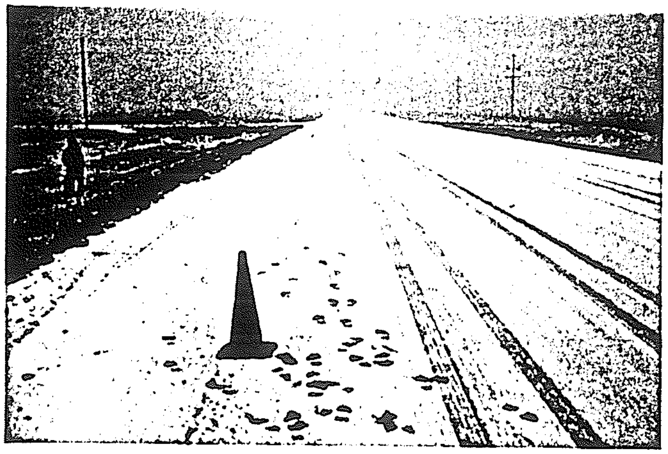
This collision event was initiated as the driver attempted to prevent the cat from escaping from the box it was placed in. This action caused the driver to allow her vehicle to move left, crossing the westbound traffic lane into the north shoulder area. V1 proceeded along the north shoulder for approximately 40 m when the driver steered right, moved off the shoulder area and crossed the normal travel lanes. It is probable that, as the driver entered the south shoulder area (approximately 5 m from where it left the north shoulder), the driver steered left again. This steering input caused V1 to rotate in a counter-clockwise direction approximately 90° to its original direction of travel. V1 then tripped on its right side tires initiating a simple four-quarter turn clockwise roll-over about its longitudinal axis. V1 eventually came to rest upright approximately 20 m from where it tripped.

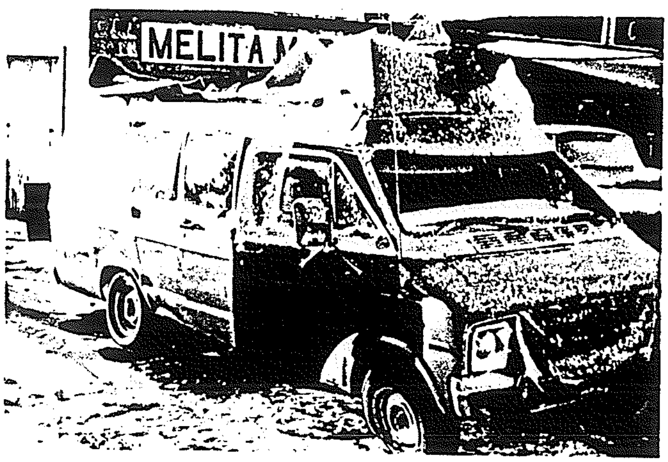
During the roll-over, the driver, restrained by the lap belt, was completely ejected from her vehicle. She sustained critical head (MAIS 4), facial (MAIS 2), chest (MAIS 4) and abdominal (MAIS 4) injuries and was pronounced dead upon arrival at hospital. The restrained right-front passenger remained fully in the occupant compartment and was uninjured.

It is probable that the conversion of the van to a camper-type vehicle increased the center of gravity of V1 and, therefore, reduced its stability. This would have increased the likelihood of the vehicle rolling over in cases of lateral deceleration.


V1 MOVED LEFT AND ON TO THE NORTH GRAVEL SHOULDER.
V1 PROCEEDED ALONG THE SHOULDER FOR APPROX. 120 METERS BEFORE RETURNING TO THE ROAD SURFACE.
V1 ENTERS THE SOUTH SHOULDER AREA APPROX. 5 METERS EAST OF THE POINT IT LEFT THE NORTH SHOULDER.
V1 CAME TO REST APPROX. 20 METERS FROM WHERE THE 4 QUARTER TURN ROLLOVER BEGAN.
AFTER THE DRIVER STEERED LEFT, V1 BEGAN TO ROTATE IN A COUNTER CLOCKWISE DIRECTION UNTIL V1 TRIPPED ON ITS RIGHT SIDE.
FINAL REST POSITION OF DRIVER
V1
N

Representative Photographs: UOM 722





This two-vehicle collision occurred at approximately 1200 hours on a two-lane, two-way, undivided, rural roadway. The asphalt-surfaced road with gravel shoulders was in good condition, however visibility was reduced under blowing-snow conditions. A snow drift extending into the eastbound travel lane had formed immediately west of the location of the collision. This drift was created due to an earth berm erected south of the roadway. The drift is known to form whenever southerly blowing snow conditions occur.

