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Motor Vehicle Collision Injury Analysis: Design and Development of an Injury Analysis Team Collaborating with Expert Police Collision Reconstructionists

By

Mohammed N. Hoque ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of **Master of Science**

in

Medical Sciences – Public Health Sciences

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Abstract

The University of Alberta Injury Analysis Team (IAT) is the first agency in the province of Alberta collaborating with police to investigate mechanisms of motor vehicle collision injuries. Considering the burden of the injury problem in this province, an agency of this sort, collaborating with police, emergency medical services, trauma physicians, medical examiners, and injury epidemiologists, is an important step in contributing to the knowledge of injury biomechanisms and to design injury prevention strategies. This pilot study is intended to document the biomechanics of injury in 23 serious car crashes in the City of Edmonton and to act as a model for other communities to develop generic injury analysis teams that investigate mechanics of injury. The ultimate goal of investigating injury biomechanics is to devise injury prevention strategies in order to reduce the burden of this disease.

"When there is an understanding about injury mechanism or modes of transmission, many interventions become as obvious as the control of food-borne outbreaks through adequate refrigeration."

Barss, Smith, Baker, and Mohan-Injury Prevention: An International Perspective. Epidemiology, Surveillance, and Policy. 1998

University of Alberta

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled *Motor Vehicle Collision Injury Analysis: Design and Development of an Injury Analysis Team Collaborating with Expert Police Collision Reconstructionists* submitted by Mohammed N. Hoque in partial fulfillment of the requirements for the degree of Master of Science in Medical Sciences-Public Health Sciences.

Louis Hugo Francescutti (Supervisor)

J. Peter Rothe (Committee member)

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JUNE 13, 2000
Date

To my parents Dr. M.Z. Hoque and Mrs. Sajeda Hoque, my brother Enam, and my sister Sarah.

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List of Abbreviations

AAAM	Association for the Advancement of Automotive Medicine
AB	Alberta
ACICR	Alberta Center for Injury Control and Research
AIS	Abbreviated Injury Scale
ATLS	Advanced Trauma Life Support
CI	Trauma Center Crash Investigation Personnel
CI	Contact and intrusion
CO	Contact only
CPR	Cardio-Pulmonary Resuscitation
CRASH	Calspan Reconstruction of Accident Speeds on the Highway
CRT	Dynamic Science Crash Reconstruction Team
CT	Calculated Topography
DATS	Disabled Adult Transit Service
ED	Emergency Department
EES	Energy equivalent speed
EMS	Emergency Medical Services
EMT	Emergency Medical Technician
EPS	Edmonton Police Service
ER	Emergency Room
F	Frontal
IAT	Injury Analysis Team
ICU	Intensive Care Unit
ICD-9	International Classification of Disease (Ninth Revision)
ISS	Injury Severity Score
L	Lateral
MAIS	Total injury severity
MVC	Motor vehicle collision
NHTSA	National Highway and Transportation Safety Administration
NCIPC	National Committee for Injury Prevention and Control
OR	Operating Room
PDOF	Principal direction of force
RAH	Royal Alexandra Hospital
RCMP	Royal Canadian Mounted Police
RICRC	Regional Injury Control and Research Center
UAH	University of Alberta Hospitals
U of A	University of Alberta
US	United States
χ^2	Chi Square
δV	Change in velocity

CHAPTER ONE
Introduction

1.1 Scope of Thesis

1.1.1 Goals and Objectives

This descriptive pilot study describes the analysis, design, development, implementation, and evaluation of an injury analysis team that investigates the biomechanics of injury resulting from motor vehicle collisions in the City of Edmonton, Alberta, and in Strathcona County, Alberta. The goal of this study was to show that an injury analysis team, collaborating with other investigative agencies such as the police, emergency medical services, trauma physicians, and injury epidemiologists, can maximize the use of data that is already routinely collected. This data, when synthesized and added to by an injury analysis team, can help design injury prevention strategies that eliminate or reduce the severity of injury.

This study was performed in collaboration with the Edmonton Police Service, Traffic Section, Sherwood Park Detachment Royal Canadian Mounted Police, University of Alberta Hospital, Royal Alexandra Hospital, Edmonton Emergency Medical Services, Strathcona County Emergency Medical Services, and Office of the Chief Medical

Examiner. The goal was to collaborate with these organizations to collect and combine data pertaining to injury biomechanisms.

1.1.2 The Burden of Motor Vehicle Collision Injury in Alberta

In 1998 there were nearly 100,000 motor vehicle collisions in Alberta. The City of Edmonton alone had 19,128 motor vehicle collisions. Of these 19,128 crashes, 5,927 (31%) of them caused 8756 injuries and 24 fatalities. Alberta has the highest rate of motor vehicle collision injuries in Canada (Alberta Infrastructure, 1999). Injury is the leading cause of death in the 1-44 age category and accounts for more years of life lost than any other disease process. Motor vehicle-related injury is the leading cause of unintentional injury death in Alberta. For the past 10 years, motor vehicle-related injuries have been the leading cause of death for people under age 25 (Alberta Center for Injury Control and Research, 1998). The average annual direct and indirect cost of motor vehicle collisions in Alberta in 1996 was estimated to be $3.55 billion (Alberta Motor Association, 1996). Clearly, injury is a major public health issue.

1.1.3. Previous Model

A 1993 Ph.D. thesis by Harold S. Dalkie, P.Eng (University of Manitoba) designed a model to investigate *road safety* issues. Primary data sources were police reports, hospital charts, and in-depth collision investigations. As in Dalkie's study, the following were objectives for this model design:

1. Use of existing data sources must be maximized.
2. Appropriate analysis systems must be in place.
3. The model must be feasible and sustainable.
4. The model must have general applicability.

However, the methods of this project differed from Dalkie's in that the researchers arrived at the scene of collision as soon as possible to study *injury mechanism* factors. In Dalkie's study, the researchers worked retrospectively, studying the vehicles at a compound within 24 hours of a crash. In this study, the police shared collision reconstruction data with the researchers at the scene. A feature of this model design was to be able to give emergency room physicians a precise mechanism of injury when the patient arrives at the trauma center so that injury control procedures can be optimized. This was done by proceeding to the trauma center after data from the scene was collected and sharing it with the trauma team in addition to collecting patient injury data.

This thesis used Dalkie's model, along with frameworks for establishing injury prevention programs and collaboration, to design an injury analysis team model, collaborating with other community agencies to study injury biomechanics. The model design included a feedback mechanism to police and injury control infrastructure with the ultimate goal to reduce the volume and severity of injury.

The findings of this present study will provide information that can:

1) help add to the existing body of knowledge of injury biomechanism;
2) show that collaborative injury analysis is feasible;

3) help guide other communities in Alberta is establishing their own injury analysis team;
4) support the Alberta Center for Injury Control and Research (ACICR) in meeting their mandate of maintaining a coordinated approach to injury control in the Province of Alberta (mandate given by Alberta Health and Wellness to ACICR);
5) emphasize the importance of police support in injury control;

1.2 Organization of Thesis

This thesis is composed of five chapters. Chapter Two, "Literature Review of Injury Biomechanism" reviews the literature of motor vehicle and generic injury analysis/reconstruction as well as injuries typically seen in different crash scenarios. As well, it discusses the Crash Injury Research and Engineering Network (CIREN). Chapter Three, "Methodology", outlines the methodology used for the study, including the sample population, inclusion criteria for the cases studied, data collection methods, and data collected. Chapter Four, "Results and Discussion", includes a case by case description of the collision, injury severity scores (ISS), Haddon's Matrix which describes the injury event, and injury prevention strategies for each case. Chapter Five, "Conclusions and Future Directions", discusses the implications of this research and recommendations for future data collection, and analysis.

CHAPTER TWO

Literature Review

2.1 Introduction to Injury Analysis and Reconstruction

The objective of this chapter is to review the relevant research regarding injury analysis, reconstruction, and biomechanism. The goal is to see what previous research can be applied to designing a model of an injury analysis investigator, particularly interested in motor vehicle collisions (MVCs), but with the generalizabilty to investigate all injury events. The intent is not to reconstruct "accidents", but rather to reconstruct the injury resulting from the adverse event. Though these two events are inherently related, the purpose here is to design a tool that will be able to capture data on injury epidemiology. This is important in a region such as the Capital Health Authority since injury is the leading cause of death in Alberta in the 1-44 age category (Alberta Center for Injury Control and Research). As with other diseases, if the frequency, distribution, and mechanisms of injuries can be analyzed, appropriate preventative measures can be designed.

The literature review included a search of Medline, EMBASE, HealthSTAR, Web of Science, a dissertation database in the University of Alberta library Internet site, and the Internet. The Medline search resulted in 27 articles of which 9 articles were of relevance. The EMBASE search resulted in 14 articles of which 6 articles were of relevance. Web of Science is a database linking the basic sciences, medical sciences, and social sciences. Fourteen articles were found here of which 8 articles were used. The dissertation database revealed an important reference, a 1993 Ph.D. dissertation from the University of Manitoba on the "Development and Application of a Model to Investigate Road Safety Issues".

As mentioned above, to understand injury epidemiology, the frequency and determinants of injury are needed. Mechanisms of injury need to be investigated in order to describe trends and predict outcomes. Loo et.al. report on a prospective study of the interaction between airbag and seatbelt protection versus vehicle compartment intrusion effects on injury patterns in MVC trauma patients (Loo et al, 1996). This was a prospective cohort study of 200 MVC patients admitted to two Level 1 trauma centers in two states in the northeastern U.S.A.. Patients admitted to one of the two centers, one in New Jersey, the other in Baltimore, by either helicopter or ground ambulance, were considered for case selection. The methods used here to investigate injury mechanisms are applicable to our proposed injury investigation research. In this study, the Trauma Center Crash Investigator Personnel (CI), who evaluated all potential study patients upon admission, conducted patient selection. If a patient was selected, the CI notified the Dynamic Science Crash Reconstruction Team (CRT) and EMS information coordinator within a 2-hour period of the MVC, so that data collection could begin. The CI observer photographed all visible body surface injuries and/or penetration wounds, x-ray films, CT scans, surgical procedures, and pathological specimens. The patient's cardiovascular and respiratory physiological measurements were also recorded.

The CRT visited the crash scene and examined all vehicles. They made detailed scene and vehicle measurements and photographs to determine the location, direction, and magnitude of all intrusion deformities in the vehicle compartment structure. This information was related to the patient injuries to identify injury producing contact points within the occupant compartment with special attention to their intrusion magnitude. They also calculated the vehicular principal direction of force, initial speed, and the change in impact deceleration velocity, δ V. Detailed attention was paid to the seating position, environmental conditions, restraint use, occupant entrapment, and extraction procedures for proper consideration during reconstruction analysis and clinical evaluation. Investigators paid close attention to correlating the superficial and deep-tissue, bone, and organ injuries found by the surgical CI team, with the motor vehicle passenger compartment intrusion related injury contact points identified by the CRT. Fisher's Exact Test or χ^2 were used for statistical analysis.

Data acquisition involved entering each patient's information into a computer-based medical graphics program to establish uniformity in the conventions of injury designation. This program utilizes anatomic images enabling direct graphic entry of all pertinent injury data in a manner that precisely delineated the site, location, and nature of the injuries. Once all injuries have been localized to a specific body part, organ, or structure, the portion of the motor vehicle's internal passenger compartment structure that resulted in the injury-producing contact with that body part could be related to the specific injury. The injury and the impact site can be related to the principal direction of force (PDOF) of the crash and to any crash photographs. Results of this study described the effects of airbag and seatbelt use on severity (Glasgow Coma Scale) and location of injury, specifically on patterns of injury to the brain, face, spine, thorax, lung, heart, liver, spleen, kidney, and bone fractures. The methods and results of injury analysis in this paper will proved useful in designing a model and protocol for use in a local environment.

Further research has been done in studying lower extremity (LE) injuries resulting from MVCs. A case study by Burgess et. al. is another example showing that injuries are predictable (Burgess et al, 1995). The authors attempted to determine the relationship between airbags and LE injuries by studying 10 drivers admitted to a Level 1-trauma center. Methods were similar to Loo's study. Data collection was begun concurrently with the admission process. Photographic documentation of each patient's injuries, radiographs, and CT scans were obtained as soon as possible. The investigator performed a detailed surgical exploration during debridement of open wounds or fracture fixation to treat them appropriately and to describe the injury mechanism, pattern of fracture, pattern of soft tissue insult, and the extent of periosteal stripping.

In terms of reconstructing the injury event, a detailed crash reconstruction, including force, contact point, and vehicle intrusion data was performed for each case studied. Authors paid close attention to the dashboard and toe pan areas to determine deformation and intrusion and their association with thigh, leg, and foot injuries. The computer program used was the Calspan Reconstruction of Accident Speeds on the Highway (CRASH) software to generate δ V as a measurement of collision severity.

A search of the Internet reveals that the Calspan Corporation of Buffalo, NY developed this program. This company (originally named Cornell Aeronautical Laboratory) developed the first mathematical model of vehicle occupants in 1963. The company is now a subsidiary of Viridian Engineering (www.calspan.com). This was originally a "Fortran" program run on "punch cards". The contract was originally for the US government who currently owns the rights to this program. The old mainframe computer program has been updated to a PC version called WINMASH and operates in a PC Windows environment. The algorithm relies primarily on stiffness parameters derived from short duration 35 mile per hour rigid barrier impact tests (Personal communication, Veridian Engineering, 2000). The CRASH program is currently used for investigations performed by the Crash Injury Research and Engineering Network (CIREN), which will be discussed later. A change in velocity calculation is vital to understand the stresses the body undergoes in a collision and how this effects injury severity (Burgess, et al, 1995).

After data collection was completed, each case was reviewed by a multidisciplinary group of orthopedic, crash reconstruction, and epidemiologic experts to determine the mechanisms of injury for lower extremity fracture. This study was not generalizable since only 10 cases were studied. Their results show that the mean δ V was 28.3 mph and mean maximum crush was 32.4 inches. This resulted in a mean Injury Severity Score (ISS) of 13.2.

Another study by several of the same authors of the Burgess study used a three year prospective study design examining 76 frontal (F) and 45 lateral (L) MVC patients with regard to seatbelt restraint use and occupant compartment contact and intrusion injuries. One hundred twenty one MVC patients with multiple injuries admitted to a level-1 trauma center were studied by collision reconstruction and medical data analysis. They had a MVC mean impact change in velocity (δ V) of 30 +/- 11 mph and a Injury Severity Score of 29+/- 12. The methods of this study are similar to the previous study discussed. An important aspect studied was patterns of organ injuries as a function of crash direction and belt use. This was a detailed study looking at effects of injuries owing to contact and intrusion (CI) and contact-only (CO) impacts. The authors studied the relationship of collision and seat belt use in terms of brain injury, facial lacerations, facial bone fractures, spinal column injury, thoracic injury, abdominal wall injuries, abdominal visceral injuries, pelvic fractures, and extremity fractures. Results show that there is a distinct epidemiology to these types of injuries and should be examined for during investigation of F and L collisions involving injury.

Brain injuries occurred in 47% of patients (42% of F and 56% of L crashes). Proper restraint use reduced brain injury in front F MVCs (30% F belted vs. 47% F non-belted) but had no statistically significant effect in L MVCs (63% L belted vs. 30% F belted [$p < 0.06$]). Facial lacerations ($p < 0.0001$) and facial fractures ($p < 0.008$) were significantly more common in F crash patients than in L patients. This was found to be independent of belt use. While the incidence of patients with facial fractures was similar in F belted and F non-belted (39% and 40%), the location and percent distribution of the specific facial bone fractures were different. In F belted cases, the majority of the facial bone fractures were in the central face: the maxillae, zygomas, nasal bones, and orbital floor bones. In F non-belted, these patients showed a higher percentage of injuries to the jaws and to the upper orbital nasoethmoid complex of bones. This difference suggests that different structural contacts may be responsible for the injuries seen in F belted vs. F non-belted crashes.

The evidence that the steering wheel was the most frequent head contact site in 42%, the A-pillar in 26%, and the windshield in 21% of the F belted patients supports this suggestion. This is compared to contact in 30% with the windshield and its upper frame and 28% A-pillar contact in F non-belted cases. In L crashes, the side window frame was mainly responsible for head injuries with 38% of the L non-belted and 25% of the L belted receiving facial or skull trauma, or both from these locations.

Sixty-two percent of the 121 study patients received some type of thoracic injury (rib fractures, lung trauma, and aortic injuries). The incidence of thoracic injury was significantly greater in the 29 L non-belted patients compared to the 53 F non-belted patients ($p< 0.04$). There was no overall difference in the incidence of thoracic injuries between F belted and L belted patients. Lung trauma was present in 37% of the 121 cases in the study group. There was no significant difference between F and L crash patients. Fifteen percent of patients received abdominal wall soft tissue injuries. In 6 of these patients, injury was located in the mid- to anterior axillary line and consisted of abrasions, contusions, or hematomas from the seatbelt or steering wheel contacts. Again, there was no significant difference between F and L crash patients. Thirty nine percent of the patients received abdominal visceral injuries (23 F and 24 L). This included 22 spleen, 22 liver, 8 kidney, 8 bowel, 2 colon, and 1 pancreatic injury. Liver injuries were located in the right lobe in nine patients and were usually capsular avulsions or parenchymal fractures >1 and < 3 cm deep.

There was a significant difference in the number of kidney injuries between the one F patient and the seven L patients who sustained them ($p< 0.004$). There was injury of the spleen in 16% of F and 22% of L crashes (not significantly different).

There were 44 pelvic fractures amongst the 121 study patients. There was a significant difference between the number of F crash patients (19 [25%]) and the L crash patients (25 [56%]) ($p< 0.001$). (Detailed results of exact injury location are given in the paper). Seatbelts did not protect against pelvic injury. Contact intrusions of the car occupant compartment in F crashes were the main cause of brain (A-pillar), lung and liver (steering wheel and instrument panel), and LE (toepan) injuries. In contrast, contact only injuries of the steering assembly were mainly responsible for injuries to the lung, heart, and liver in F crashes, and side-door CO for lung, aorta, liver, and pelvic injuries.

This study will prove helpful in our study in that it gives detailed mechanisms of injury resulting from MVC. It gives insight in what should be expected, and looked for, when reconstructing MVC injuries and also when evaluating the care provided by EMS and hospital services.

Injuries resulting from MVC are also extensively studied at the Institute of Forensic Medicine, University if Heidelberg, in Heidelberg, Germany The literature search found two studies by Miltner (Miltner et al, 1992, 1995). The first study involved examining 79 belted front seat occupants whom were involved in car-to-car side collisions with main impact point at the front door or B-pillar. The purpose of the study was to evaluate injury mechanism to the liver and spleen. The authors used police reports from 1987-1990 and autopsy reports from the Institute of Forensic Medicine in Heidelberg. Collision speed, energy equivalent speed (EES), and δ V were calculated. EES is a unit of measure for the energy that causes the deformation of the collision car compared with a crash against a rigid wall (Miltner et al, 1995). Injuries were coded according to the 1985 Abbreviated Injury Scale (AIS), with AIS of 0 (uninjured) to AIS of 6 (fatal). The scale classifies injuries in 7 body regions: external, head, neck, thorax, abdomen, spine, and extremities. The total injury severity (MAIS) refers to the most severe individual injury (Miltner et al, 1995).

In logistic regression, EES, δ V, and maximum deformation had a highly significant influence on the occurrence of liver and spleen ruptures ($p < 0.001$). The crucial point for liver and spleen ruptures was an EES of 45 km/h for occupants seated on the opposite side of the collision. At an EES of up to 80 km/h, the liver and spleen of passengers seated on the opposite side of collision could remain uninjured. Front seat passengers on the impact side had liver ruptures from an EES of 40 km/h. At an EES $\geq$ 50 km/h, all such passengers had liver ruptures or combined liver and spleen ruptures. Drivers on the impact side sustained liver and spleen ruptures from an EES $\geq$ 40 km/h. From the EES crucial point of 40 km/h, almost all the drivers on the impact side sustained combined liver and spleen injuries.

The EES had the greatest influence on liver ruptures, while the number of rib fractures of the left hemithorax had a stronger influence on the occurrence of spleen ruptures than did the EES. Except in one case, the mean EES increased with increasing AIS. At an EES $\geq$ 40 km/h, all occupants on the impact side sustained abdominal injuries. Age had no significant influence on liver and spleen ruptures, but did on the occurrence of pelvic rupture ($p < 0.05$).

A second study by Miltner looked at influencing factors on the injury severity of restrained front seat occupants in car-to-car head on collisions (Miltner et al, 1992). Three hundred nineteen cases were examined using Heidelberg police road collision records from 1987-1990 and from autopsy records for the years 1983-1990 at the Institute of Forensic Medicine. Investigators found that the main cause of the 27 fatalities was polytrauma and hemorrhage. The main factors influencing injury severity were EES, δ V, maximum deformation depth, and the collision angle. With an EES of $>$50 km/h, fatal injuries can be expected, and above 60 km/h no occupant remained uninjured. A multivariate analysis showed that EES influenced the severity at all body locations except spinal cord; occupant position effected only head injury severity, with drivers being more severely injured; occupant age influenced the injury severity at the thorax (increasing bone fragility with age), abdomen, extremities and MAIS as well. With an EES of 50 km/h, the probability of being fatally injured was 30%-40% higher for occupants over 59 years than those under 20.