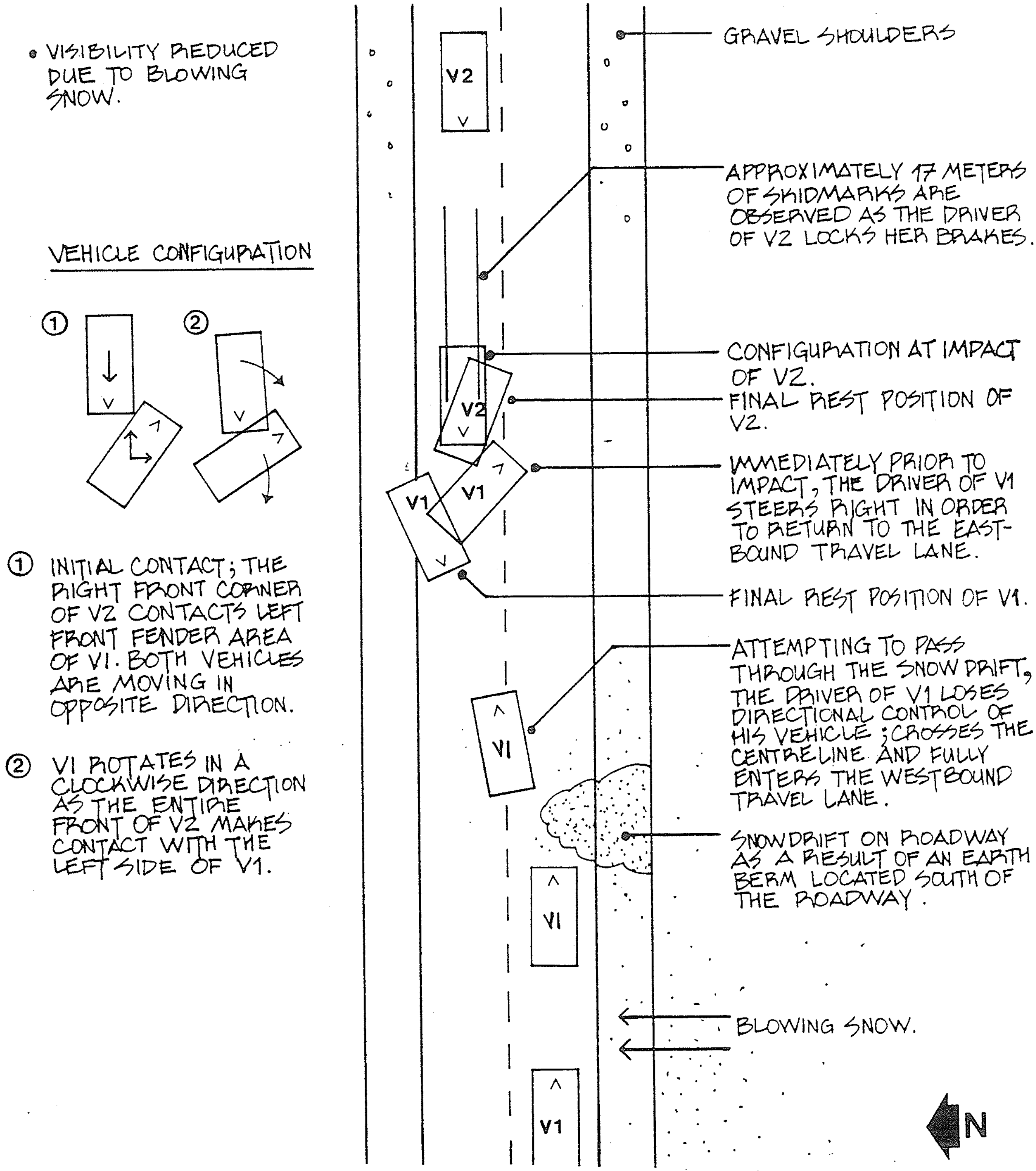
V1, a 1974 Ford two-passenger car, operated by a 22-year-old male, was eastbound. The driver was accompanied by a 22-year-old female seated in the right-front passenger seat. Both occupants of V1 were restrained. V2, a 1974 Mercury station wagon, operated by a 33-year-old female, was westbound. Six children aged 2 to 10 years occupied unknown seat positions in the rear of V2. All occupants of V2 were unrestrained.

While attempting to drive through the approximately 0.5 m deep snowdrift which had accumulated in the eastbound lane, the driver lost directional control of his vehicle and moved left into the westbound lane. The driver of V1 was in the process of steering right to return to the eastbound lane when it was struck on the front left fender area by the left front corner of V2. As the collision event proceeded, the entire front of V2 contacted the left side of V1 and V1 rotated in a clockwise direction. Since the driver of V2 had locked her brakes, leaving 17 m of skid marks to the POI, she was not able to undertake an evasive steering manoeuvre.

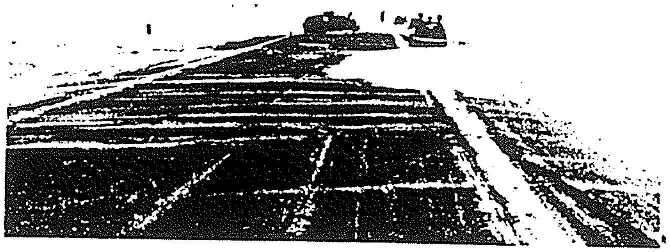
During the impact, the restrained driver moved forward and to the left towards the front of V2, slightly loading his restraint system and impacting the interior of the driver side and "A" pillar. The interior occupant space was severely compromised as the side door was intruded, the steering assembly shifted upward and the front dash moved rearward towards the occupants. The right-front-seat passenger also moved forward and to the left impacting the dash area and loading her restraint system.

The driver sustained critical chest (MAIS 5) and abdominal (MAIS 5) injuries and was entrapped in his vehicle. The "jaws of life" were required to extricate the driver due to the structural deformation of the car. He was pronounced dead on arrival at hospital. The right-front passenger sustained minor injuries to her extremity (MAIS 2), was taken to hospital, treated and released. The occupants of V2 sustained undetermined moderate injuries.

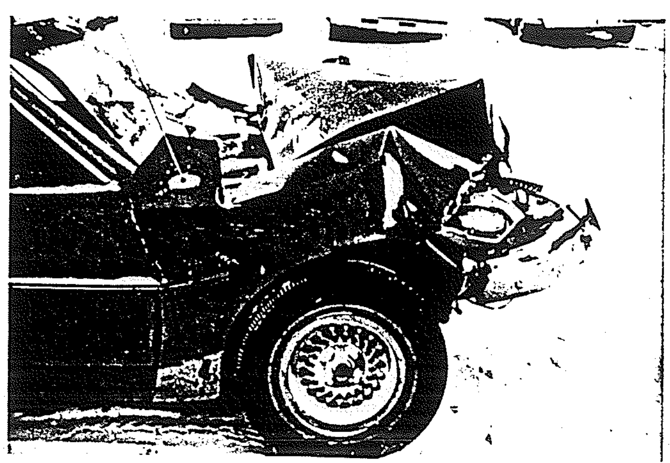
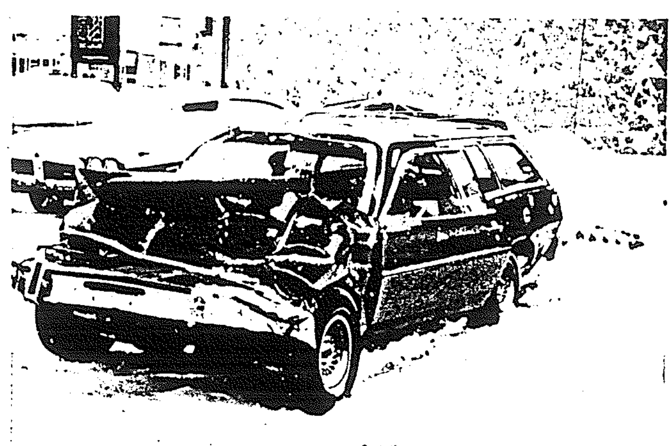
Scene Diagram: UOM 765