In investigations of MVC, vehicular occupants are not the only people injured during collisions. Pedestrian injuries are serious cause for concern in urban as well as rural areas. When struck by a vehicle such as a passenger car, the legs and lower body of an adult pedestrian are accelerated forwards (in the direction of travel of the vehicle). The head and torso then rotate downwards on to the vehicle. This results in primary impact of the head against the vehicle surface, sometimes followed by a second impact of the head against the ground (Vilenius et al, 1994).

An Australian study aims to develop a method of reconstructing the primary impact between the head and the vehicle so as to quantify the peak force, and thereby acceleration, acting on the head (Vilenius et al, 1994). The model uses Newton's laws of force and acceleration. The information required includes the velocity of the head at impact with the vehicle (which is assumed to be the vehicle's speed), the location of the impact on head, and the dynamic deformation properties of both the head and the impacted surface (A-pillar, windshield, hood, fenders). The authors have a system of deriving the stiffness of the vehicle surface (e.g. A-pillar = 600kN/m) and the mass of the head is derived from the mass of the whole body using a regression equation.

Kong et al describe pedestrian-motor vehicle trauma as “a common injury, with distinct epidemiological features that may be useful in prevention strategies” (Kong et al, 1996). Their study of 273 pedestrian injuries at the Cedar-Sinai Medical Center in Los Angeles showed that ISS were successively higher with increasing age and significantly higher in the elderly. Extremity trauma was the most common, followed by head injuries. The elderly patients were more prone to chest and pelvic injuries and the children most often had femur fractures. The majority of these collisions occurred during nighttime hours, especially in adults. Half of the collisions occurred on the weekend, with the greatest number on Saturday. One-third of the collisions occurred during the months of October to December. The epidemiological risk factors they have found for children include density of housing, socioeconomic status, and types of clothing worn, among others. For the elderly, associated risks include slow walking speeds and decreased visual acuity.

All of the above studies describe methods on how to reconstruct injuries in MVC. However, these techniques should be able to study injury mechanisms in all type of injuries, with appropriate modifications. All injury events can be described by Haddon’s Matrix (Dembert, 1984). Any final report of an investigation involving injury should include this matrix. For example, in a fatal diving injury, phases will include pre-injury, injury, and post-injury. Factors will include diver, equipment, ancillary support, environment, and medical support (Dembert, 1984).

A British research group at the University of Liverpool has developed an intelligent, knowledge based computer program called MAIM (Merseyside Accident Information Model) (Davies et al, 1994). This program can collect and analyze detailed information on the causes of all injuries. Patients presented with questions on a PC are requested to select the most suitable answers relevant to their "accident" for a list of possible answers that determine the following question. On starting the program a unique number is automatically assigned to the event. The first question establishes that the injury was caused by an "accident". Questions then appear on the screen followed by a list of possible answers. The patient is requested to choose the answer most nearly describing an aspect of his or her injury event. After completion of the questionnaire, the PC presents a summary of the events occurring in the injury event, and the patient is asked to place them in the correct sequence to be confirmed by pressing return for each event. When events are not in the correct sequence the up and down arrows and return key change the order. Data stored in this form can be searched by the computer programs for common factors and correlations. The quality of information collected from patients in a clinical setting is believed to be more accurate and less biased than data obtained from employers (in industrial injuries for example) and it is possible to trace nearly all important injuries in a hospital based study (Dembert, 1994). For most injuries seen in the ER, MLAM can collect very detailed information in a form that can be searched for factors contributing to a number of injuries and for correlations between all the events and other components.

A search of the Internet reveals that there are several U.S. companies involved in designing injury reconstruction software. The first is the Calspan Corporation of Buffalo, NY. This is the company that has developed the software used by Dynamic Science, Inc. of Baltimore. This is a crash reconstruction firm that is working with the CIREN group. CIREN is a multi-center research program involving a collaboration of clinicians and engineers in academia, industry, and government pursuing in-depth studies of crashes, injuries, and treatments to improve processes and outcomes (www.umich.edu/~ciren). The 8 centers are: U. of Maryland, Baltimore, MD, U. of Medicine and Dentistry, NJ, Children's National Medical Center, Washington, DC, U. of Michigan, Ann Arbor, MI, William Lehman Injury Research Center, U. of Miami, FL, Harborview Medical Center, Seattle, WA, and San Diego County Trauma System, San Diego, CA, and Mercedes Benz of Alabama. CIREN's mission is to improve the prevention, treatment, and rehabilitation of MVC injuries and to reduce deaths, disabilities, and human and economic costs.

In terms of data collection, CIREN members take detailed information from the crash scene and trauma center to reconstruct the event and the injury. As described in several of the papers above, injury documentation involves capturing photographic and video images of the injuries at the trauma center to establish occupant contacts and movement within the vehicle. An inspection of the vehicle is essential in establishing occupant contacts in the car. Baseline measurements include bumper height, front and rear crush zone, wheelbase, and front and front and rear overhang, and interior intrusion (above web site). From this data, investigators analyze occupant kinematics and injury source determination. Also, a search of the University of Maryland, School of Medicine homepage revealed that this school currently has a research project titled "Epidemiology of Injury Patterns in MVCs" (SOM1.ab.umd.edu).

Finally, a 1993 Ph.D. thesis project by Dalkie at the U. of Manitoba designed a model to investigate road safety issues (Dalkie, 1993). Dalkie describes existing information programs (police-based, hospital-based, and In-depth collision investigation) with the intention of maximizing existing data sources. In designing the model, considerations included: appropriate analysis systems must be in place, an integrated systems approach should be implemented, system must be feasible and sustainable, and the model must have general applicability. Five options were considered, weighing the pros and cons of each. These being: 1) expand the standard police-based collision reporting program, 2) expand the hospital-based program to include police-reported collision information, 3) expand the program of in-depth collision investigations, 4) link existing information systems through creation of a single automated system describing specific incidents, and 5) integrate existing information programs through a coordinated analysis framework, without merging data describing specific incidents. Each option was considered with the above considerations, and the fifth option was chosen.

The thesis integrates information from current sources. The police based investigation programs generate data that include primarily factual information such as the time and location of the collision; the number of persons injured; the type of vehicles involved; and the type or configuration of the collision. The hospital based programs can be used to address issues related to the health-care-delivery system and the incidence of MVC injuries; evaluate measures designed to affect the frequency or distributions of injuries; or identify trends in MVC injuries which should be recognized and further examined.

The model involves 3 components: 1) a collision information system, 2) an injury information system, and 3) a system of in-depth collision investigation. The model considers the criteria that it must be able to maximize the use of existing data sources without requiring fundamental changes in the existing road-safety delivery system. The collision information system comes from the police reports that can provide general knowledge describing the frequency and nature of MVCs. The injury information system (hospital-based) gives information regarding detailed descriptive injury data. For in-depth collision investigation, Dalkie describes in detail the data and reference requirements, such as vehicle damage data, that need to be examined by an investigator.

This thesis provides a framework for an application at the local level. It provides a model for investigation to establish injury causation mechanisms using available data and personnel resources.

The literature search shows that injury analysis is important if the epidemiology is to be understood. The Americans, through CIREN, and Europeans have been investigating injury mechanisms with relative success. With the formation of the Alberta Center for Injury Control and Research, the investigation of injuries should be a priority in this province. By maximizing current resources, and applying methods used from other research, a project of this sort should prove beneficial in describing all injury events, and more importantly, provide insight on how these injuries can be prevented. If mechanisms can be understood, countermeasures can be devised.

2.2 General Biomechanics of Motor Vehicle Collision Injury

Injury mechanisms can be classified as either blunt, thermal, penetrating, or blast; all of which involve an energy transfer to tissue (ATLS, 1997)

2.2.1. Basic Assumptions of Energy Laws (Adapted from ATLS Instructor Manual, 1997)

1) Energy can only change form, not be created or destroyed
2) A body in motion or a body at rest tends to remain in the respective state unless acted upon by an outside force
3) Kinetic energy (KE) equals the mass (M) of an object in motion multiplied by the square of the velocity (V) and divided by two ($KE = (MxV^2)/2$)
4) Force (F) is equal to the mass times deceleration (acceleration) and mass times distance (d) ($Mxd = F = MxV$)
5) Injury depends on the amount and velocity of energy transmission, the surface area over which the energy is applied, and the elastic properties of the tissue to which the energy transfer is applied

6) Energy transfer can be considered as a shock wave (identical to a sound wave) that moves at various speeds through different media. Stress imparted on the tissue is dependant on:
   - the velocity of the material particles initiating the shock wave
   - the velocity of the waves in the tissue, and
   - the mass density of the tissue

   If the velocity of the energy exceeds the tolerance level of the tissue, tissue disruption occurs, thereby producing injury

2.2.2 Blunt Trauma (From ATLS, 1997)

Blunt trauma motor vehicle injury patterns include:

1. Vehicle impacts in which a patient is inside the vehicle
2. Pedestrian impact

Vehicular Impact

Motor vehicle collisions can be categorized further into:

- Collision between patient and vehicle, or patient and some object outside the vehicle if patient is ejected, and

- The collision between the patient's internal organs and the external framework of the body (organ compression).

Interaction between patient and vehicle occur from five possible crash scenarios- frontal, lateral, rear, angular (front or rear quarter), and rollover.

1. Occupant collision

A. Frontal Impact

A frontal impact is any collision with an object in front of the vehicle. Increasing the time of energy transfer from the vehicle to the occupants, and increasing the surface area over which the energy is transferred to, decreases the likely hood of occupants being injured.

Unrestrained occupants involved in a collision experience an event much like that of a crashing vehicle. As the vehicle comes to a stop, the passenger continues moving forward with the same initial velocity until something stops the occupant, usually the dashboard, windshield, steering wheel, or ground in the case of ejection. The kinetic energy from the initial motion is transformed into shock waves that the tissues must absorb.

When the vehicle strikes an object, the passenger may follow a down-and-under path, with the lower extremities being the first contact point of the body with the vehicle, with the knees and feet receiving the first energy transfer point. The forward motion of the torso onto the extremities may result in:

- Fracture-dislocation of the ankle
- Knee dislocation as the femur overrides the tibia and fibula
- Femur fracture
- Posterior dislocation of the femoral head from the acetabulum as the pelvis overrides the femur

The second component of the down-and-under path involves the forward motion of the torso into the steering column or dashboard. If the structure of the seat and the passenger position are such that the person's head is the lead point, the skull will crash into the windshield or the windshield frame. The cervical spine absorbs some of the initial energy while the chest and abdomen absorb energy from the impact on the steering column or dashboard. Depending on head position upon impact, the energy transfer may produce direct or shear forces to brain tissue, rotational, flexion, or extension forces to the cervical spine, as well as directional compressive forces to facial structures. Lacerations to soft tissues from broken components of the vehicle may also occur.

B. Lateral Impact

A Lateral impact is defined as any collision against the side of a vehicle that accelerates the occupant in the opposite direction of the impact. In addition to many of the injuries that also occur in a frontal collision, compression injuries to the torso and pelvis may occur. Internal injuries are related to the side of the vehicle on which the collision occurred, the position of the occupant relative to the collision (impact side or opposite side of impact), and the force of impact and time over which the force is applied (intrusion of the passenger cabin). Collisions occurring on the driver side of the vehicle with occupants sitting on this side generally result in patients with higher risk for left-sided injuries, including left rib fractures, left-sided pulmonary injury, spleen injury, and left sided skeletal fractures, including pelvic compression fractures. Passengers sitting on the right side of the vehicle may receive similar right-sided skeletal and thoracic injuries, with liver injuries being common.

The head may also rotate and laterally bend the neck as the torso is accelerated away from the side of the collision. Injury mechanisms include shear force, torque, and lateral compression and distinction. With sufficient rotation and torque, nerve root avulsion and brachial plexus injury can occur.

C. Rear Impact

In a rear collision, the vehicle as well as occupants are accelerated forward from the transfer of energy from the impact. The torso is accelerated forward along with the vehicle. If a headrest is not present, the head is not accelerated forward, but experiences a hyperextension. This stretches the supporting structures of the neck, resulting in whiplash. Fractures of the posterior elements of the cervical spine, eg, as laminar fractures, pedicle fractures, spinous fractures, may occur and are equally distributed through the cervical vertebrae. Fractures at multiple levels are common and are usually due to direct bony contact.

D. Quarter Panel Impact

Both front and rear quarter panel crashes result in a variety of frontal, rear, and lateral impact collision injury patterns.

E. Rollover

An unrestrained occupant may impact any part of the vehicle interior as well as being ejected from the vehicle. Injuries from this type of impact are generally more severe because of the multiple and violent nature of the motions the vehicle occupants experience, especially for the unrestrained.

F. Ejection

The likelihood of injury is 300% higher for an ejected occupant versus an occupant remaining in the vehicle during a collision. Injuries received during the actual ejection may be more severe than those may when the occupant contacts the ground.

2. Organ Collision

A. Compression Injury

Internal compression injuries occur when the anterior portion of the torso stops moving and the posterior portion and the internal organs continue their motion. The organs are then compressed from behind by the advancing posterior thoracoabdominal wall and the vertebral column, and in the front by the impacted anterior structures. Blunt myocardial injury is an example of this type of injury mechanism. This type of mechanism can occur in lung parenchyma or abdominal organs. The lungs and abdominal viscera represent a particular variation of this mechanism of injury and accentuate the principle that the state of the tissue at the time of energy transfer influences the tissue damage. During a collision, it is instinctive for an occupant to take a deep breath and hold it, closing the glottis. Compression of the thorax produces alveolar rupture with a resultant pneumothorax and/or tension pneumothorax. The increase in intraabdominal pressure may produce diaphragmatic rupture and translocation in intraabdominal organs into the thoracic cavity. Transient hepatic congestion with blood from this transient valsalva maneuver may cause the liver to burst when compression occurs. Similarly, small bowel rupture can occur if a closed loop is compressed between the vertebral column and an improperly worn seat belt.

Compression injuries of the brain may also occur since movement of the head associated with the application of a force through impact can be associated with sudden acceleration forces applied to the brain. This produces stress and deformation of the intracranial gray and white matter. Angular acceleration can also produce movement of the brain over the irregular surfaces of the internal bony calvarium, producing injury. Any axis in which the brain is accelerated can produce contra coup injury to the central nervous system tissue opposite to the point of impact. The accelerated brain also produces stress and stretch forces at critical junctions such as the brain and brainstem or spinal cord, and at the junction of brain parenchyma and meningeal membranes. Compression injuries also can occur from depressed skull fractures.

B. Deceleration Injury

These injuries occur as the stabilizing portion of an organ, such as the renal pedicle, ligamentum teres, or descending thoracic aorta, ceases forward motion with the torso while the moveable body part, such as the spleen, kidney, or heart and aortic arch, continue to move forward. Shear force is developed in the aorta by the continued forward motion of the aortic arch with respect to the stationary descending aorta. The distal aorta is anchored to the spine and decelerates more rapidly with the torso. The shear forces are greatest where the arch and stable descending aorta join at the ligamentum arteriosum. This mechanism is also applicable with the spleen and kidney at their pedicle junctions; with the liver as the right and left lobes decelerate around the ligamentum teres, resulting in a central hepatic laceration; and the skull, tearing vessels and causing space-occupying lesions.

C. Restraint Injuries

Seatbelts may not always eliminate injury, but can reduce the severity of its damage. If the seatbelt is not worn properly, it can also cause injury. For example, if worn above the anterior/superior iliac, the forward of the posterior abdominal wall and vertebral column traps the pancreas, liver, spleen, small bowel, duodenum or kidney against the belt in front. These organs can burst or lacerate. Hyperflexion over an incorrectly worn seatbelt can produce anterior compression fractures of the lumbar spine. During deceleration, the transfer of energy can be so great that clavicular fractures, blunt cardiac injury, and pneumothorax can occur.

D. Pedestrian Injury

The majority of pedestrians struck by vehicles sustain thoracic, head, and lower extremity (in that order) injuries. There are three impact phases during a pedestrian collision:

1. Vehicular bumper impact

Bumper height versus pedestrian height is an important determinant of what specific injury will occur to the pedestrian. Upright adult pedestrians first sustain impact with the front bumper against the legs and pelvis. Knee injuries are as common as pelvis injuries in this type of collision. In children, collision with the bumper often results in chest and abdominal injuries.

2. **Vehicular hood and windshield impact**

   Injuries associated with this segment of collision are torso and head injuries

3. **Ground Impact**

   As the pedestrian falls of the vehicle, head and spine injuries can result. As well, compression injuries may occur.

CHAPTER THREE

Methodology

3.1 Injury Prevention Program Development and Collaboration

The National Committee for Injury Prevention and Control (NCIPC) (1989) describe a coalition as an organization representing a variety of interest groups who come together to share resources and effect change. This included using data to define the local injury problem, collaborate with other agencies to design and develop programs based on these findings, implementing a combination of interventions that reflect modern injury control, and evaluating the programs achievement of process and outcome objectives (NCIPC) (1989); (Sharma, 1999).

The University of Alberta Injury Prevention Center (1993) designed a program development model in conjunction with a collaboration framework designed by Larry Cohen, Nancy Baer, and Pam Satterwhite of the Contra Costa County Health Department Prevention Program. This collaboration framework was suggested by the NCIPC (1989) for injury control groups working to implement injury prevention programs. These models were used in this study to develop a model of collaborative injury biomechanics analysis.

The following steps from the University of Alberta Injury Prevention Center model for program development were used in this study. All of these steps were implemented using the above mentioned collaboration framework:

1. **Gather and Analyze Data**
2. **Select Target Population**
3. **Identify, Select and Commit Agencies**
4. **Develop Protocols and Materials**
5. **Implement the program**
6. **Monitor and Support**
7. **Intervention Strategies**
8. **Evaluate and Revise**

Step 1-Gather and Analyze Data

This step in the model defines what the problem is, and how might data collection occur. It identifies who is being injured and what type of data needs to be collected

Step 2-Select a Target Population

This step of the model defines a target injury and population. The three most important criteria for deciding which injuries to prevent are severity of injury, frequency of the injury, and if there is an effective counter measure available. This step defines what type of injury should be studied, and why it should be studied.

Step 3-Identify, Select and Commit Agencies

According the U of A Injury Prevention Center (1993), a coalition of community agencies is the most powerful and far reaching tool to implement a program designed at studying and preventing injuries. The essential ingredient is the lead agency that takes responsibility for coordinating the program. This step in the model designates which groups might help in achieving the program objectives.

Step 4- Develop Protocols and Materials

Protocols refer to the instructions of who is going to do what for whom and how (Injury Prevention Center) (1993). This involves assigning tasks and what materials will need to be developed.

Step 5- Implement the program

This step of the model describes how the program will be launched. In this study, this would refer to the pilot study of the model.

Step 6- Monitor and Support

Monitoring the program is the responsibility of the lead agency and requires keeping in touch with the member organizations of the coalition. This includes giving encouragement, listening to problems, and offering suggestions. Monitoring the program means watching that planned activities are done.

Step 7-Intervention Strategies

This step of the model involves analyzing the injuries using Haddon's Matrix. Injury prevention strategies should be targeted at any cell of the matrix. Prevention strategies should focus on educational, engineering, enforcement, and economic techniques (Francescutti, 1997). This step considers which interventions are likely to be the most effective.