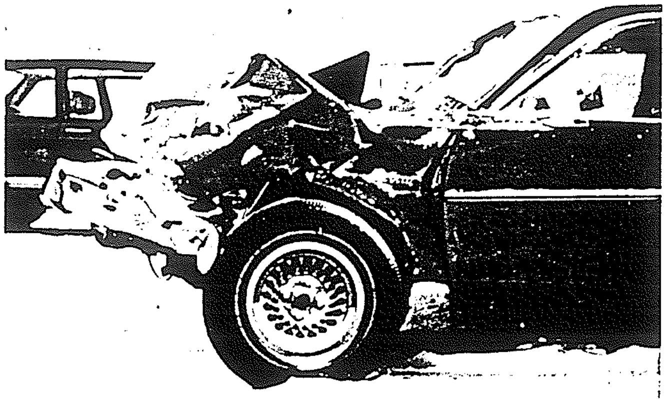
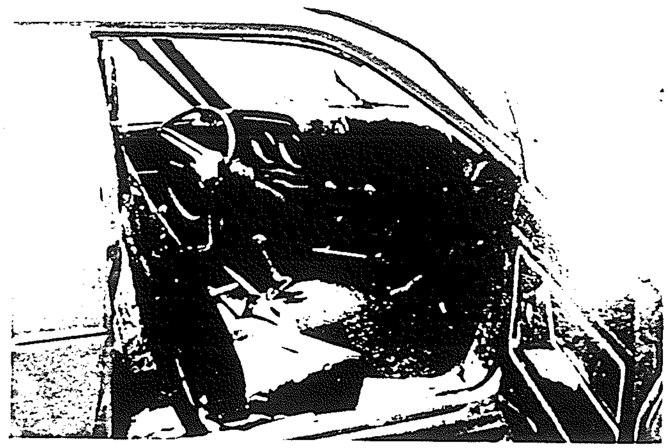
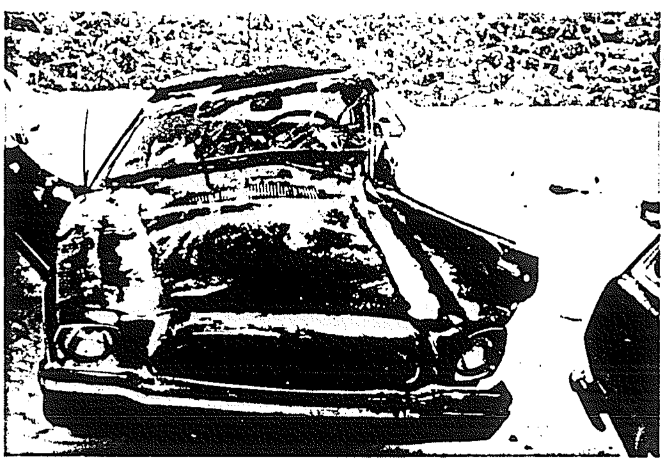
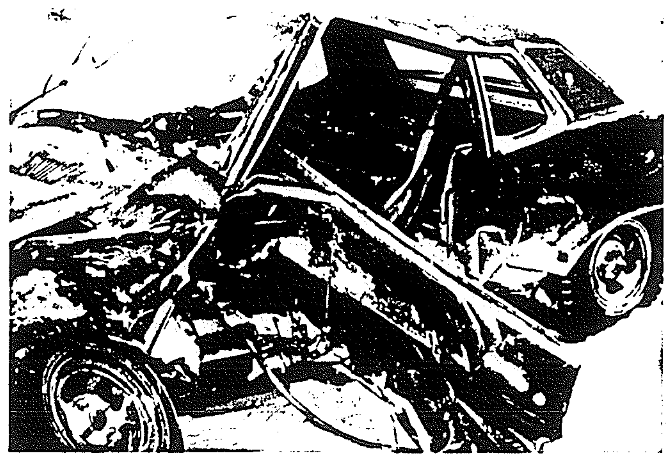
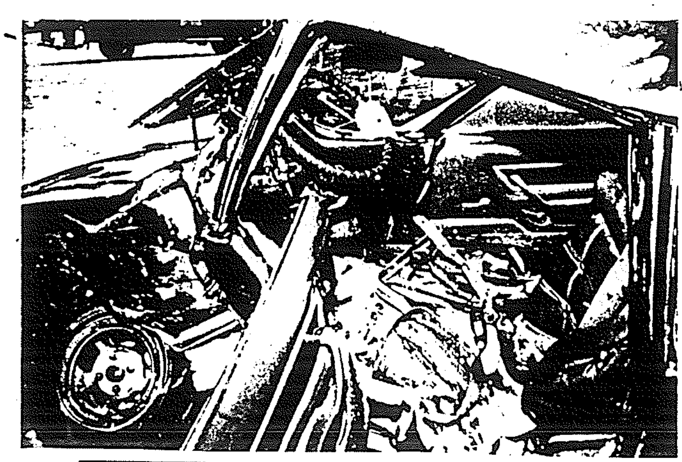
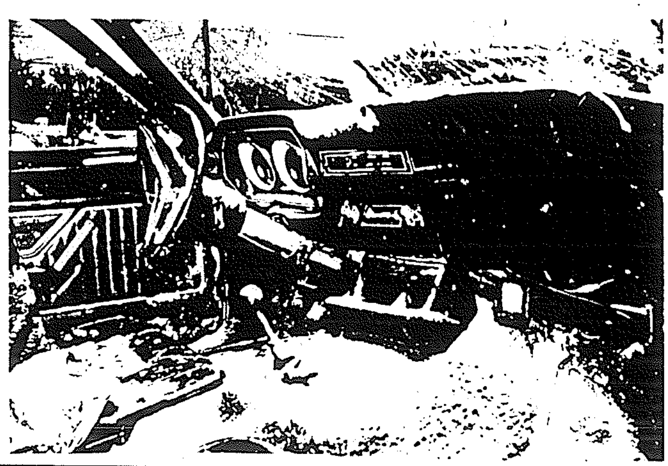
Representative Photographs: UOM 765





Representative Photographs: UOM 765

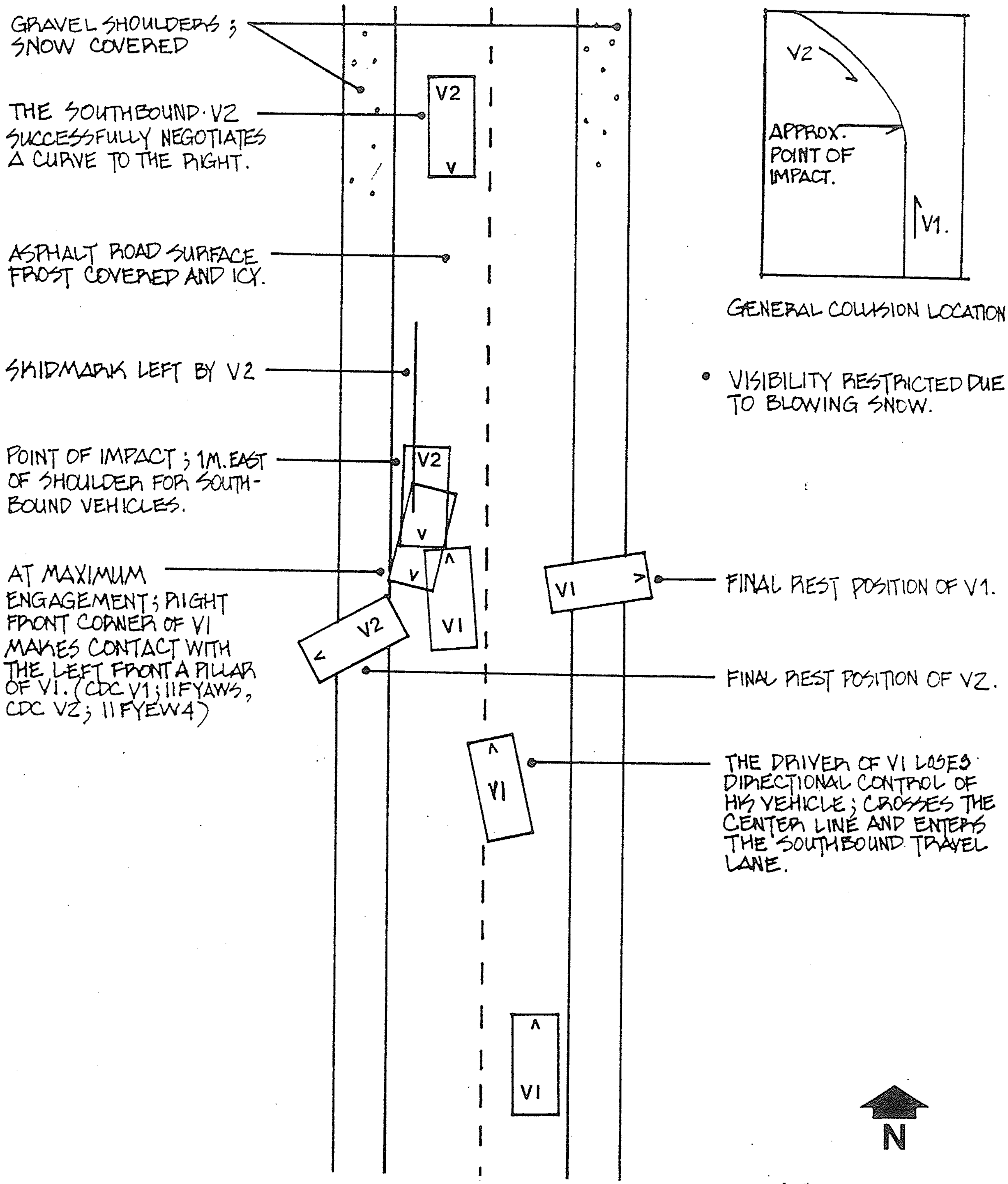
This two-vehicle, head-on collision occurred at approximately 0800 hours on a two-lane, two-way, undivided, rural highway. At the time of the collision, the concrete road surface was frost-covered and slippery. Visibility was reduced under overcast skies and blowing snow. The general collision location is at the beginning of a curve requiring northbound vehicles to move left.