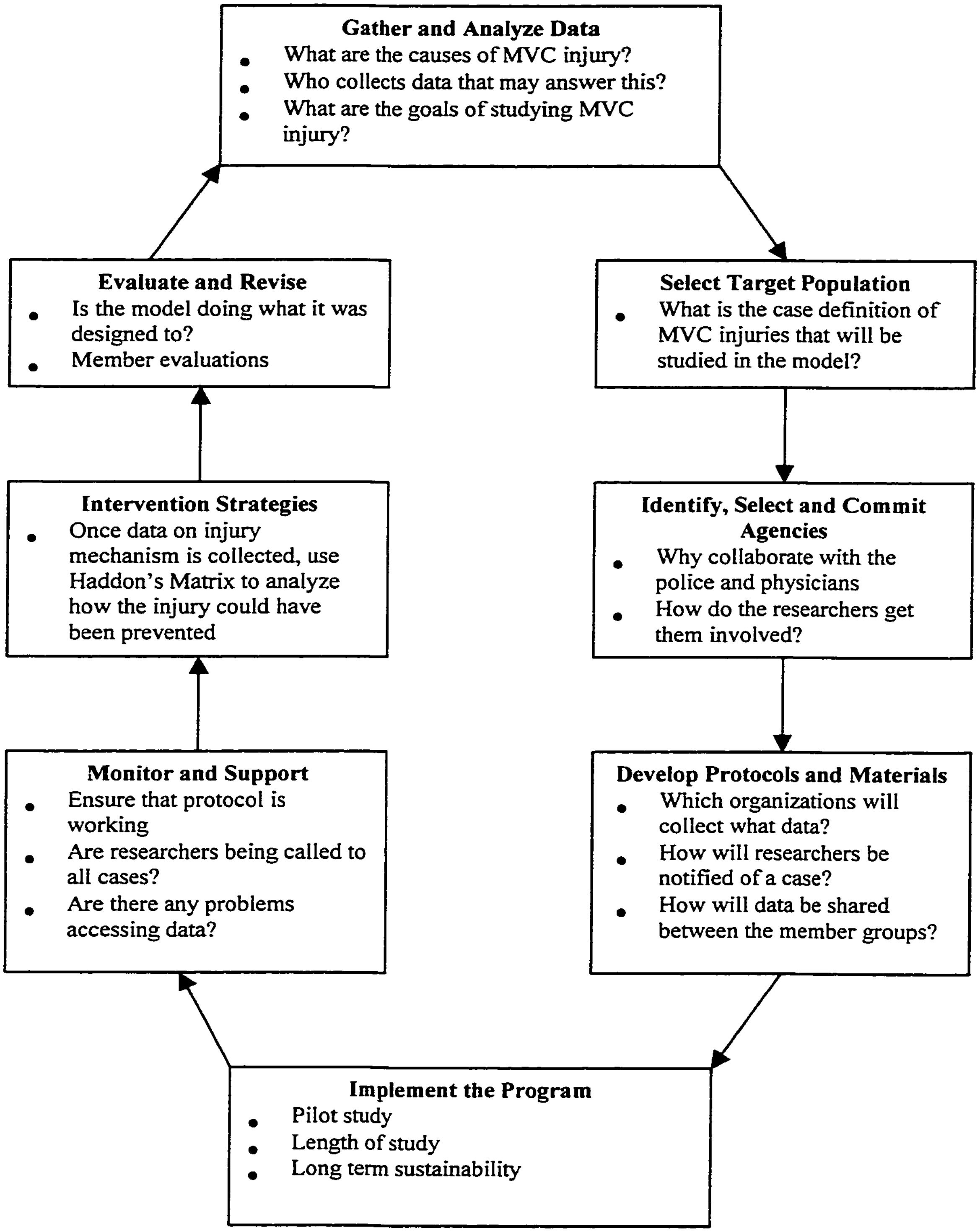
Step 8- Evaluate and Revise

Program evaluation is done to see if the program is doing what it was designed to do. This involves evaluating processes and outcomes, and seeing if protocols are occurring as planned.

3.1.1 Problem Definition-Analysis

The number of collisions in the province of Alberta is at epidemic proportions. In 1998, there were approximately 100,000 motor vehicle collisions. The statistics for the City of Edmonton are alarming. In 1998, 19,128 collisions occurred including 5, 927 injury collisions resulting in 8,756 injuries (Alberta Infrastructure, 1999). Twenty-four fatal collisions resulted in 24 fatalities. The statistics for collisions and injuries involving bicycles, motor cycles, and pedestrians are staggering. Injuries are predictable and preventable. An injury analysis team is an important component of an infrastructure to support injury surveillance activities that generate information about injury etiology. This information can be used to design prevention and control strategies that can reduce the burden of illness associated with traumatic injuries. The Investigator will provide leadership and coordination in the investigation and maintenance of injury-related data. As a result, the data may be used to prevent or decrease the severity of future injuries. The objective of this model is to maximize the use of rich data already being collected by police, hospital, and EMS. The goal of the model is to understand the biomechanics of injury so that injury prevention strategies can be implemented. The goal of this study is to design an injury analysis team model that can collaborate with police, trauma physicians, EMS, the medical examiner's office and injury epidemiologists. This will be done by using University of Alberta Injury Prevention Center's program development model in conjunction with Cohen et al's collaboration framework and the Dalkie thesis as underlying models. Thirty injuries will be studied to design and refine investigation protocol.

Figure 3.1 Program Development Conceptual Framework (Adapted from University of Alberta Injury Prevention Center, 1993)



Gather and Analyze Data

- What are the causes of MVC injury?
- Who collects data that may answer this?
- What are the goals of studying MVC injury?

Select Target Population

- What is the case definition of MVC injuries that will be studied in the model?

Identify, Select and Commit Agencies

- Why collaborate with the police and physicians
- How do the researchers get them involved?

Develop Protocols and Materials

- Which organizations will collect what data?
- How will researchers be notified of a case?
- How will data be shared between the member groups?

Implement the Program

- Pilot study
- Length of study
- Long term sustainability

Monitor and Support

- Ensure that protocol is working
- Are researchers being called to all cases?
- Are there any problems accessing data?

Intervention Strategies

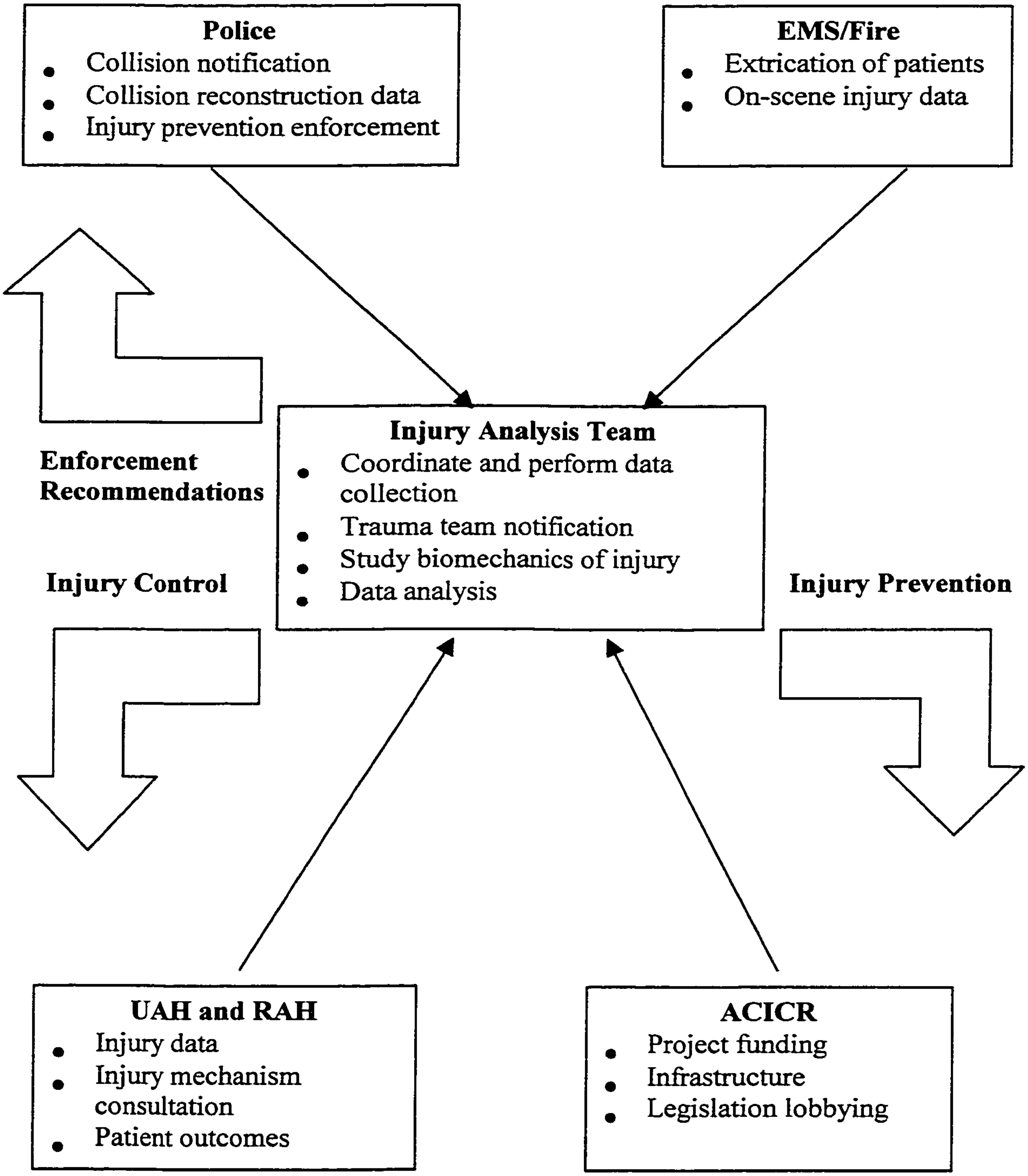
- Once data on injury mechanism is collected, use Haddon's Matrix to analyze how the injury could have been prevented

Evaluate and Revise

- Is the model doing what it was designed to?
- Member evaluations

3.1.2. Program Design

Figure 3.2-Proposed Model of Collaborative Injury Biomechanics Analysis and Prevention Implementation



This model is specifically targeting the study of serious motor vehicle collision injuries. In the City of Edmonton, the Edmonton Police Service, Traffic Section, only respond to collisions involving serious injury as determined by the first patrol unit on scene. A serious injury is defined as a pedestrian or vehicle occupant who sustained injury requiring emergency medical services and transportation to a trauma center. The EPS, Traffic Section, has members with Level 3 and Level 4 collision reconstruction training. This level of training allows for in-depth collision reconstruction. By collaborating with police, in-depth collision information such as vehicle compartment intrusions, vehicle speeds, angle of impact, driver and passenger position data, seatbelt use, type of collision, driver and pedestrian data, and vehicle access, is obtainable for research purposes.

As in Dalkie's study, the following design criteria were considered for this Albertan model:

1. Use of existing data sources must be maximized.
2. Appropriate analysis systems must be in place.
3. The model must be feasible and sustainable.
4. The model must have general applicability.

1. Use of existing data sources must be maximized.

By collaborating with the police, an injury analysis team is able to access in-depth collision data (i.e. factors that caused a particular injury, such as door intrusion into the occupant compartment) that is being collected by them at injury resulting MVC investigations. This data source is already in place and does not require additional funding to access by the researchers. As collaborators in this model, the police expert collision reconstructionists agreed to share any data that an injury analysis team would require to reconstruct an injury. This would include analysis of vehicle speeds prior to impact, collision angles, depths of intrusions, occupant and pedestrian locations, occupant seatbelt use, scene photographs, and any other data pertaining to injury causation factors. However, police are not always concerned with why the injury occurred, rather, with why the collision occurred. In addition to collaborating with police, an injury analysis team would require collision and biomechanics reconstruction training in order to perform in-depth injury analysis.

By collaborating with emergency physicians and trauma surgeons, an injury analysis team has access to detailed patient injuries, medical interventions performed and patient outcomes. This data is already collected by the two hospitals participating in this study, so no addition expenditure of resources is required to access this data source.

EMS data, including extrication details, patient condition at the scene, and stabilization procedures, are already routinely collected, so once again, no addition expenditure of resources is required to access this data source.

2. Appropriate analysis systems must be in place.

As mentioned above, the police already perform collision analysis. In this model, the expert collision reconstructionists have agreed to share any of their analysis that an injury analysis team would require. The Chief of Staff at the UAH and RAH emergency departments agreed that their trauma teams would share any injury data required by an injury analysis team, therefore satisfying this criteria as well. Looking at patient admission forms to the ER, the researchers found that in many cases, “motor vehicle accident” was listed as the cause of injury. It is a goal of the model to be able to electronically transfer injury causation data to the trauma room as soon as the injury analysis team arrives at the scene. This will allow the trauma physicians to have an idea of the type of injuries to expect from digital photos of the collision scene as well as from background knowledge on motor vehicle collision injury biomechanics.

3. The model must be feasible and sustainable.

The development process of this model showed that this model is feasible. Police and trauma physicians/surgeons were willing participants in this injury prevention research. The researchers found no difficulties accessing injury data from the trauma centers. Police were always willing to share any data required by the injury analysis team, and in many cases expanded their investigation to facilitate the researchers.

Through injury control infrastructure, the Alberta Center for Injury Control and Research, this model is sustainable through funding from this center. Alberta Health and Wellness has mandated the ACICR to maintain a strengthened and coordinated approach to injury control in the Province of Alberta (ACICR, 1998). The ACICR would be able to house an injury analysis team, providing office space and any other infrastructure that would be required. It would also provide a voice to legislators to implement injury prevention measures deemed necessary by the injury analysis team research.

4. The model must have general applicability.

This model can be applied to any type of MVC injury investigation. What the model shows is that collaboration, when mutually beneficial, allows the sharing of data between various agencies. This data, when analyzed and disseminated, can be directed in designing injury prevention programs.

3.1.3 Collaboration Framework

Research Methods

The NCIPC (1989) stated that "involving the community and getting to know its resources is a key step in getting injury prevention off the ground". The NCIPC text (1989) identifies possible collaborators in injury prevention, including police departments, hospitals, emergency medical services, epidemiologists, and schools of public health. A goal of this study was to design a model with researchers collaborating with other organizations in order to study how MVC injuries occur. Larry Cohen, Nancy Baer, and Pam Satterwhite of the Contra Costa County Health Department Prevention Program developed an effective coalition building framework, recommended by the NCIPC (1989) for establishing coalitions. This coalition-building framework arose out of frustration due to a lack of communication with colleagues establishing a forum for coordinating educational services and brainstorming solutions to common problems (NCIPC) (1989). From this frustration, a group of service providers from California's Contra Costa County formed the Abuse Prevention Training Committee in 1982. From these experiences, Cohen, Baer, and Satterwhite published *"Developing Effective Coaliitons: An Eight Step Guide".* An updated version of the article was published in the

"Injury Awareness and Prevention Center News," Vol. 4, No. 10, Alberta, Canada, December 1991 and was used as a framework in this study to establish collaborative injury analysis. The paper outlined general principles for initiating and maintaining effective coalitions that emerged from the Contra Costa Health Services Department Prevention Program's ten year experience as well as from a review of material on coalition building (Cohen, Baer, Satterwhite, 1991).

Cohen, Baer, and Satterwhite (1991) define a coalition as " a union of people and organizations working to influence outcomes on a specific problem". For this study, the collaborators were a "network", defined as "...(a) group formed primarily for the purpose of resource and information sharing" (Cohen, Baer, Satterwhite, 1991). In this network, the researchers were the "lead agency", which "convened the coalition and assumed responsibility for its operation" (Cohen, Baer, Satterwhite, 1991).

"Member organizations" included the Royal Alexandra Hospital Emergency Department and University of Alberta Hospital Emergency Department, Edmonton Police Service, Traffic Section, Royal Canadian Mounted Police (Sherwood Park Detachment), Emergency Medical Services, and Office of the Chief Medical Examiner.

Applicable Advantages of Coalitions (Cohen, Baer, Satterwhite, 1991):

1. Coalitions can conserve resources:

In this model, resource sharing is an important component. The police possess the legal authority to conduct vehicle seizures and investigations of MVCs. The police also have sophisticated equipment for photographing and digitally mapping and measuring a collision scene, as well as trained collision reconstructionists to conduct investigations. In joining the coalition, police agreed that the above would be at the disposal of the researchers for the purposes of studying injuries. In return, the researchers would disseminate injury data back to the police once the study progressed in order for police to target needed areas of injury prevention that they could enforce.

The trauma centers agreed to give the researchers information regarding injuries directly from the attending physician thus allowing rapid access to information, as well as accurate information. In return, the researchers would describe the crash scenario to the physician, which in some cases helped guide the physician during clinical investigation.

2. Coalitions provide a forum for sharing information:

This model considers the fact that the member organizations each collect data pertaining to MVCs. No one member can solve the etiology of the injuries without access to information that the other members are gathering. As such, a coalition allows for the sharing of knowledge in a timely fashion with the collective goal of understanding how the injuries are occurring.

Eight Steps to Building an Effective Coalition (Cohen, Baer, Satterwhite, 1991):

1. **Analyze the program's objectives and determine whether to form a coalition.**
2. **Recruit the right people.**
3. **Devise a set of preliminary objectives and activities.**

4. **Convene the coalition.**
5. **Anticipate the necessary resources.**
6. **Define elements of a successful coalition structure.**
7. **Maintain coalition vitality.**
8. **Make improvements through evaluation.**

Step 1-Analyze the program's objectives and determine whether to form a coalition.

The objective of this thesis was to design a model of an injury analysis team that collaborates with police, trauma physicians, EMS, the medical examiner's office and injury epidemiologists in order to study the mechanics of injury resulting from MVCs and to use this knowledge in devising injury prevention strategies. The problem definition described above describes why this objective is important. The researchers, based on findings described by Dalkie, decided that a collaboration was the most efficient method to collect accurate and timely data on the mechanisms of injury resulting from MVCs. Also, the cost saving benefits of working with these organizations necessitated the forming of this coalition. The researchers did not have to pay for any of the information received, and the remuneration for the traffic investigators and physicians was already covered by their respective employers.

Step 2-Recruit the right people.

The researchers approached the police because they have authorized access to MVC scenes and because members of Traffic Section are trained in collision reconstruction and have the equipment required for investigating crashes. The trauma centers and emergency physicians were approached because they are the people whom treat the injuries and have first hand knowledge of what the injuries are. According to the NCIPC (1989), going directly to the source of injury data, such as police, EMS, and emergency physicians, can reveal what is systematically left off written records or point out what is left off of written records during busy periods. The medical examiner's office was approached in order to collect injury data in cases where there was a fatality.

Step 3-Devise a set of preliminary objectives and activities.

The preliminary objective of this study was organize the coalition, and to conduct a pilot study to implement the model. The police stated that they wanted to be a member of the coalition so that they could be guided by the researchers in targeting enforcement towards injury prevention. The objective of the emergency physicians was to have accurate information obtained from the scene so that they would have an idea of what injuries to expect, which would result in faster treatment of the patients, strengthening secondary injury prevention. All member organizations agreed that MVC injury is a major public health problem, and that studying the mechanism of injury is crucial to designing injury prevention strategies.

Member Activities

The police stated that participating in the research would be a second priority to them. Their first priority would be to proceed with their regular duties, investigating the collision occurred and who was at fault. They also emphasized that they did not want the research to interfere with their investigation. As the pilot study progressed, the atmosphere between the collision investigators and the researchers was one of cooperation. The police expressed no concerns of the researchers hindering their investigation. Police activities in the research included:

- Allowing researchers access to the scene and vehicles.
- Measuring the scene and vehicle damage.
- Photographing the vehicles and scene.
- Calculating vehicle speeds and angles of impact.

In conducting an investigation at the scene, the researchers would:

- Assist the police in making scene measurements when requested.
- Identify to the police which patient was riding in which vehicle, by accessing this information from the patient hospital admission form.

The emergency physicians would:

- Give the researchers data on precise patient injuries.

The researchers would:

- Give the emergency physicians data on what type of crash occurred.
- Give the emergency physicians information on speed of vehicles.
- Present photos of the scene to emergency physicians when available.

Step 4-Convene the coalition.

This step described by Cohen, Baer, and Satterwhite was attempted for the pilot study, but the member organizations met with the lead agency individually, and not collectively. The researchers had attempted to organize a meeting in which the emergency physicians and EPS Traffic Section members would meet to discuss the project. However, due to the shift work nature of emergency medicine and policing, only a few physicians showed up at the meeting, and no police officers. In the future however, once the program is fully implemented and an injury investigator is chosen by the lead agency, a monthly (or every second month) meeting should be held to review cases in order to study how the injury occurred. This would include the injury investigator, police reconstructionist, emergency physicians, and trauma surgeons. Having all the experts meeting together will allow for discussion of the specific cases pertaining to how the injury occurred from different aspects of investigation. It will be the responsibility of the lead agency to organize the timing and location of the meetings. The lead agency will also be responsible for clerical demands such as taking minutes of the meetings, planning agendas, drafting press releases, making contacts with local media reporters, coordinating media campaigns, and directing fund raising.

In recruiting the Edmonton Police Service, the researchers had a meeting with the Superintendent and Staff Sergeant of Traffic Section. After discussing the injury problem with the police, the police agreed that studying the mechanisms of injury was important and would help them in planning enforcement campaigns. As such, they fully supported the coalition.

The researchers gave a presentation on the project at a staff meeting of the Royal Canadian Mounted Police, Sherwood Park Detachment. At the end of the meeting, the RCMP also agreed to join the coalition to study injury mechanisms.

The researchers met individually with the Chiefs of Staff of the UAH and RAH Emergency Departments. The Chiefs also agreed that studying the mechanisms of MVC injury were important in understanding how to prevent these injuries from occurring. The Chiefs agreed to have their emergency physicians give injury data to the researchers when a case patient was seen in the respective emergency department.

The researchers, who had a previous working relationship with EMS in Edmonton and Strathcona County, met with the respective directors and also received support from them to join the coalition. The directors agreed to have their personnel who were on scene to give the researchers any injury data that they required. Finally, a meeting was also held with the Chief Medical Examiner. He agreed to have his staff give injury data to the researchers when a MVC fatality occurred in Edmonton or Strathcona County.

Step 5-Anticipate the necessary resources.

For the most part, all of the necessary resources for this pilot study were already in place. There were no resources required from the police or emergency physicians other than their technical expertise. The police did provide photographs at no charge to the researchers when requested.

The researchers were required to purchase a laptop computer for the pilot study (Toshiba Satellite 2060CDS, $2000 Canadian) and a digital camera (Nikon 950, $1300 Canadian). The University of Alberta provided office supplies. For the pilot study, the researchers used their own vehicles to arrive at crash scenes and at the hospitals.

Step 6-Define elements of a successful coalition structure.

A) Coalition life expectancy.

From October 1999 to May 2000, the researchers attended 23 motor vehicle collisions. Because of the criteria that only cases attended to by the Traffic Section and reconstructionists of the RCMP, the volume of cases was not large. At the beginning of the pilot study, a time frame of seven months was chosen by the researchers to conduct the implementation. A life expectancy of the program was not discussed with any of the member organizations. However, it was the intention of the researchers to have this as a long-term relationship with the other members.

B) Decision making methods.

The purpose of the lead agency was to coordinate injury analysis between the member organizations. This is not a classic collaboration. Instead, the researchers acted more as a hub of information. Crash data obtained at the scene would be given to the researchers and passed on to the physicians. Injury data from the physicians would be given to the researchers and passed on to the police for injury prevention purposes. The lead agency can only make recommendations for injury prevention to the member organizations. It is up to the member organizations if they will accept and implement recommendations. For example, if it is recommended by the lead agency to police that speed enforcement on a certain road may help decrease the number of injuries there, it will be up to the Traffic Section administration if they will have their members increase enforcement in this area. Also, the lead agency can only give information, verbally or electronically, to the emergency physicians. It is at the discretion of the physicians what they will do with that information.

In terms of making policy recommendations and writing of scientific papers, these will be coordinated by the lead agency, with consulting the member organizations.

Step 7-Maintain coalition vitality.

The network was formed with the purpose of information sharing. In ensuring that the coalition remained feasible, timely and accurate data collection had to remain a priority. Case notification to the researchers was the responsibility of the police. Police administration informed Sergeants that they were to page the researchers in the event of an injury collision that they were going to investigate. In the beginning of the pilot study, sergeants often times forgot to page the researchers, or could not find the researchers pager number. To alleviate this, Traffic Section administration had the researcher's pager number printed on the dashboard of each Traffic Section police car. The researchers read the newspaper and watched the nightly news for injury MVCs and informed the Traffic Section administration in cases when they were not being called. The researches missed three cases due to illness, and another four cases that were known because police did not call them. Two cases in Strathcona County were missed because the RCMP paged the researchers near the end of their investigation, which did not allow enough time for the researchers to arrive.

Celebrating and sharing success.

Cohen, Baer, and Satterwhite state that celebrating and giving credit to coalition members for success is important for maintaining morale and a sense that the coalition is playing a vital role in addressing the problem. This research was featured on the front page of the City Section of the Edmonton Journal (March 6, 2000). It was also the cover story of the University of Alberta Faculty of Medicine and Dentistry Newsletter (March 2000). An article on the research, authored by Heather Kent, is in press and will be published in July in the Canadian Medical Association Journal. When the journalists interviewed the researchers, the researchers emphasized that the member organizations deserved credit for making this concept a reality.

Step 8-Make improvements through evaluation.

In evaluating the model, the researchers considered the following:

1) Use of existing data sources must be maximized.
2) The model must have general applicability
3) Appropriate analysis systems must be in place.
4) The model must be feasible and sustainable.

Pros and cons in Chapter Five, "Conclusions and Future Directions" evaluate these criteria.

The main problem, discussed above, was the issue of the researchers not being called to crashes, or being called to late to scenes. Informing police administration alleviated these issues.

Each member organization will have to evaluate if participation in the coalition is achieving their objectives. For example, police will have to look at their own statistics of enforcement type, volume and location, prior to recommendations made by the researchers and after. Although a change in injury rate may appear, epidemiological studies will be required to confirm a cause and effect relationship.

The Chiefs of Staff at UAH and RAH will have to conduct an evaluation amongst emergency physicians as to whether they feel that the patient and physician are benefiting from receiving information about the crash from the researchers. They will also have to evaluate if discussing cases with the researchers after the patient arrives interferes with the physician's regular duties.

3.1.4 Implementation

Once all of the above organizations were willing to collaborate in the model design, the researches approached the University of Alberta Health Research Ethics Board for permission to conduct a study that would allow the implementation of the model. It was proposed that 30 MVC injury patients involved in collisions investigated by the EPS, Traffic Section or Sherwood Park Detachment R.C.M.P., with patients transported to either the RAH or UAH by EMS, would be included in the study. Ethics approval was granted, and the study commenced from October 1999 to May 2000.

Study Objectives:

1) To develop a model for investigating injuries resulting from motor vehicle collisions in collaboration with police, emergency medical services, trauma physicians, and the medical examiners office.

Case Definition:

Subjects included in this model development pilot study were those involved in motor vehicle collisions in Edmonton, Sherwood Park, or Strathcona County, Alberta. All persons injured, including drivers, passengers, and pedestrians were studied. Those collisions involving fatalities or injuries and attended by the Edmonton Police Service, Traffic Section, or Sherwood Park Royal Canadian Mounted Police, and the researcher were studied.

To be included in the study, patient injuries must have required care by pre-hospital emergency medical services and transportation to the Emergency Departments of either the University of Alberta Hospital or Royal Alexandra Hospital by EMS. In the event of a serious motor vehicle collision causing injury in Edmonton, police patrol units notified the EPS Traffic Section. Once the traffic section had been notified, they notified the researchers who then proceeded to the scene of the collision.

Time Frame: October 1999-May 2000

Study Design: Case Series

This descriptive study integrated existing information programs through a coordinated analysis framework. The researchers combined data collected by police, RCMP, EMS, hospitals, coroner, and researchers, into a single analysis.

Sensitivity and Specificity:

Sensitivity is the ability of a data collection system to include all of the cases of a particular injury (MVC injuries in this case). Specificity is the ability of the system to exclude other phenomena that may be mistaken for the one being studied (NCIPC) (1989). In this model, the researchers only wanted to study serious MVC injuries, i.e., those requiring EMS and transport to a trauma center. Since the EPS Traffic Section only responds to injury MVCs, the researchers decided this was the best method of capturing the serious MVC injuries. However, a short coming of this data collection system was that in some crashes which may not seem to cause serious injury and not investigated by the traffic section, patient injuries may prove to be critical after investigation by a physician. The researchers will miss these types of cases. The data collection system is sensitive because only MVC injuries are being studied, and these types of acute injuries will be evident in the clinical investigation.

Reliability:

The researchers modified the data collection forms designed by Dalkie in order to collect data on how the injury occurred. The forms were changed because Dalkie developed a model to investigate basic road safety issues so that the incidence and severity of MVCs may be reduced (Dalkie, 1993). Dalkie applied his model to investigate the introduction of mandatory seat-belt-use legislation and the introduction of motor cycle helmet-use legislation in Manitoba. The researchers in this model were only concerned about the mechanics of injury and thus modified Dalkie's forms accordingly to capture vehicle damage data. Dalkie has shown that working with police and hospitals are the best method for capturing crash and injury data. Since the researchers were working with three different crews from the EPS, the issue of reliability arose. It was an observation of the researchers that each traffic crew conducted investigations differently. One crew in particular was content on measuring the entire scene, including vehicle intrusions. This data was critical to the study. Another crew, however, was more concerned about clearing the scene. This issue of reliability of the data collection system necessitates the fact that the researchers require training in collision reconstruction in order to have a reliable, and consistent, data collection system.

Variables

(Note: * Collected by Researchers, + Collected by Police, -Collected by EMS)

Primary Police Data (Level 3 or 4 Investigation) included (Adapted from Dalkie, 1993):

- 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, 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 (*+));
- Vehicle data (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, (*));
- Pedestrian data (age, sex, and action (*,+)), and
- Interpretive collision data (contributing factors to the collision and first or second harmful events (*+)).
- Assessment of the principal direction of force (+);
- Extent of vehicular crush (+);
- Intrusion into the occupant compartment (+);
- Estimated change in velocity during violent phase of collision (+);
- Type and damage to the available restraint system (*,+);
- The seat position of the injured occupant (*,+);
- Seat back and head restraint data (*,+); and
- Vehicle mechanical inspection (*,+)

Hospital data included (Adapted from Dalkie, 1993):

- Hospital of admission (*-))
- Time of admission (*)
- Hospital identification number (*)
- Trauma physician (*)
- Details of injured person (age, sex (*))
- Details of injury (*-); and
- Details medical procedures performed (*)

Data for the two components were merged into a single file.

The following criterion was used to investigate serious motor vehicle collision injuries occurring in the City of Edmonton and Strathcona County with the cooperation of the EPS and RCMP. The investigators:

- Arrived at the scene of a collision involving injury, which was investigated by the EPS, Traffic Section, or Sherwood Park RCMP. Researchers were paged in the event of a serious collision and arrived at the scene as soon as possible, obeying all traffic laws.
- Attended the collision investigation with the police
- Assisted the police in such tasks as vehicle and road measurements
- Completed modified forms developed by Dr. Dalkie documenting environmental and vehicular at the scene of the collision (initiated by the researchers at the scene and completed at the hospital)
- Inspected all vehicles involved in the collision along with the police as soon as police began their investigation of an injury involving collision.
- Inspected all hospital charts of injured patients, detailing injuries sustained and medical procedures performed. Estimates were then made to identify the probable injury sources and mechanisms; and
- For each case studied, a case narrative was completed, providing details of how the injury likely occurred. A scene diagram illustrated the vehicle kinematics. Photographs of the scene, vehicles, and injuries were used for documentation and presentation of analysis and conclusion as to possible injury prevention measures.

Primary data sources were police expert collision reconstructionists, and emergency physicians. Secondary data sources were police reports, which included witness statements.

Verification

The researchers collected the scene data with police. However the researchers also read the police reports which contained witness and driver statements. The researchers did not verify these statements, so the validity of these statements comes into question. Driver statements may not be accurate because the driver may be trying to protect his or her own interests. Therefore, the statements made by drivers should be read with caution, and the primary data source, the actual scene investigation and collision reconstruction using scientific methods, should be relied upon as the truth. There was not a need to verify the injury data because the information came directly from the physician during the clinical investigation, which included diagnostic imaging tests, X-rays, etc.

Analysis

Analysis involved describing what factors likely caused patient injuries and how they could have been prevented using Haddon's Matrix, as well as descriptive statistics of the cases involved. For each case, the patient injuries were reported using the Abbreviated Injury Scale, with an estimate of the Injury Severity Score. In cases where injury codes had a 9 after the decimal place of the code, the reported ISS will be lower than the actual ISS because the use of a 9 after the decimal place is an indication of a general injury, and not a specific one.

A Microsoft Access database was built for future in-depth statistical analysis.

Haddon's Matrix

Epidemiology is the study of the distribution and determinants of health-related events in a defined population and its application to the control of events (Last, 1990). An injury is damage to an organism (host) and is defined by the following two factors (Barss, Smith, Baker, Mohan, 1998):

- Damage occurs rapidly and its effects are usually immediately apparent
- The causative agent is energy or an agent that disrupts with normal energy exchanges in the body.

An injury is similar in etiology to other diseases, except that exposure to energy occurs over a very short period of time. As such, injuries can be analyzed according to the same epidemiological principles as other diseases, with attention to the host, agent, and environment (Barss, Smith, Baker, Mohan, 1998). Host is the person who is injured, with characteristics including age, physical health, level of safety knowledge and habits, which all can effect injury severity. The agent, in this case, the vehicle, is the object that transfers energy, resulting in the injury. The environment encompasses the physical, social, and economic factors that surround the injury (Sharma, 1999).

William Haddon, an engineer, physician, and epidemiologist proposed a nine-cell matrix for analyzing injury events. The matrix divides an injury into three phases-the pre-event, event, and post-event. The pre-event determines whether a crash will occur. Analyzing event factors during the crash functions to reduce the severity or eliminate the injury from occurring. Post-event factors contribute to the outcome of the patient once the injury has occurred (Barss, Smith, Baker, Mohan, 1998). Haddon's Matrix analyzes each of these events in relation to the host, agent, and environment in order to identify appropriate points of intervention so that the injury may have been eliminated, or reduced in severity.

For this study, the researchers applied a Haddon's Matrix to each case in order to analyze where interventions may have prevented or reduced the severity of the injury. Although there are many prevention strategies, the methods used in this study will be considering the ten counter measures proposed by Haddon (Barss, Smith, Baker, Mohan, 1998). The 10 counter measures are:

1. Prevent the creation of the hazard. (Example-stop the manufacture of motor cycles)
2. Reduce amount of the hazard. (Example-reduce speed limits)
3. Prevent inappropriate release of the hazard. (Example-lower vehicle power)
4. Modify rate or spatial distribution. (Example-hydraulic bumpers on vehicles)
5. Separate release of the hazard in time or space. (Example-install pedestrian sidewalks)
6. Put a barrier between the hazard and people at risk. (Example-install guard rails between busy roads and sidewalks)

7. Change basic nature of the hazard. (Example-make dashboards smooth instead of sharp)
8. Increase resistance of people to the hazard. (Example-prevent fractures due to weak bones and osteoporosis by regular exercise or estrogen intake)
9. Begin to counter damage already done. (Example-rapid rescue and resuscitation of trauma victims)
10. Stabilization, definitive care, and rehabilitation. (Example-rapid availability of trauma care systems)

CHAPTER FOUR

Implementation: Trial Results and Discussion

4.1 Introduction

The proposal for designing and implementing an injury analysis team arose in the summer of 1998. Support was sought from the Chief of Staff of the Emergency Departments of the University of Alberta Hospital and Royal Alexandra Hospital, Superintendent of the Edmonton Police, Traffic Section, and Director of the Edmonton Emergency Medical Services, and Office of the Chief Medical Examiner. Support from the Sherwood Park Royal Canadian Mounted Police, and Sherwood Park Emergency Medical Services was sought and received in February of 2000. All of the above organizations involved agreed that there was a need for injury analysis considering the fact that injuries are a major problem in this province. The police were enthusiastic about collaborating with the researchers because it would allow the Traffic Section to target their enforcement to decrease motor vehicle collision injuries. Enforcement is an integral part of the injury control model for targeting injury prevention. Ethics approval was received from the University of Alberta Health Research Ethics Board in September of 1999 and the project was officially initiated at this time.

In the initial stages of the study, the researchers went on regular ride-alongs with members of the EPS Traffic Section in order to establish a working relationship with the members and expert collision reconstructionists. In the event the researchers were not on a ride-along, the EPS paged the researchers after the patrol unit first to arrive on scene contacted them. If the patrol unit determined that the collision was serious and caused injury, the Traffic Section was called. This was the criterion for cases to be included in this study.

For each case studied, a collision summary, similar to *Accident Investigation Quarterly* magazine format, was written to describe the details of the collision, along with the corresponding injuries (Accident Investigation Quarterly, Winter 1998). The collision summary will not describe the social issues of the crash, but rather, objectively describe the collision and how it resulted in injury.

4.2 Case 1-Honda Accord vs. Pedestrian

4.2.1 Collision summary:

On a clear night of November 23, 1999, at 19:24, a 51-year-old male driver of a 1984 Honda Accord was travelling southbound on a downtown inner city street. As the 1984 Honda was leaving an intersection, a 55-year-old female pedestrian was walking northbound in the driver's lane near the west side curb. This is a two way street, with one lane of traffic flowing in opposite directions. According to the driver as stated in the police report, the Honda approached the pedestrian at a driver-estimated speed of 25 kilometers per hour. The pedestrian suddenly walked into the path of the vehicle and was stuck the on the left side of the body. Contact occurred on the front passenger side of the vehicle. The pedestrian rolled onto the hood, and then rolled off of the right quarter panel onto the ground. There was no contact with the windshield as there was no evidence of dirt on the windshield being shifted nor was there any damage to the glass. An estimate of vehicle speed was not possible because the tires of the vehicle did not leave a skid mark on the road. As such, the police were not able to perform a skid test for vehicle speed determination. The driver ran two blocks the Police Headquarters to have EMS dispatched to the scene. Pedestrian was transported to RAH.

Injuries sustained were typical of those described in the literature for this type of crash. (ATLS, 1997).

4.2.2 Injuries

1. Pedestrian:

Table 4.1-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Subdural bilateral facial fractures	250400.1	Head/Neck	1	1
Bilateral femur fractures	851800.3	Extremities	3	9 ISS=10

4.2.3 Haddon's Matrix

Figure 4.1-Haddon's Matrix

Phase **Factor**

	Host	Vehicle	Environment
Pre-event	• Pedestrian intoxication	• Brakes in working order	• No pedestrian overpass • No sidewalk fencing • Poor lighting
Event	• Elder pedestrian • Osteoporosis	• Low bumper height • Driver wearing safety belt	• Asphalt
Post-event	• Elder age • Poor physical condition	• Acceptable tire tread depth for stopping	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.2.4 Injury Prevention Measures:

1. Primary Prevention:

The location this collision occurred in is one frequented by many bar and liquor store patrons. It is also the scene of past car-pedestrian collisions. Primary injury prevention in this neighborhood is an urban planning issue. Engineering methods shown to be effective in reducing car-pedestrian collisions include better illumination of roadways where car-pedestrian collisions are likely to occur (Accident Investigation Quarterly, Winter 1998). Also, wire fencing on the sidewalks separating pedestrians from vehicles will reduce the possibility of pedestrians crossing at locations other than at a proper crosswalk. As well, engineers may consider a pedestrian overpass in this location.

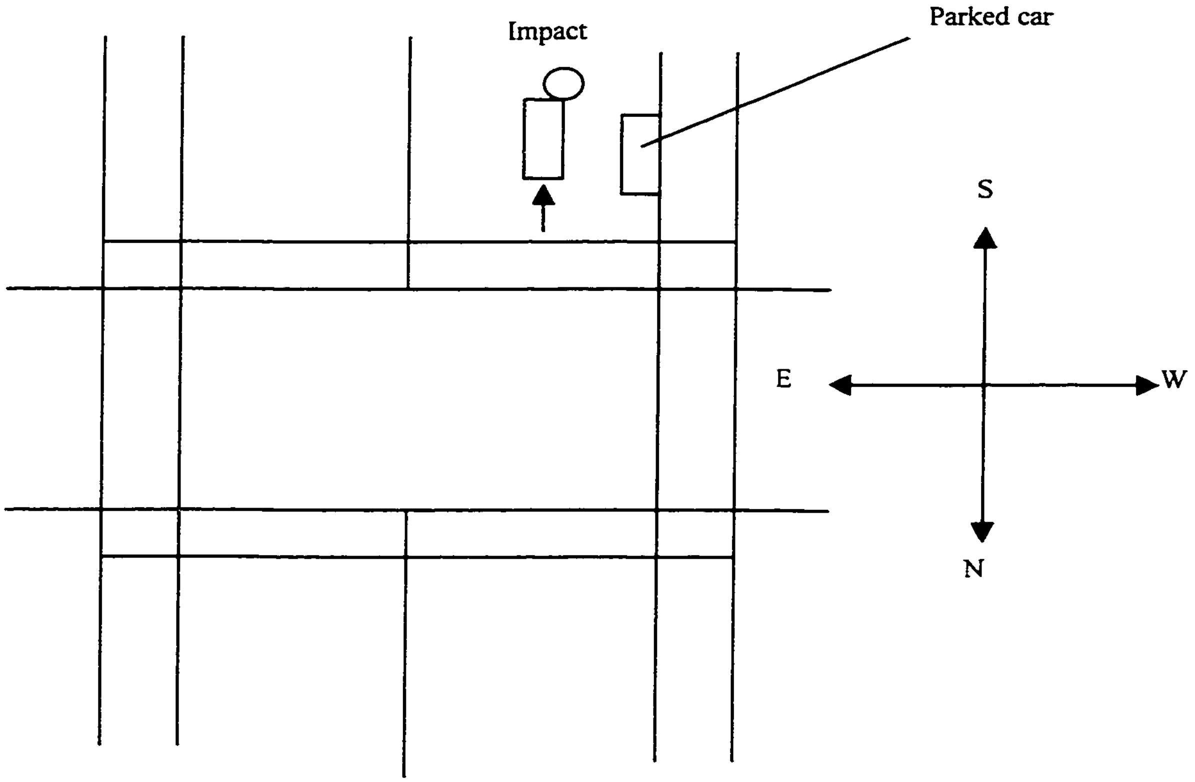
2. Secondary Prevention

Once the collision occurred, critical time was lost to treat the pedestrian as the driver of the vehicle had to run two blocks in order to contact EMS. Bystander first-aid training is an important component of an injury control model (Francescutti, 1997). EMS transported the patient to RAH.