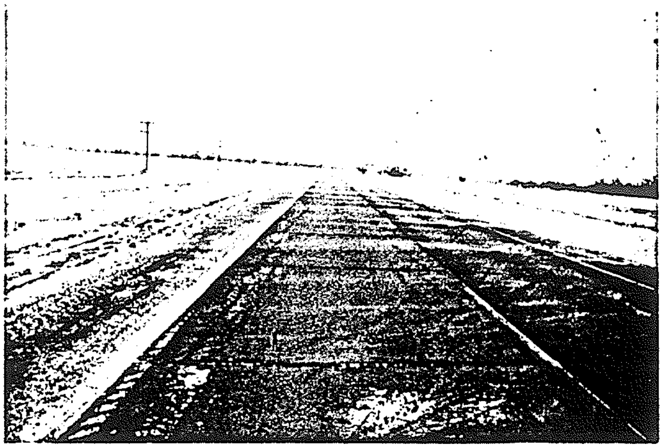
V1, a 1984 Chevrolet five-door passenger car, operated by a 19-year-old male, was northbound. The driver and sole occupant of V1 was utilizing his three-point lap-and-shoulder restraint system. V2, a 1981 GMC van, operated by a 61-year-old male, was southbound. The driver was accompanied by a 60-year-old female seated in the right-front passenger seat. Both occupants of V2 were using the available restraint system.

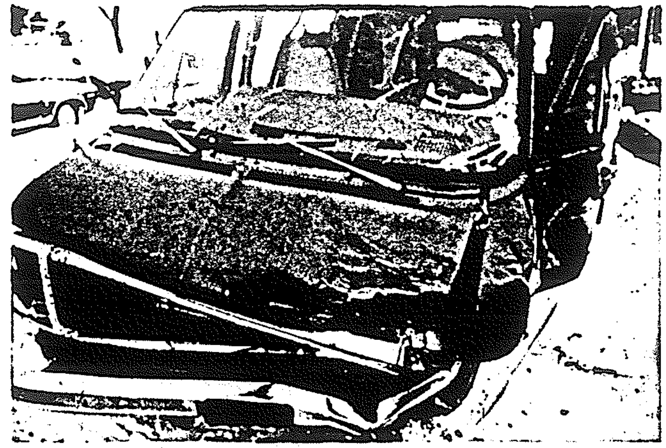
The collision event was initiated as the driver of V1 lost directional control of his vehicle under adverse driving conditions, crossed the center line and entered the southbound travel lane. The driver of V2 braked immediately prior to impact and steered right before striking the left front of V1 (CDC V1, 11FYAW5; CDC V2, 11FYEW4). Following the collision, V1 rotated approximately 90° in a clockwise direction and came to rest on the east shoulder adjacent to the POI. V2 rotated approximately 45° in a clockwise direction before coming to rest on the west shoulder within 2 m of the POI.