3. Tertiary Prevention

The Glenrose Rehabilitation Center in Edmonton is a facility designed to help rehabilitate victims of injury. The patient in this case had full access to all of these services. For all subsequent cases, it will be assumed that each injury patient had full access to the Glenrose Rehabilitation Center when recommended by a physician.

Figure 4.2-Scene Diagram



4.3 Case 2-GMC Sierra vs. Pedestrian

4.3.1 Collision summary

On November 27, 1999 at approximately 08:30 just as the sun was rising, a 52-year-old male driver of a 1999 GMC Sierra was attempting to make a left turn at a major four way intersection controlled by traffic lights. The driver, turning northbound was in the left turning lane. The intersection consisted of two lanes heading eastbound with one left turning lane in which the driver left the intersection from. There were two westbound lanes, with two left turning lanes heading southbound (See scene diagram). The driver stated in the police report that he was concentrating on trying to find a gap in traffic heading westbound in order to make the left turn. The vehicles in the two left turning lanes, which headed southbound also distracted him. In essence, he was turning northbound against four lanes of traffic. The driver stated that he made the left turn but did not see the 26-year-old female pedestrian who was in the crosswalk heading westbound. The traffic light was green for the truck to proceed, but the pedestrian had the right of way in the crosswalk. The vehicle was travelling at a driver estimated 15-20 kilometers per hour. The vehicle stuck the pedestrian on the passenger front side of the GMC truck. The pedestrian's head struck the hood of the truck. Damage to the vehicle included a dent on the grill and a large dent on the hood (0.45 meters from front right corner of hood and 0.54 meters back from the front of the hood). The police did not perform a skid test for vehicle speed determination due to lack of skid evidence, and as such, accepted the estimate of speed of the driver after examining the damage to the vehicle and consulting with witnesses. A bystander attended to the pedestrian as the driver called EMS on his cellular phone. Patient was conscious after impact. Pedestrian was transported to RAH. The large dent on the hood of the truck would correspond to the pedestrian's head (left side) striking it. The dent on the grill corresponds to the initial contact of the truck with the pedestrian.

4.3.2 Injuries

1. Pedestrian:

Table 4.2-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Head Swelling	No Code	Head/Neck		
Leg bruising	No Code	Extremities		

4.3.3 Haddon's Matrix

Figure 4.3-Haddon's Matrix

Phase **Factor**

	Host	Vehicle	Environment
Pre-event	• Driver inattention	• Brakes in proper working order	• No pedestrian overpass • No dedicated left turn arrow • Poor lighting • Heavy traffic location
Event	• Young pedestrian • Strong bone strength	• High bumper height • Driver wearing safety belt	• High traffic Intersection • Injury causing asphalt
Post-event	• Young pedestrian • Pedestrian in good physical condition	• Good remaining tire tread depth	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.3.4 Injury Prevention Measures:

1. Primary Prevention

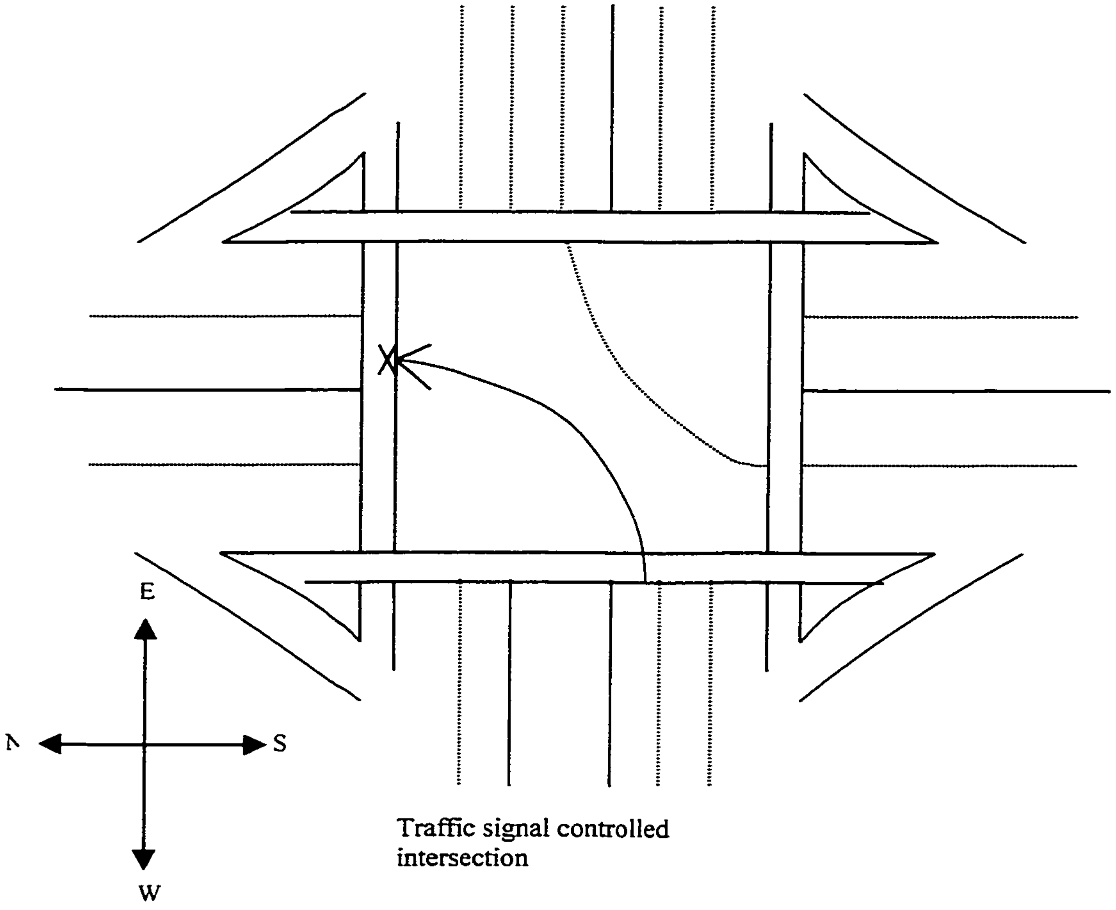
The location this collision occurred has a high traffic volume. The engineering solution to prevent this injury would be to separate vehicles from the pedestrian. In this intersection, vehicles turning left, northbound, must concentrate on vehicles heading westbound, as well as those turning southbound, i.e. 4 lanes of traffic. Left turning collisions are associated with high injury rates (Accident Investigation Quarterly, Winter 1998). Installing signals for left turn only when opposing traffic is stopped reduces crashes at intersections (Ulrich, 1991 (Accident Investigation Quarterly, Winter 1998)).

2. Secondary Prevention

As in case 1, vehicle exterior airbags would likely have prevented the head injury the pedestrian sustained at the time of the collision. Bystander first aid was not required at the scene as the patient was conscious and alert. EMS was called immediately.

Patient was transported to RAH, and did not sustain any internal or permanent injuries. A trauma physician examined the patient, but no medical interventions were required to decrease the severity of injury.

Figure 4.4-Scene Diagram



4.4 Case 3-Pontiac Sunfire vs. Ford E350 (Double fatality)

4.4.1 Collision summary

On November 30, 1999 at 14:30 on a clear afternoon, a 47-year-old driver of a 1998 Pontiac Sunfire was travelling eastbound at a police estimated speed of 125 km/h on an exit from a major Edmonton freeway. The speedometer of the vehicle was found after the crash stuck at 125 km/h. The speed limit of the off ramp is 50 km/h. A 42-year-old female was in the front passenger seat. The driver was not wearing a seatbelt, the female passenger was. According to skid evidence, the driver attempted to turn right at the top of the off ramp, but was unable to negotiate the turn. The vehicle jumped the island that separates the right and left turning lanes. At the impact with the curb of the island, both driver and passenger airbags deployed. As the vehicle left the island, a collision occurred in the number one southbound lane with a 1994 Ford E350 bus. A 46-year-old male was driving the bus. A wheel chair bound passenger, in the third row on the right (impact) side of the vehicle. The DATS bus sustained severe intrusion on the right side. The Sunfire sustained severe frontal crush to the engine bay. Firefighters extricated both passengers of the Sunfire. The driver of the Sunfire, driver of the DATS bus, and the DATS passenger were transported to RAH. The female passenger of the Sunfire was transported to UAH.

4.4.2 Injuries

1. **Driver of Sunfire (47-year-old male):**

Patient was transported to RAH but was dead on arrival.

Table 4.3-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Crushed chest	415099.9	Chest		No ISS

2. **Passenger of Sunfire (42-year-old female):**

Patient was transported to UAH and received cardiopulmonary resuscitation, but died shortly after arriving to the ER.

Table 4.4-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Crushed chest	415099.9	Chest		
Multiple rib fractures	450201.2	Chest	2	4
Fracture of both right and left tibia	853404.2	Extremities	2	4
Fracture of both left and right fibula	851605.2	Extremities		ISS=8

3. **Driver of DATS Bus (46-year-old male):**

Table 4.5-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Laceration of forehead	210600.1	Head/neck	1	1 ISS=1

Note: It was not possible for the researchers to obtain the injuries sustained by the passenger of the DATS bus.

4.4.3 Haddon's Matrix

Figure 4.5-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver education on effects of speed • Behavior modification	• Brakes in working order • Plywood flooring in DATS bus	• Speed Limit • Off ramp • Heavy traffic location
Event	• Middle aged • Reaction time • Drivers unbelted	• Low bumper height of Sunfire • Automatic safety belts • Air bags deflating during second crash	• No island barrier
Post-event	• Middle age • Average physical condition	• Good tire tread depth on both vehicles	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.4.4 Injury Prevention Measures:

1. Primary Prevention

The driver of the Sunfire was unbelted. However, the passenger of the Sunfire was, and she still sustained fatal injuries. The driver crashed into the steering wheel while the passenger crashed into the dash area. The airbags were likely deployed when the Sunfire hit the curb of the island. The velocity at which the occupants hit the vehicle was more than the tolerance of the body. The injuries were a result of speed. Crashes at high speed are survivable. The occupants could have sustained less severe injury if the vehicle design allowed for more of the energy transfer to be dissipated to the vehicle crumple zone, and not to the passengers. Of course, the injuries in this case would have been less severe had the vehicle not been travelling at such a high rate of speed.

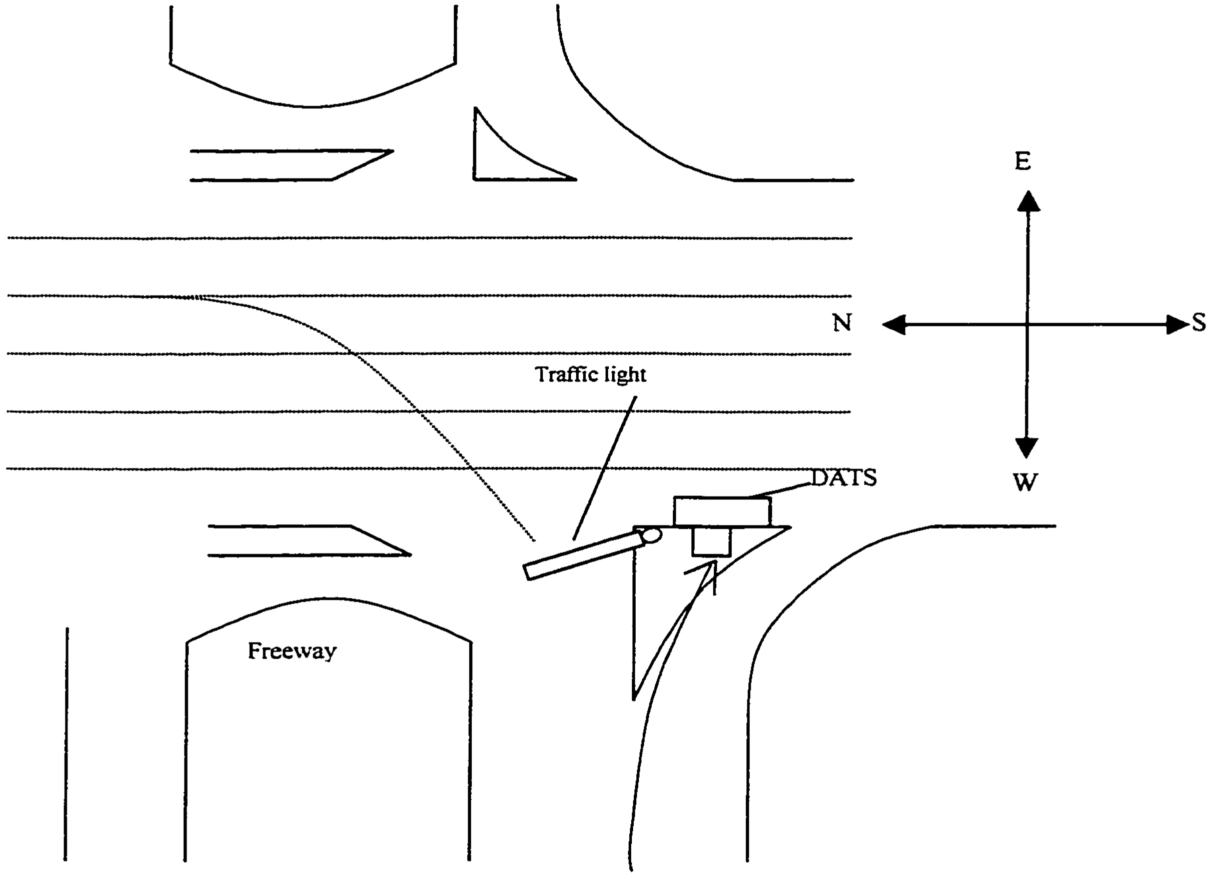
The built quality of the DATS bus was poor. The police and researchers noted that under the metal floorboard of the passenger compartment, the flooring was supported by plywood. The plywood is simply not strong enough to withstand a collision and to dissipate energy.

Secondly, an engineering solution that may have prevented these injuries would be to have a concrete barrier in front of the island to separated vehicles on the off ramp from those travelling northbound. If this had been the case, the Sunfire would have crashed into the barrier, and only one collision would have resulted. The combination of airbags and seatbelt would have likely saved the occupants.

2. Secondary Prevention

Firefighters extricated the occupants of the Sunfire. EMS transported the drivers of the DATS bus and Sunfire, along with the passenger of the bus to RAH. The passenger of the Sunfire was transported to UAH.

Figure 4.6-Scene Diagram



4.5 Case 4-GMC 3500 vs. Pedestrian

4.5.1 Collision summary

On a clear and sunny day at 14:30 on December 6, 1999, a 47-year-old driver of a 1988 GMC 3500 truck towing a flat bed carrier was attempting to make a left (southbound) turn at an intersection controlled by a traffic light. Once the light turned green for the driver, he proceeded to make the turn at a driver estimated 15 km/h. The intersection he was turning into was dark due to the shadow cast by a building. As the driver was completing the left turn and entering into the crosswalk (east-west), a 59-year-old female pedestrian walking eastbound was stuck by the center of the front bumper (height of 0.45-0.7 meters from the ground) of the truck. The truck struck the left side of the pedestrian. The pedestrian's head did not strike the hood of the vehicle, but did strike the road when she fell. The driver stated that in the police report that in addition to the darkness caused the by the shadow of the building, as he turned southbound, he was affected by the glare of the sun.

4.5.2 Injuries

1. Pedestrian:

Table 4.6-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Basal skull fracture	150200.3	Head/Neck		
Right frontal subhematoma	140638.4	Head/Neck	4	16
Subarachnoid hematoma	140684.3	Head/Neck		
Frontal subdural bleeding	140650.4	Head/Neck		
Fracture left lower fibula	851699.1	Extremities	1	1
Fracture left lower tibia	853499.1	Extremities		ISS=17

4.5.3 Haddon's Matrix

Figure 4.7-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver attention	• Brakes working • Windshield needs cleaning • No daytime running lights	• Poor lighting in intersection • No dedicated left turn traffic signal
Event	• Osteoporosis	• High bumper height	• Asphalt
Post-event	• Age • Physical condition	• Proper tire tread depth for stopping	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.5.4 Injury Prevention Measures

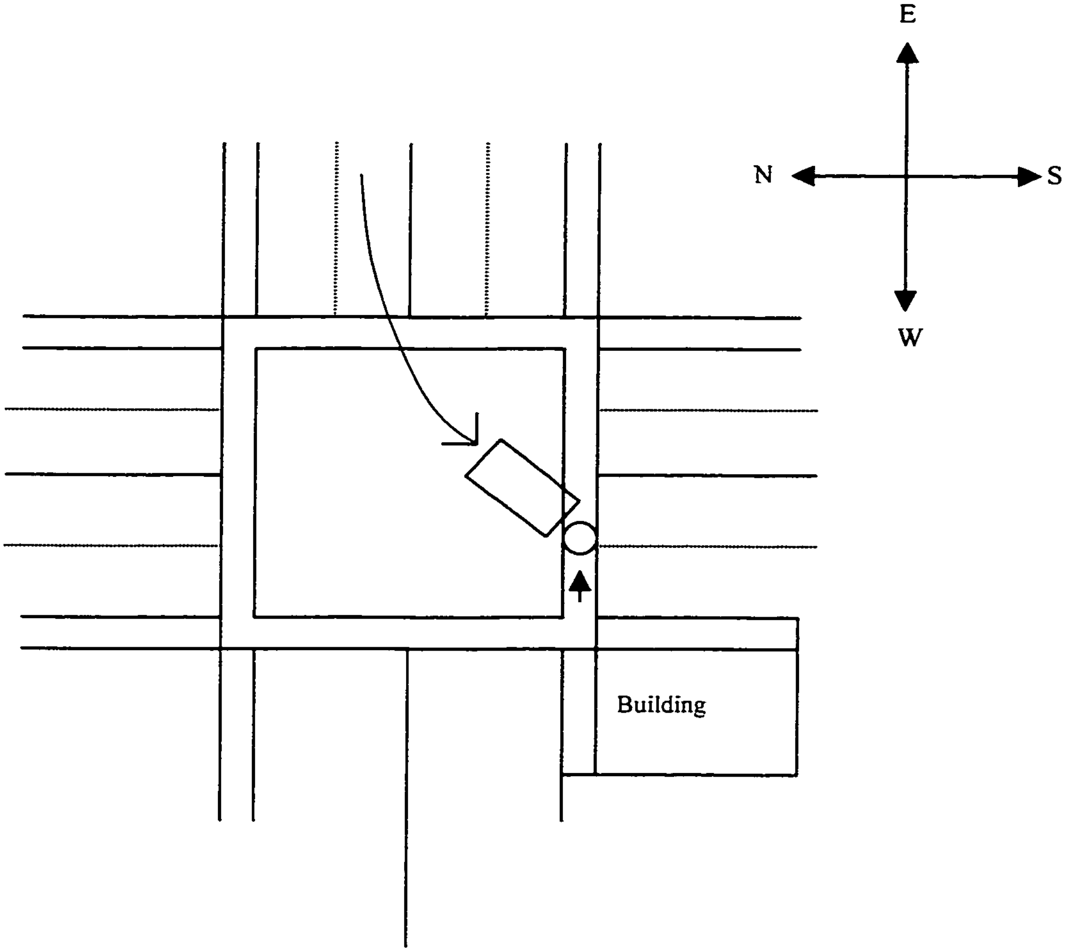
1. Primary Prevention

This collision occurred on a December afternoon. Due to the building on the southeast side of the intersection, a shadow was cast upon the intersection. At the same time, as drivers are negotiate a left turn southbound, the sun glare affects the drivers while they enter the east-west crosswalk. Therefore, the vision of drivers is compromised. In order to prevent another pedestrian injury at this intersection, a dedicated left turn signal would prevent vehicles and pedestrians entering the intersection at the same time. As seen by this crash, a vehicle travelling low rate of speed can cause serious injury. A dedicated left signal would separate pedestrians from traffic, and prevent the injury from occurring in the first place. Left turning collisions are associated with high injury rates (Accident Investigation Quarterly, Winter 1998). Installing signals for left turn only when opposing traffic is stopped reduces crashes at intersections (Ulrich, 1991 (Accident Investigation Quarterly, Winter 1998)).

2. Secondary Prevention

EMS was called immediately. Patient was transported to RAH and was stabilized by a trauma team.

Figure 4.8-Scene Diagram



4.6-Case 5-Mercury Sable vs. Pedestrian

4.6.1 Collision Summary

At 18:30 on a clear night on December 21, 2000, a driver of a 1991 Mercury Sable was heading northbound on a double lane road at a police estimated 50 km/h. As the driver approached a traffic light controlled crosswalk, a 30-year-old male pedestrian heading westbound walked into the intersection. According to witness statements in the police report, the traffic light was green for the Sable. The Sable, with a bumper height of 0.46 meters (center), struck the left side of the pedestrian. The height of the hood from the ground was 0.7 meters, with the windshield a height of 0.93 meters above the ground. The pedestrian rode the hood of the vehicle, and then smashed headfirst into the center of the windshield, penetrating into the occupant compartment. The pedestrian then fell to the ground. The driver was uninjured in this collision.

4.6.2 Injuries

1. Pedestrian:

Table 4.7-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Left mandible	250600.1	Head/neck	1	1
Multiple head lacerations	110600.1	Head/neck		
Right humerus fracture	752600.2	Extremities		
Right tibia multiple compound fracture	853404.2	Extremities		
Right fibula multiple compound fractures	851800.3	Extremities	3	9
Left tibia multiple fractures	853404.2	Extremities		
Pneumothorax	441414.3	Chest	3	9 ISS=20

4.6.3 Haddon's Matrix

Figure 4.9-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Pedestrian with history of suicide attempts • Inattention	• Brakes in working condition • No anti lock brakes	• Lighting in intersection • No pedestrian overpass
Event	• Physically fit • Not wearing reflective clothing	• Bumper height	• Asphalt • Speed limit not lower at crossing
Post-event	• Physically fit	• Proper tire tread depth for stopping	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.6.4 Injury Prevention Measures

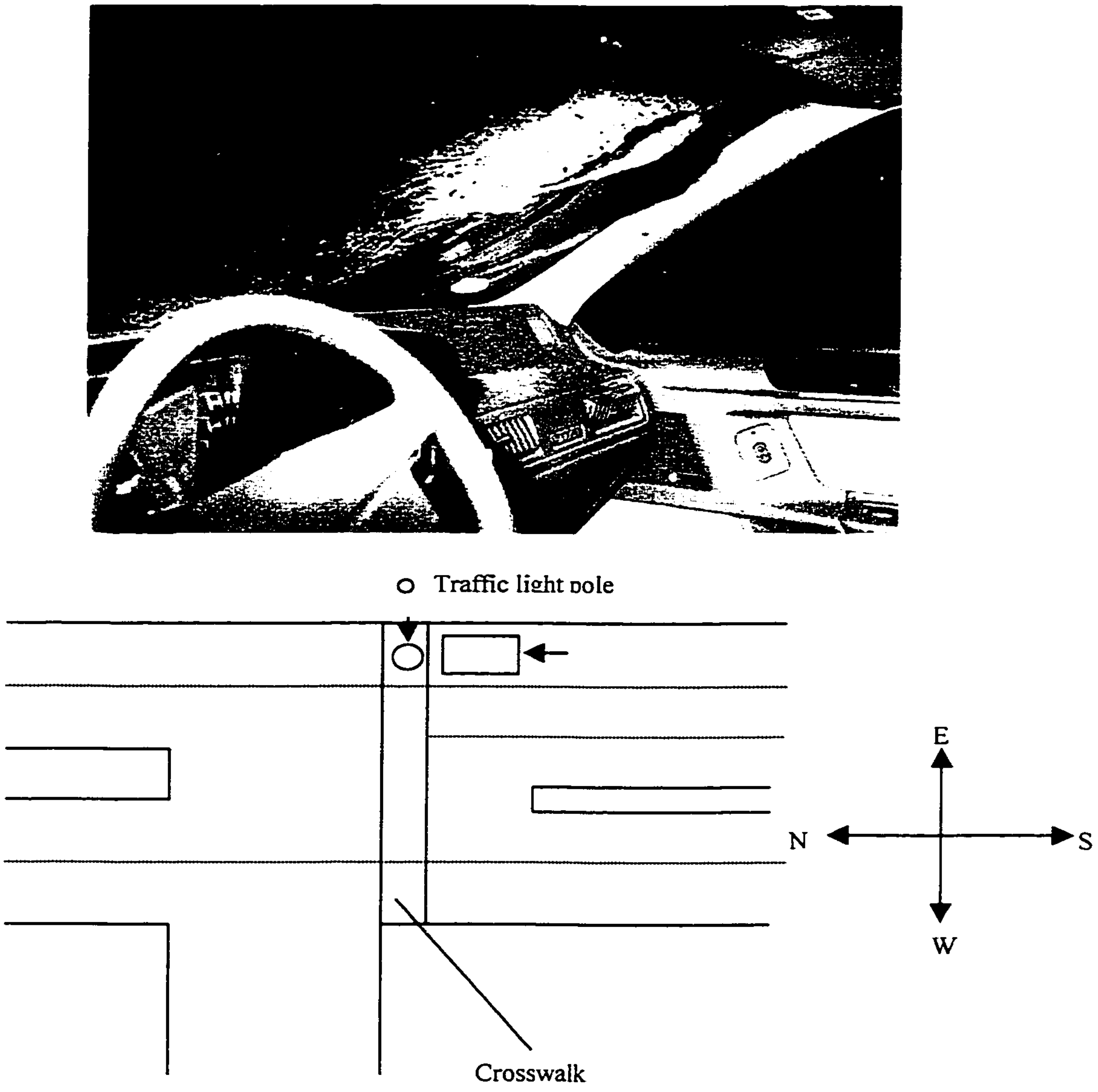
1. Primary Prevention

This injury could have been prevented had the hazard, the vehicle, been separated from the pedestrian. A pedestrian overpass crossing the intersection would have prevented the vehicle from hitting the pedestrian. A lower speed limit in the crossing area may give drivers better reaction time to avoid pedestrians.

2. Secondary Prevention

EMS transported to the patient RAH. Patient was stabilized by a trauma team and admitted to hospital. Patient will required rehabilitation.

Figure 4.10-Scene Diagram



4.7-Case 6-Grand Am vs. Light pole

4.7.1 Collision Summary

At approximately 19:40 on a clear winter night on December 30, 1999, a 27-year-old female driver was travelling eastbound on a one-way freeway. The driver was in the number one of four lanes. The freeway was well lit and traffic was light. The vehicle appeared to hit the right curb, then corrected, and the hit the right curb again, jumping the curb. The left side of the vehicle, starting with the left front door struck the light post. The skin of the door peeled off and the vehicle returned to the freeway, crossed four lanes of traffic, jumped the left curb, and then was finally stopped by a barb wire fence. This was all evident from tire tracks on the grass and skid marks on the road. The damage to the vehicle consisted of a broken windshield, a buckled A-pillar (the site of the first impact), intrusion of the driver side door, and the left side of the roof over the driver depressed into the occupant compartment. The driver, whom was unrestrained, was found in the front passenger seat of the vehicle by bystanders. It was apparent that the driver struck the A-pillar upon impact with the light pole from the damage to the vehicle. A large volume of blood was found on the driver's seat. The driver died 5 days later in ICU after debridement of the frontal lobe and frontal sinus.

4.7.2 Patient Injuries

1. Driver:

Table 4.8-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Crush of cranium and skull	113000.6	Head/neck	6	36
Multiple basal skull fractures	150202.3	Head/neck		
Frontal laceration	110600.1	Head/neck		ISS=36

4.7.3 Haddon's Matrix

Figure 4.11-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Fatigue? • Animal? • Unknown	• Brakes in working order	• Good lighting
Event	• No seatbelt use	• Speed • No airbags	• No guard rails
Post-event	• Young age • Good physical condition	• No engine cutoff	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.7.4. Injury Prevention Measures

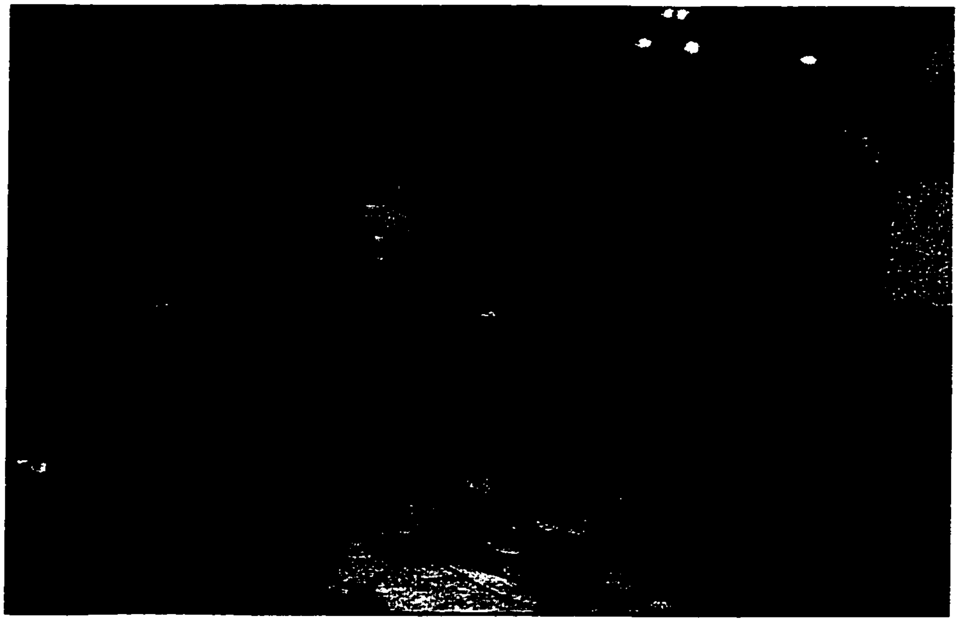
1. Primary Prevention

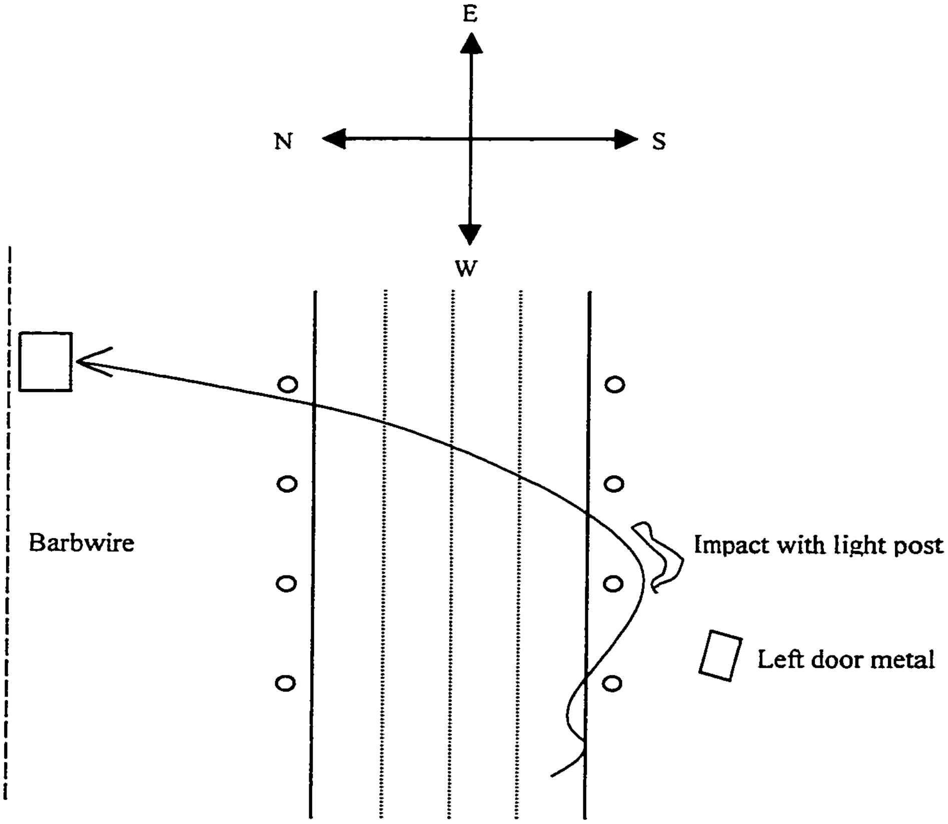
The primary cause of injury in this case was the head impacting with either the A-pillar or the light pole. This injury could have been prevented or greatly reduced had the driver been wearing a seat belt and had the vehicle design included side and head airbags. BMW has shown in vehicle side impact tests of 20 miles per hour with a stationary pole, injury to the head of front seat occupants can be reduced by 86%, to the point where the driver can walk away from the vehicle (Nickel, 1998).

2. Secondary Prevention

EMS transported driver to UAH. A trauma team saw patient. Trauma surgeons performed a debridement of the right frontal lobe and of the right frontal sinus. Patient died 5 days later.

Figure 4.12-Scene Diagram





4.8-Case 7-GMC 2500 vs. Pedestrian

4.7.1 Collision Summary

At approximately 18:40 on January 10, 2000, the driver of a 1992 GMC Sierra 2500 was travelling northbound in the number one lane of a four lane street (2 lanes in each direction of traffic separated by a yellow line). As the vehicle crossed an intersection and entered into the north crosswalk at a police estimated 55 km/h, a 55-year-old male pedestrian was walking eastbound in the crosswalk in the number one lane. According to skid evidence, the driver swerved to the right in order to avoid the pedestrian, but the front right corner of the vehicle struck the right side of the pedestrian. Damage to the vehicle consisted of a broken right headlamp assembly and grill. (Vehicle measurements were not possible as the researcher arrived as the vehicle was being removed) The pedestrian received a head injury, likely when he struck the ground. The chest injuries were received when contact occurred with the truck.

4.8.2 Patient Injuries

1. **Pedestrian:**

Table 4.9-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Closed head injury	115099.9	Head/neck		
Hematoma	140629.4	Head/neck	4	16
Laceration of forehead	210600.1	Head/neck		
Laceration of nose bridge	210600.1	Head/neck		
Right pneumothorax	441414.3	Chest	3	9
Right rib fractures	450210.2	Chest	2	4
Pelvic fracture-pubic bilateral ramii	852600.2	Extremities		
Right elbow laceration	710602.1	Extremities		
Right lower leg laceration	810602.1	Extremities		

Right fibular head fracture	851606.2	Extremities		ISS=29

4.8.3 Haddon's Matrix

Figure 4.13-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver inattention	• Brakes in working order	• Poor lighting • Poor signage
Event	• Pedestrian age • Pedestrian physical condition • No reflective clothing	• Speed	• Asphalt • Speed limit not lower at crosswalk
Post-event	• Age • Physical condition	• Proper tire traction for stopping	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.8.4. Injury Prevention Measures

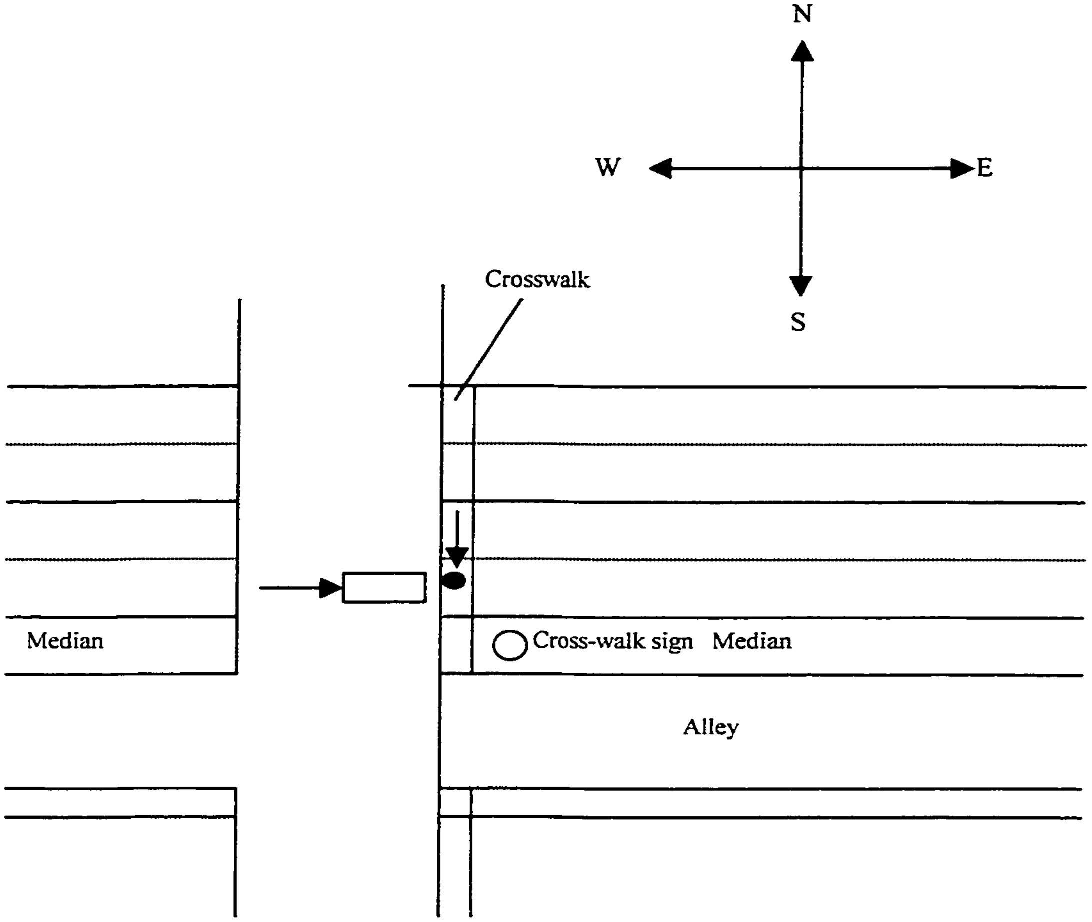
1. Primary Prevention

This collision occurred on a high volume road. The intersection in which the collision occurred has a pedestrian crossing sign, but the sign has poor visibility. Also, the intersection is poorly lit and is difficult for drivers to see pedestrians crossing the road. Engineering methods shown to be effective in reducing car-pedestrian collisions include better illumination of roadways where car-pedestrian collisions are likely to occur (Accident Investigation Quarterly, Winter 1998).

2. Secondary Prevention

Patient transported to UAH by EMS. Trauma team intubated and stabilized patient.

Figure 4.14-Scene Diagram



4.9-Case 8-Nissan Pulsar vs. 5 Pedestrians

4.9.1 Collision Summary

On January 12, 2000 at 13:45 on a clear winter day, a 26-year-old male driver of a 1989 Nissan Pulsar was travelling eastbound at a driver estimated 50 km/h below an underpass at. The driver, in the number three of three lanes, lost control of his vehicle when the right front tire burst. According to the driver's statement in the police report, the driver applied the brakes with maximum pressure, but was unable to regain control. The roads were covered with several inches of snow and were unsuitable for normal driving conditions. According to marks in the snow, the vehicle started to skid to the number one lane. The vehicle jumped the curb where four people were standing and one sitting on a bench while waiting for a bus.

The vehicle struck the four standing people and crashed into the wall of the underpass, destroying a concrete garbage can and the bus bench. The person on the bus bench ran away from the bench, but was struck as the vehicle rebounded off the wall and came to a rest in the number two lane. The driver was uninjured in the crash.

4.9.2 Patient Injuries

1. **Pedestrian 1:**

41-year-old male pushed against wall by vehicle. Transported to RAH and discharged after receiving a pain reliever.

Table 4.10-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Bilateral leg pain (soft tissue injury)	No code			

2. Pedestrian 2:

17-year-old male transported to RAH and discharged after receiving a Jones Brace for knee injury.

Table 4.11-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Abrasions of left and right ears, left cheek	210202.1	Head/neck	1	1 ISS=1

3. Pedestrian 3:

Male pedestrian was sitting on bench but was struck while trying to run away from vehicle. Patient transported to RAH and released after examination.

Table 4.12-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Abrasion right lateral thigh	810202.1	Extremities	1	1
Painful to walk	No code			
Pain right thigh	No code			ISS=1

4. Pedestrian 4:

20-year-old female pedestrian transported to RAH. Treated with cortisone for right calf and released.

Table 4.13-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Bilateral leg pain (soft tissue injury)	No code			

5. Pedestrian 5:

41-year-old male patient transported to UAH. Underwent surgery to set right leg.