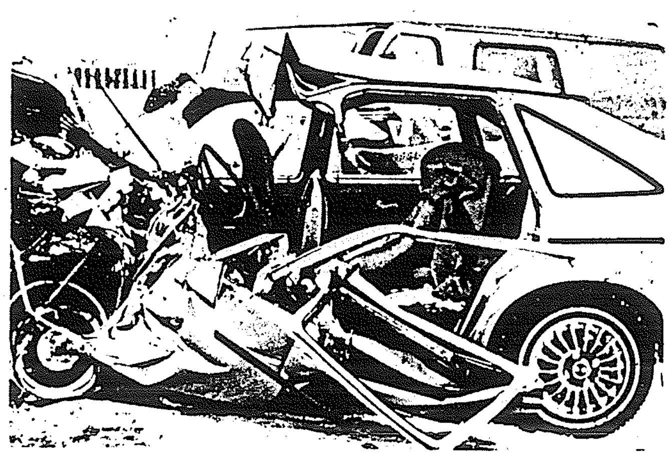
During the crash phase, the restrained driver of V1 moved forward and slightly to the left, loading the intruding steering column, the lower dash area and his restraint system. The driver's head also contacted the left "A" pillar and the intruding hood of V2. The driver sustained severe head (MAIS 5), facial (MAIS 3), chest (MAIS 4), abdomen (MAIS 5) and extremity (MAIS 3) injuries and was pronounced dead at the scene. The restrained occupants of V2 sustained undetermined minor injuries.

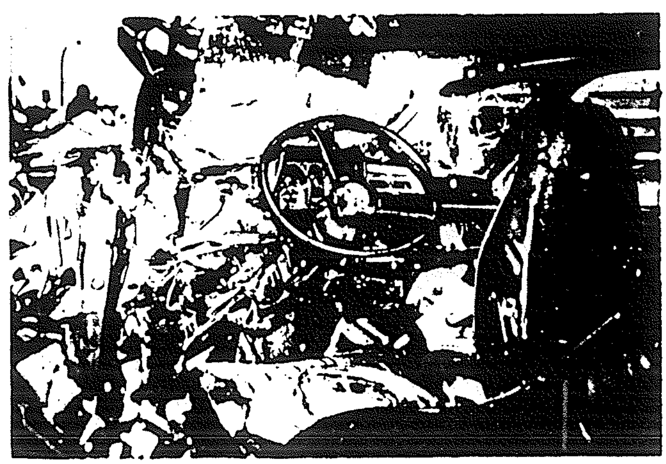
Scene Diagram: UOM 766











This single-vehicle, roll-over collision occurred at approximately 1900 hours on a two-lane, rural roadway. The roadway was straight and level and orientated in an east-west direction. The worn gravel surface was hard along the travel lanes, however the remainder of the road surface was comprised of loose gravel. At the time of the collision event, the surface was dry; the ambient weather conditions were clear and dry.

V1, a 1979 Austin Mini, operated by a 20-year-old male, was westbound. The owner of the vehicle, a 27-year-old female, occupied the right-front passenger seat. Although the passenger was restrained by the available seat belt, the driver was unrestrained.

While travelling at an estimated speed of between 76 and 85 kph, the driver lost directional control of his vehicle. It is probable that, after moving to the right, the driver over-corrected while attempting to regain directional control. This caused the vehicle to yaw in a counterclockwise direction until it rotated approximately 90° from its original direction of travel. At this point, the vehicle tripped on its right-side wheels initiating a simple three-quarter turn roll-over about its longitudinal axis. The vehicle came to rest approximately 35 m from the point where the driver originally lost directional control and began to yaw.

During the roll-over the unrestrained driver was completely ejected out of the left front window and was crushed between the bound and the roof of his vehicle. The driver came to rest approximately 5 m west of the final rest position of V1. He sustained critical head (MAIS 5) and chest (MAIS 5) injuries and was pronounced dead at the scene. The restrained front-seat passenger remained in the vehicle and sustained only minor chest (MAIS 1) injuries. She was transported to hospital, treated and then released.

Scene Diagram: UOM 879