Table 4.14-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Fractured right fibula	851800.3	Extremities	3	9
Fractured right tibia	853404.2	Extremities		ISS=9

4.9.3 Haddon's Matrix

Figure 4.15-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver attention • New driver	• Improper inflation • Tire inspection • No anti lock brakes	• Snow covered road not cleaned
Event	• Pedestrian awareness • Age • Physical condition	• Excessive speed for whether condition	• No guard rails to protect pedestrians
Post-event	• Age • Physical condition	• No antilock brakes	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.9.4 Injury Prevention Measures

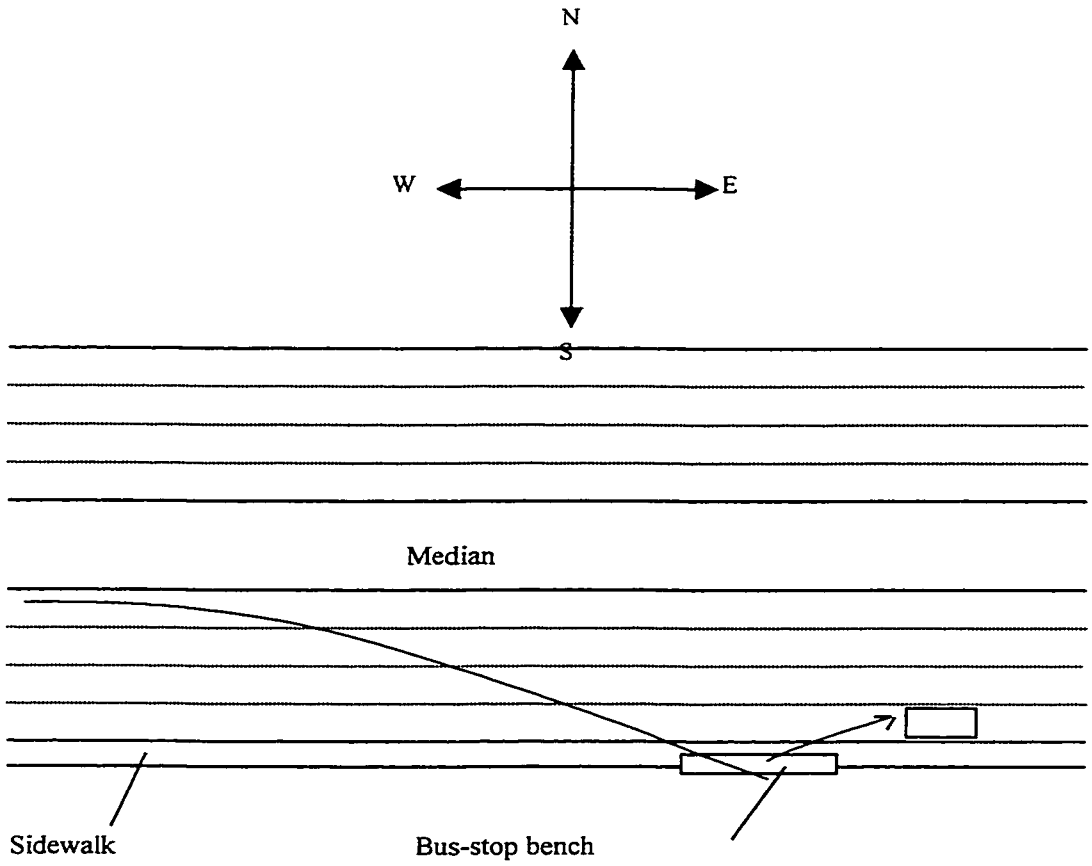
1. Primary Prevention

The cause of the injuries in this case was due to the vehicle having a mechanical failure (burst tire), and losing control. The driver was unable to take control of the vehicle due to the improper maintenance of the road. There were several inches of snow on the road and traction was at a minimum. If the roads had been cleaned and sanded, the driver would likely have been able to avoid the collision with the pedestrians. An engineering method that would likely prevented injuries would be to put a steel railing in front of the bus stop, separating pedestrians from the traffic.

2. Secondary Prevention

All injured parties were transported by EMS to the RAH or UAH. Each patient was examined by an emergency physician. Pedestrian 5 underwent orthopedic surgery to repair the fractured tibia and fibula.

Figure 4.16-Scene Diagram



4.10-Case 9-Mazda 323 DX vs. Edmonton Transit System New Flyer Bus

4.9.1 Collision Summary

At approximately 12:35 in the afternoon on January 25, 2000, a 32year-old-male driving a 1989 Mazda 323 hatchback was proceeding southbound at a police estimated 50 km/h on a four lane road (two lanes in each direction separated by a yellow line). The driver approached an intersection, which had a red flashing light above the intersection and two large stop signs on each curb of the road on which the driver was travelling. The driver, who stated to the researcher that he was affected by the noon sun, did not see the stop signs and proceeded through the intersection without braking or stopping. The Mazda, with a bumper height of 0.55 meters, crashed into an Edmonton Transit System New Flyer bus which was in the intersection at the time (see collision diagram). The Mazda crashed into the front of the bus (bumper height of 0.35 meters), causing extensive frontal crush to the Mazda. However, there was no intrusion into the vehicle compartment. The steering wheel of the vehicle did bend forward under the stress of the 190-pound driver who was wearing his seatbelt. The driver's head struck the windshield, resulting in a spiral in the glass. The bus sustained minor damage to the left bumper, bike rack, and headlamp, and none of the passengers nor the driver of the bus were injured.

4.10.2 Patient Injuries

1. Mazda driver:

Table 4.15-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Clavicle fracture	752200.2	Extremities	2	4
Wrist fracture	7520002.2	Extremities		
Sprained ankle	85206.1	Extremities		
Chest pain from seatbelt	No code			ISS=4

4.10.3 Haddon's Matrix

Figure 4.17-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver inattention • Driver inexperience on road •	• Brakes in working order	• Sun in direction of driver
Event	• Wearing seat belt • Sit further back from steering wheel	• No airbag • Speed	• Perpendicular traffic flow
Post-event	• Age • Good physical condition	• Crumple zone functioning properly	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.10.4 Injury Prevention Measures

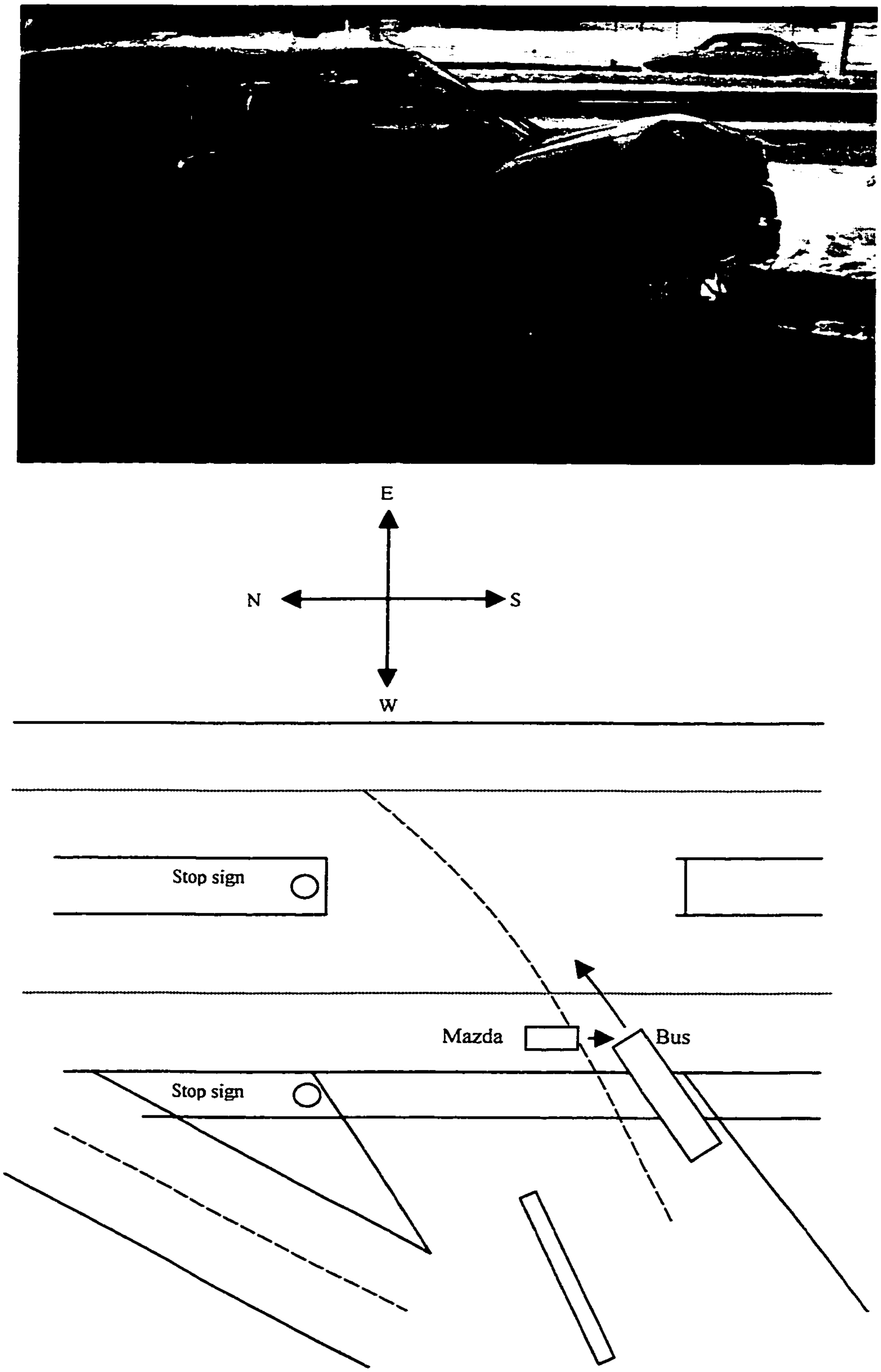
1. Primary Prevention

The front of the vehicle crumpled as it was designed to do and there was no occupant compartment intrusion. The majority of the injuries the driver sustained could have been prevented had the vehicle been equipped with a driver's side frontal airbag. The combination of seatbelts with airbag use is 75% effective in preventing serious head injuries, and 66% for serious chest injuries (National Highway Transportation Safety Administration).

2. Secondary Prevention

EMS transported the driver to UAH. A trauma team at UAH examined patient and released him.

Figure 4.18-Scene Diagram



4.11-Case 10-Pontiac Firebird vs. Pedestrian

4.11.1 Collision Summary

On a dark, clear night on January 28, 2000, at approximately 19:45, a 27-year-old male driver of a 1982 Pontiac Firebird was travelling eastbound on a major four-lane road (two lanes in each direction divided by a concrete barrier). The driver of the Firebird, in the number one lane, approached an intersection with a white reflective pedestrian crossing sign. A 60-year-old male pedestrian was heading southbound when he was struck by the Firebird, which was travelling at a driver estimated 55 km/h. There were no skids from the tires and as such, the police were not able to perform a speed analysis. The pedestrian was struck by the left side of the bumper (0.275 to 0.52 meters above ground) on the right leg. The pedestrian rode up the hood, crashed through the windshield into the vehicle compartment bending the steering wheel inwards, then rode up over the roof of the vehicle, down the back windshield, striking the spoiler, and then landing behind the vehicle. This was evident from marks on the exterior of the vehicle. The vehicle stopped after crossing the intersection, when the patient landed on the ground. The driver of the vehicle was uninjured in the crash.

4.11.2 Patient Injuries

1. **Pedestrian:**

Table 4.16-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Fracture left humerus	752600.2	Extremities		
Compound fracture of right fibula	851605.2	Extremities		
Compound fracture of right tibia	853404.2	Extremities		

Comminuted fracture of left fibula	851605.2	Extremities		
Comminuted fracture of tibia	853405.3	Extremities	3	9 ISS=9

4.11.3 Haddon's Matrix

Figure 4.19-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Pedestrian intoxicated	• Brakes in working condition • No antilock brakes	• Poor signage • Poor lighting • No pedestrian overpass
Event	• Age • Physical condition • Not wearing reflective clothing	• Speed • Low hood line	• Asphalt
Post-event	• Age • Physical condition	• Windshield slant • Rear spoiler sharpness	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.11.4 Injury Prevention Measures

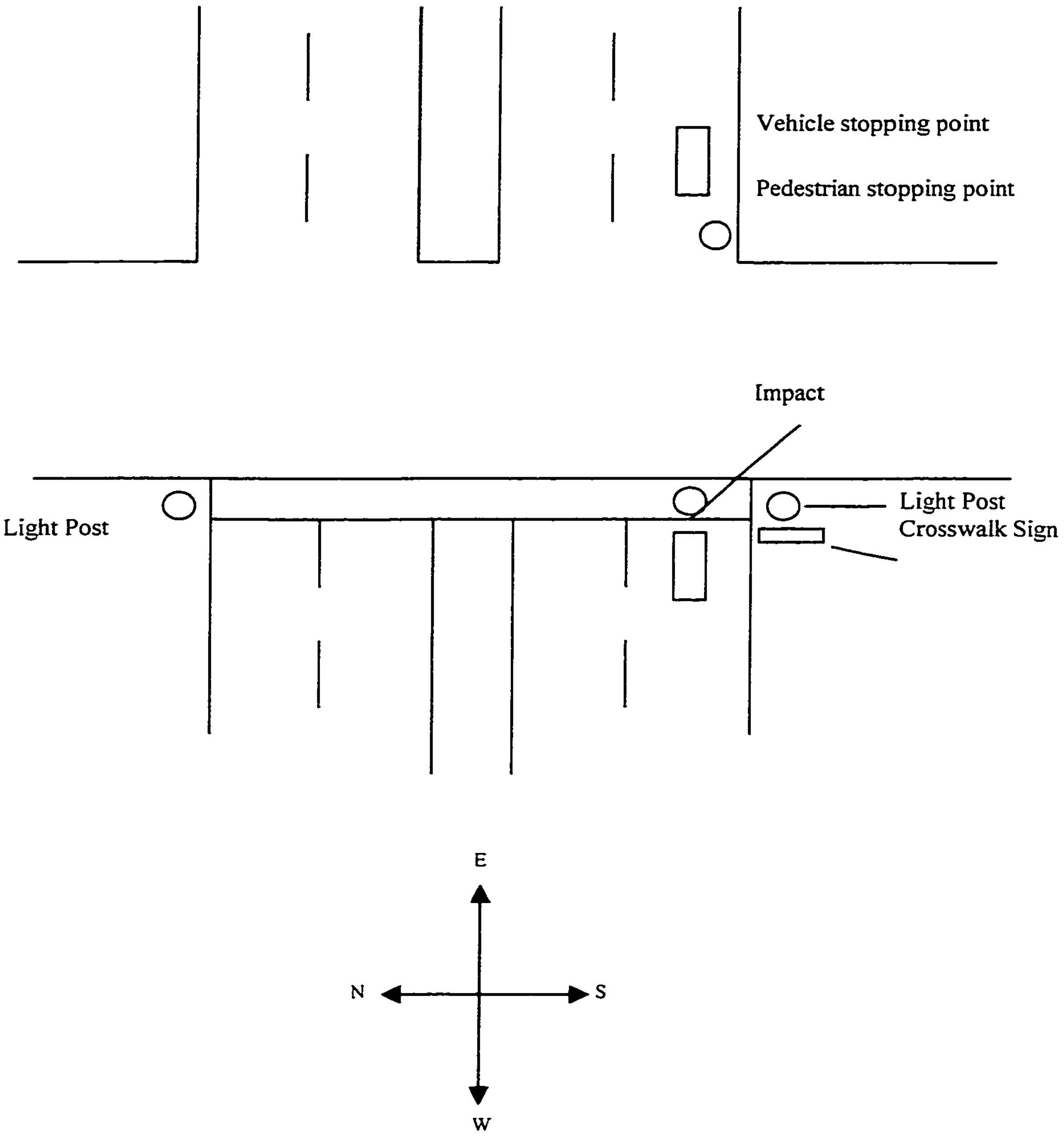
The street on which this collision occurred has a high volume of traffic. The intersection in which the collision occurred is dark and does not have a dedicated signal for crossing pedestrians. Engineering methods shown to be effective in reducing car-pedestrian collisions include better illumination of roadways where car-pedestrian collisions are likely to occur (Accident Investigation Quarterly, Winter 1998).

A dedicated crossing signal would have likely drawn the driver's attention to the crossing pedestrian.

2. Secondary Prevention

EMS transported the pedestrian to RAH. When the researcher arrived at the trauma room and discussed the mechanics of the collision, the emergency physician decided to further investigate the patient's injuries because the trauma team did not realize the seriousness of the collision. This is an example of how an injury investigator can pass information to the trauma team in order to allow the physicians to have a better understanding of what injuries they can expect to find. Trauma team examined patient. Patient underwent an open reduction for the leg injuries.

Figure 4.20-Scene Diagram



4.12-Case 11-Chevorlet Sierra vs. Tree

4.12.1 Collision Summary

At approximately 8:00 on January 30, 2000, a 25-year-old male driver of a GMC ½ ton truck was travelling on a four-lane road (two lanes in each direction separated by a yellow line) heading westbound at a police estimated 90 km/h. The driver came to a curve in the road, and according to a witness statement in the police report, did not turn. The vehicle crashed into a tree in front of a concrete privacy wall. There was massive damage to the vehicle. The dash and instrument panel intruded into the occupant compartment, with maximum intrusion on the driver's side. This likely caused the lower extremity injuries sustained by the driver. The steering wheel was pushed right into the seat back. The frame of the vehicle behind the driver's seat pushed forward intruding into the vehicle. EMS transported driver to UAH.

4.12.2 Patient Injuries

1. Driver:

Table 4.17-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Fracture left femur	851800.3	Extremities	3	9
Laceration left knee	810600.1	Extremities		
Laceration left forehead	210600.1	Head/neck	1	1 ISS=10

4.11.3 Haddon's Matrix

Figure 4.21-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver intoxicated	• Brakes in working order	• Sharp curve
Event	• No seatbelt use	• Excessive speed around corner	• No guard rail on curb
Post-event	• Age • Physical condition	• No crumple zone	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.12.4 Injury Prevention Measures

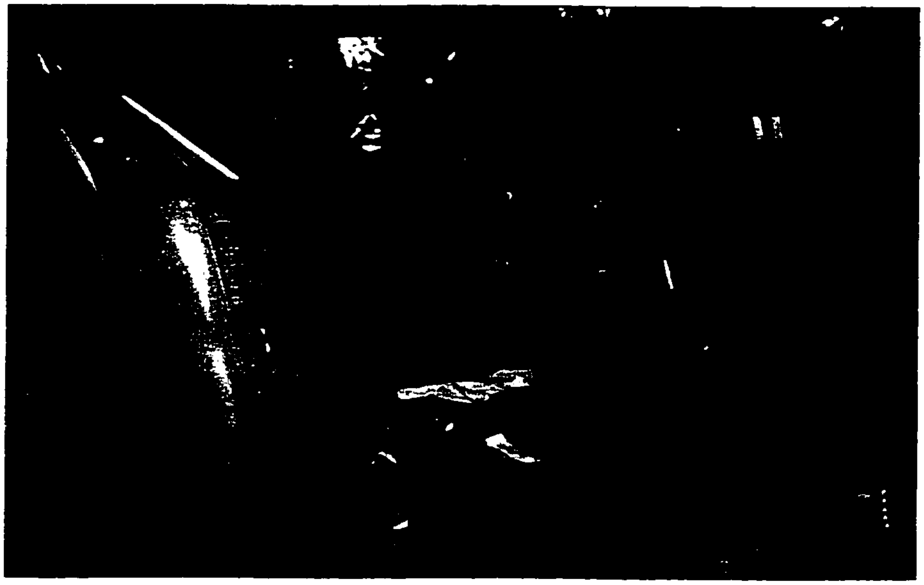
1. Primary Prevention

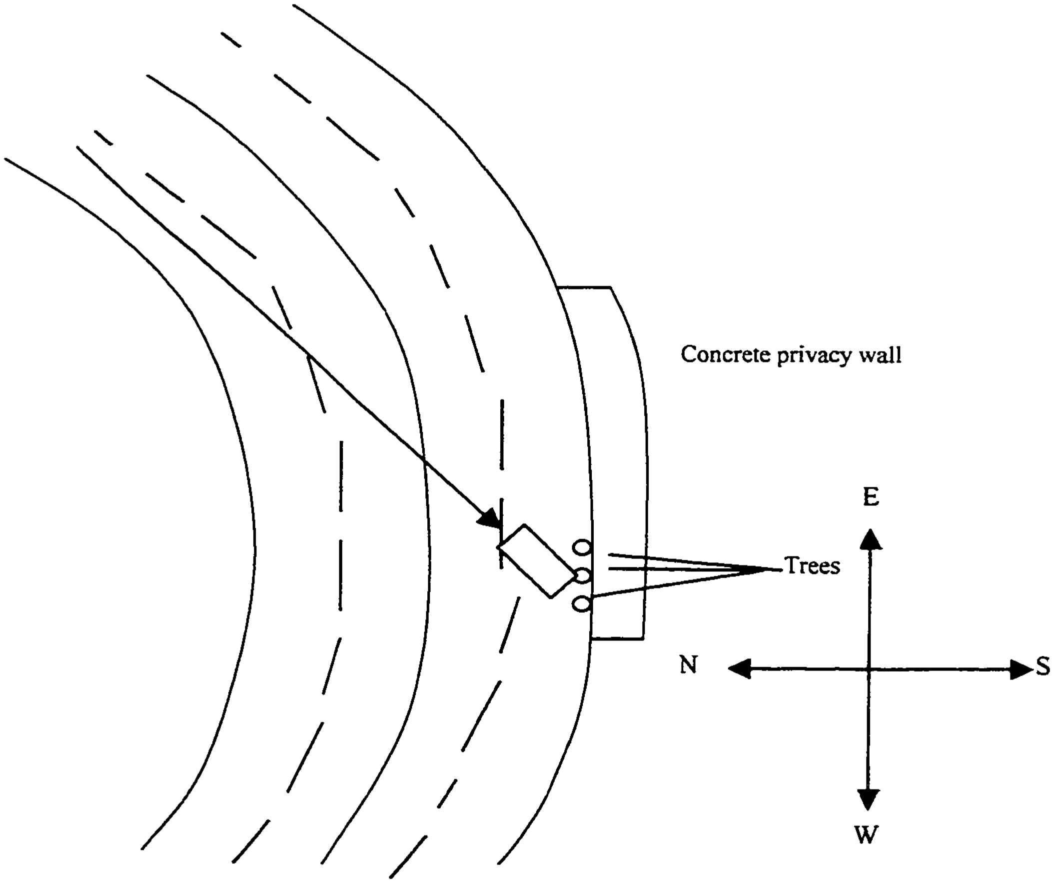
There were several factors that lead to this injury. Firstly, the driver of this vehicle was intoxicated. Also, the driver was not wearing this seatbelt during the crash. This vehicle, an early 80's model, did not crumple to protect the occupant compartment in the collision. The front of the vehicle sustained severe damage and there was extensive intrusion into the vehicle compartment, from both front and rear, contributing to the lower extremity injuries sustained by the driver.

2. Secondary Prevention

EMS transported patient to UAH where a trauma team treated patient. Surgery was performed to set fractured femur.

Figure 4.22-Scene Diagram





4.13-Case 12-Ford Tempo vs. Chevrolet Impala

4.13.1 Collision Summary

On cloudy night at approximately 17:35 on February 10, 2000, a 19-year-old female driver of a 1988 Ford Tempo was travelling eastbound on a highway when she entered into an uncontrolled intersection in which she had the right of way. As she entered the intersection, a 2000 Chevrolet Impala driven by a 62-year-old male entered the intersection from a secondary road heading northbound. The Tempo crashed into the left front door, B-pillar, and rear door. The lacerated liver, spleen, kidney, and chest injuries sustained by the driver were expected for a collision of his nature (see literature review). The Impala was equipped with a side impact airbag, which in this case, likely prevented head injury as it was designed to do. A speed analysis by the police was not possible because the road was covered with ice. The posted speed limit on the highway is 100km/h. According to tire impressions on the ice, the Impala went into a spin and came to rest on the west ditch. The driver of the Tempo was transported to RAH by EMS and released. EMS transported the driver of the Impala to RAH. Both drivers were restrained.

4.13.2 Patient Injuries

1. Driver of Impala:

Table 4.18-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Liver laceration	541820.2	Abdomen	2	4
Spleen laceration	544220.2	Abdomen		
Left kidney laceration	541620.2	Abdomen		
Bilateral rib fractures	450210.2	Chest		

Right hemothorax	441414.3	Chest	3	9
Pelvic fracture	852600.2	Extremities	2	4 ISS=17

4.13.3 Haddon's Matrix

Figure 4.23-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver inattention	• Brakes in working order	• No lighting in intersection • No intersection warning signal
Event	• Use of seatbelt • Airbag	• Speed • Side airbag present	• Ice on road, not sanded
Post-event	• Age • Physical condition	• Proper tire traction for road conditions	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.13.4. Injury Prevention Measures

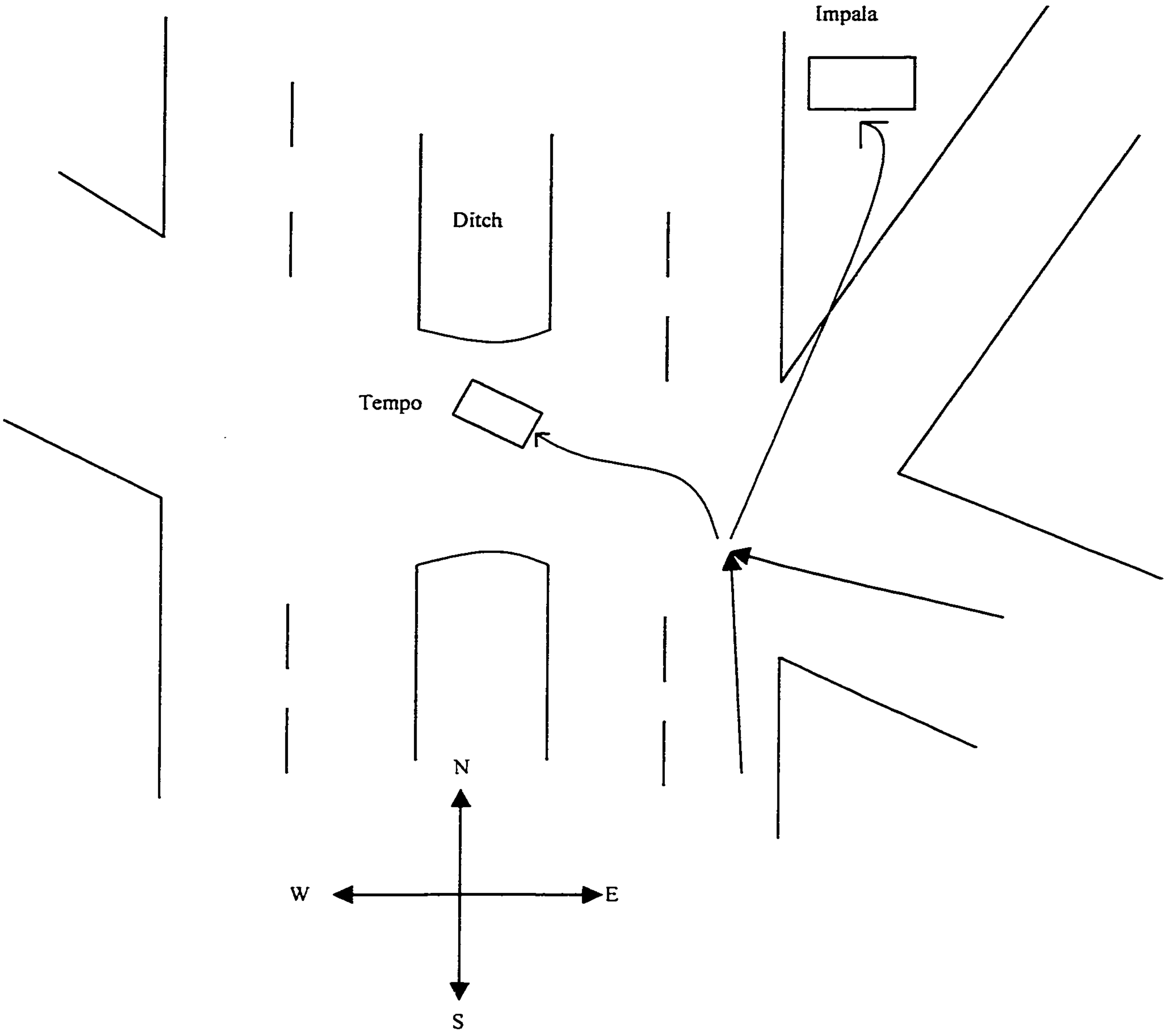
1. Primary Prevention

The driver of the Impala sustained injuries described in Chapter 2 of this thesis. However, the presence of the side impact airbag likely prevented the driver from sustaining head injury. There is no lighting at this intersection. Lighting in the intersection may have decreased the severity of the injuries by giving the driver of the Tempo more reaction time to brake.

2. Secondary Prevention

EMS transported both drivers to RAH. The driver of the Impala was stabilized by a trauma team and then transferred to ICU for one week.

Figure 4.24-Scene Diagram



4.14-Case 13-Oldsmobile Cutlass vs. Semi Trailer

4.14.1 Collision Summary

At approximately 06:45 on February 26, 2000, a 26-year-old female driving a 1986 Oldsmobile Cutlass Cierra was travelling eastbound entering into the City of Edmonton in the number one lane of a four-lane highway (two lanes in each direction, separated by a concrete island). The driver was approaching an intersection at an undetermined speed. The police were unable to determine speed because there was not enough skid evidence to allow for an analysis. The intersection, with flashing yellow warning lights, had a red light for traffic heading eastbound. In front of the Cutlass was a late model Kenworth T800 tractor with two empty Columbia fuel trailers. As the tractor-trailer was coming to a stop at the red light, the 46-year-old male driver described in the police report as what he felt as "riding over a bump", but did not recall seeing one in the road. The Cutlass, with a front bumper height from the ground of 0.65 meters, crashed into the rear of the second trailer, which had a rear bumper height of 0.58 to 0.78 meters. The Cutlass sustained damage to the left front bumper, crumple of the hood and engine bay, and intrusion of the dash into the occupant compartment. The toe pan intruded into the occupant compartment as well and there was evidence of the driver applying maximum pressure to the brake pedal as the pedal was depressed to the floor. This resulted in the lower extremity injuries sustained by the driver. The driver of the Cutlass was unrestrained and the vehicle was not equipped with airbags. There was also evidence that the driver struck the windshield by the spiral in the glass, which would correspond to a laceration on her forehead. The steering wheel of the vehicle was bent forward. Extraction of the driver took approximately 30 minutes and required removal of the left A-pillar, left door, and steering wheel. The restrained driver of the tractor-trailer was uninjured in the crash and the vehicle sustained bumper damage and damage to the right wheel well of the second trailer.

4.14.2 Patient Injuries

1. Driver of Cutlass Cierra:

Table 4.19-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Concussion	161200.2	Head/neck	2	4
Comminuted nasal fracture	251004.2	Head/neck		
Left forehead laceration	210600.1	Head/neck		
Left hip dislocation	850610.2	Extremities	3	9
Left femur head fracture	851808.3	Extremities		
Left femur fracture	851800.3	Extremities		
Right femur neck fracture	851812.3	Extremities		
Right calcaneus fracture	851400.2	Extremities		ISS=13

4.14.3 Haddon's Matrix

Figure 4.25-Haddon's Matrix

Phase **Factor**

	Host	Vehicle	Environment
Pre-event	• Driver intoxicated	• No vehicle safety cage	• Signage present • Intersection warning light present
Event	• No seatbelt use	• Speed	• Intersection
Post-event	• Age • Physical condition	• No crumple zone to protect intrusion into occupant compartment	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.14.4 Injury Prevention Measures

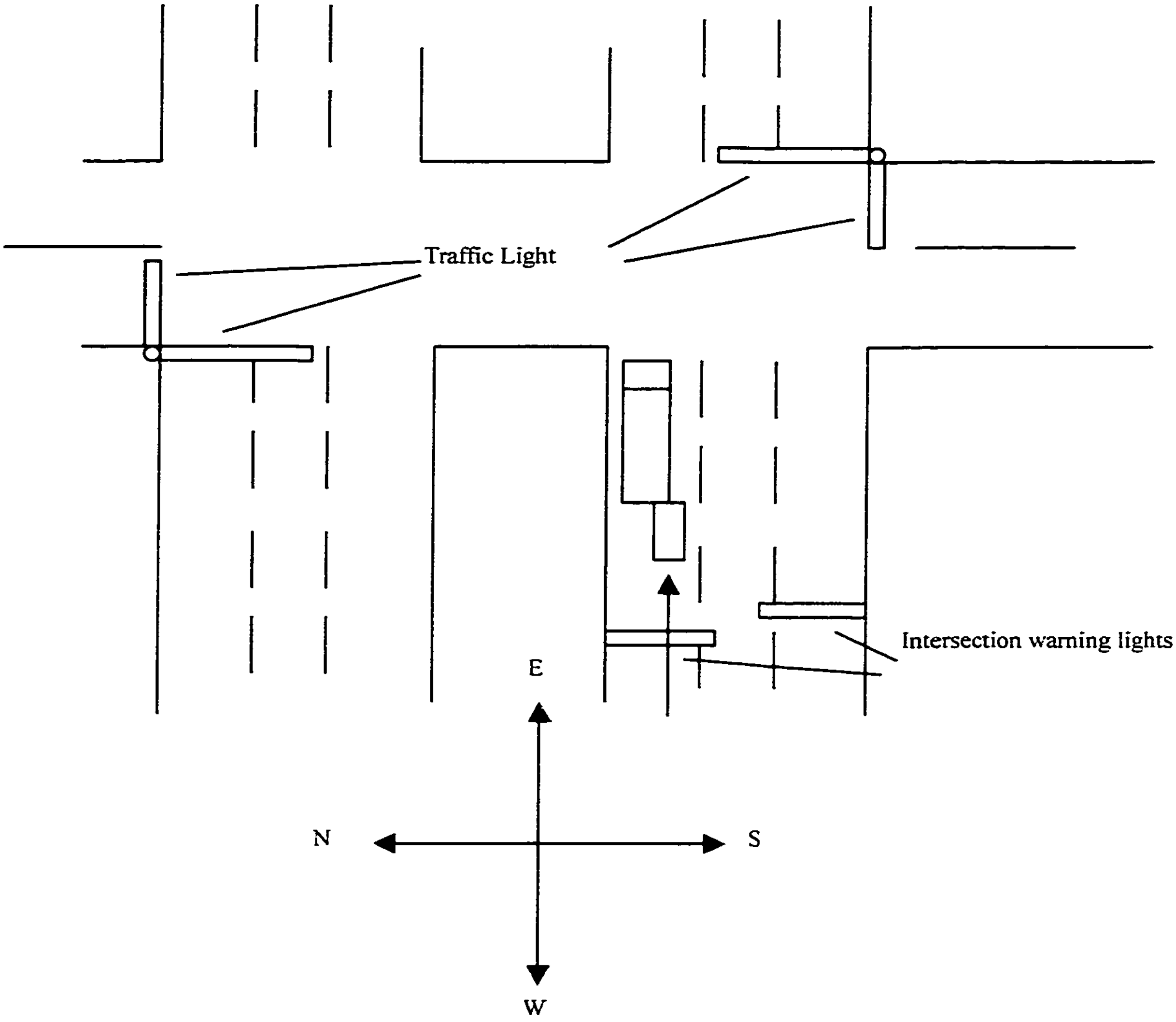
1. Primary Prevention

Alcohol and drug use combined with lack of sleep contributed to this collision, and the resulting injuries, occurring. Had the driver of the Cutlass been wearing a seatbelt, the head injuries may have been decreased in severity. Poor vehicle design resulted in the intrusion of the dashboard and toe pan into the vehicle compartment. This, combined with the driver "riding the brake pedal" contributed to the severe lower extremity injuries suffered by the driver.

2. Secondary Prevention

Extraction of the driver of the Cutlass by firefighters took approximately 30 minutes. EMS transported to driver RAH. Patient was treated by a trauma team and underwent surgery to have a steel pin placed in the left leg.

Figure 4.26-Scene Diagram



4.15-Case 14-Toyota Corolla vs. Electrical Box and Parked Car

4.15.1 Collision Summary

At approximately 23:15 on February 29, 2000, a male of undermined age driving a 2000 Toyota Corolla was traveling southbound on residential road as what police describe as high rate of speed. The vehicle was coming around a curve in the road when the driver, as he stated in the police report, lost control and jumped the curb and stuck an electrical box on the front right quarter panel of the vehicle. The right rear passenger door then struck a light post. This second collision resulted in the lacerated liver of the passenger in the right rear seat, a 15-year-old female. The vehicle came to rest after striking the left rear quarter panel of a vehicle parked on the right side of the road. Damage to the Corolla consisted of a damage to the left front quarter panel, left rear wheel well bent inwards, rear bumper cover torn off, right rear quarter panel damage, a 6 cm intrusion of the right rear door and peeling of the door metal, the rear window blowing out, and damage to the right front quarter panel. There was no skid evidence of the driver braking prior to the collision. The only passenger injured was the right rear passenger, a 15-year-old female.

4.15.2 Patient Injuries

1. **Right rear passenger (15-year-old female):**

Table 4.20-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Lacerated liver	541820.2	Abdomen	2	4 ISS=4

4.15.3 Haddon's Matrix

Figure 4.27-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver inexperience • Evading police	• Brakes in working condition	• Road curvature
Event	• 15-year-old unbelted	• Speed • No side door airbags	• No guard rail around electrical box • No guard rail around light post
Post-event	• Age • Physical condition	• Side door impact beam allowed for intrusion	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.15.4 Injury Prevention Measures

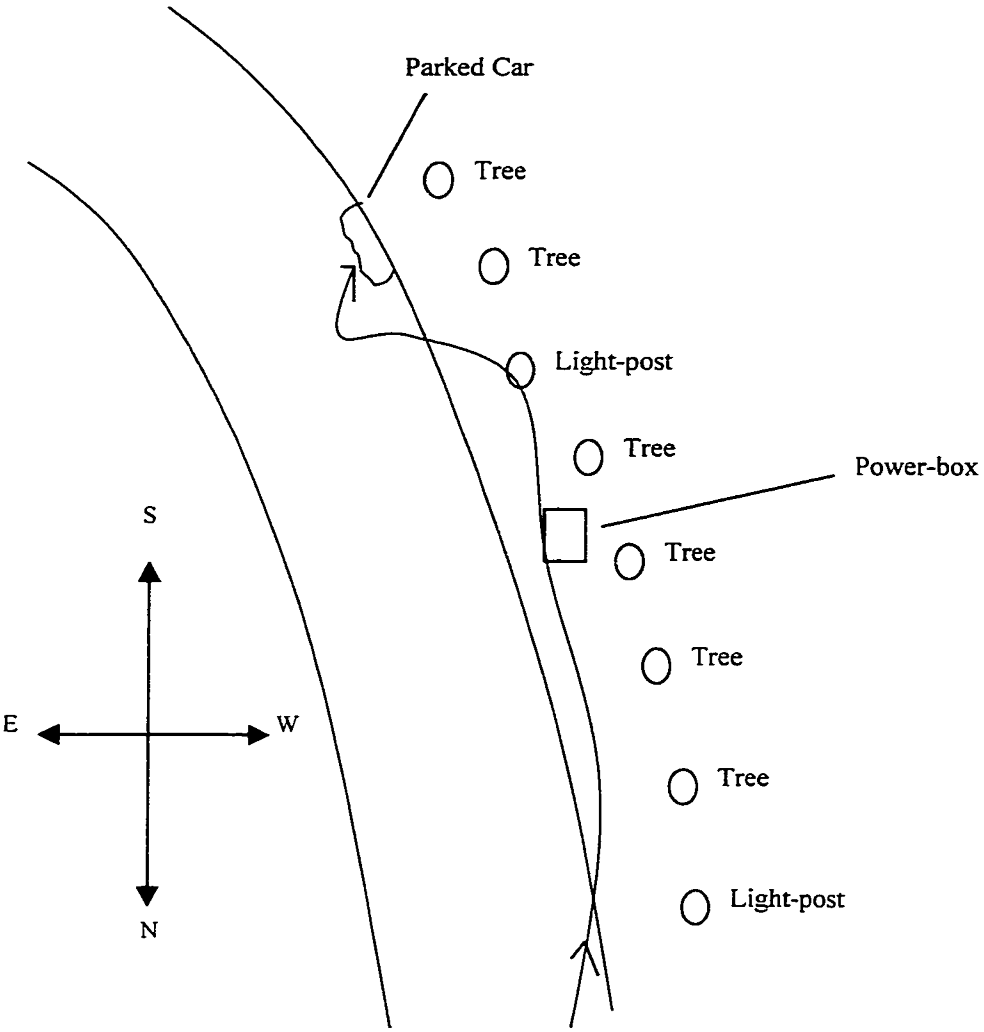
1. Primary Prevention

Speed was a factor resulting in this injury. Although the right rear passenger was unbelted, it is unlikely that the use of a seatbelt would have prevented the injury from occurring. The Corolla sustained a side impact with the light post at the rear door. This side impact is what likely caused the liver laceration of the patient (ATLS, 1997). Decreasing the speed, and the use of side door airbags would have likely reduced or eliminated the injury.

2. Secondary Prevention

EMS transported patient to RAH. Patient was seen by an emergency physician, then transported to UAH and admitted for observation.

Figure 4.28-Scene Diagram



4.16-Case 15-Plymouth Reliant vs. Pedestrian

4.16.1 Collision Summary

At approximately 22:35 on March 2, 2000, in front of Police Headquarters, a 54-year-old female was proceeding through an intersection heading eastbound when a 62-year-old male was crossing through the intersection diagonally in a southwest direction. The female driver had the right of way and the pedestrian was jaywalking. The vehicle, travelling at a police estimated 40 km/h, struck the pedestrian on the right front bumper (height of 0.55 to 0.8 meters). According to undercover police witness statements in the police report, the pedestrian then flipped into the air and onto the roof of the vehicle, and then rolled on the ground onto the right side of the vehicle. The head injuries sustained by the pedestrian occurred when the driver hit the road. The damage to the vehicle consisted of a 0.2-meter wide dent on the front of the bumper. The driver was uninjured and EMS transported to the pedestrian RAH.

4.16.2 Patient Injuries

1. Pedestrian:

Table 4.21-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Basal skull fracture	150200.3	Head/neck	3	9
Contusion of brain	140602.3	Head/neck		ISS=9

4.16.3 Haddon's Matrix

Figure 4.29-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	- Pedestrian intoxication - Not wearing reflective clothing	- Breaks in proper working condition	- No pedestrian overpass
Event	- Age - Physical condition	- Bumper height	- Asphalt
Post-event	- Age - Physical condition	- Proper tire tread depth for stopping	- 911 emergency number - EMS - Trauma care systems - Rehabilitation systems

Adapted from Haddon, 1980

4.16.4 Injury Prevention Measures:

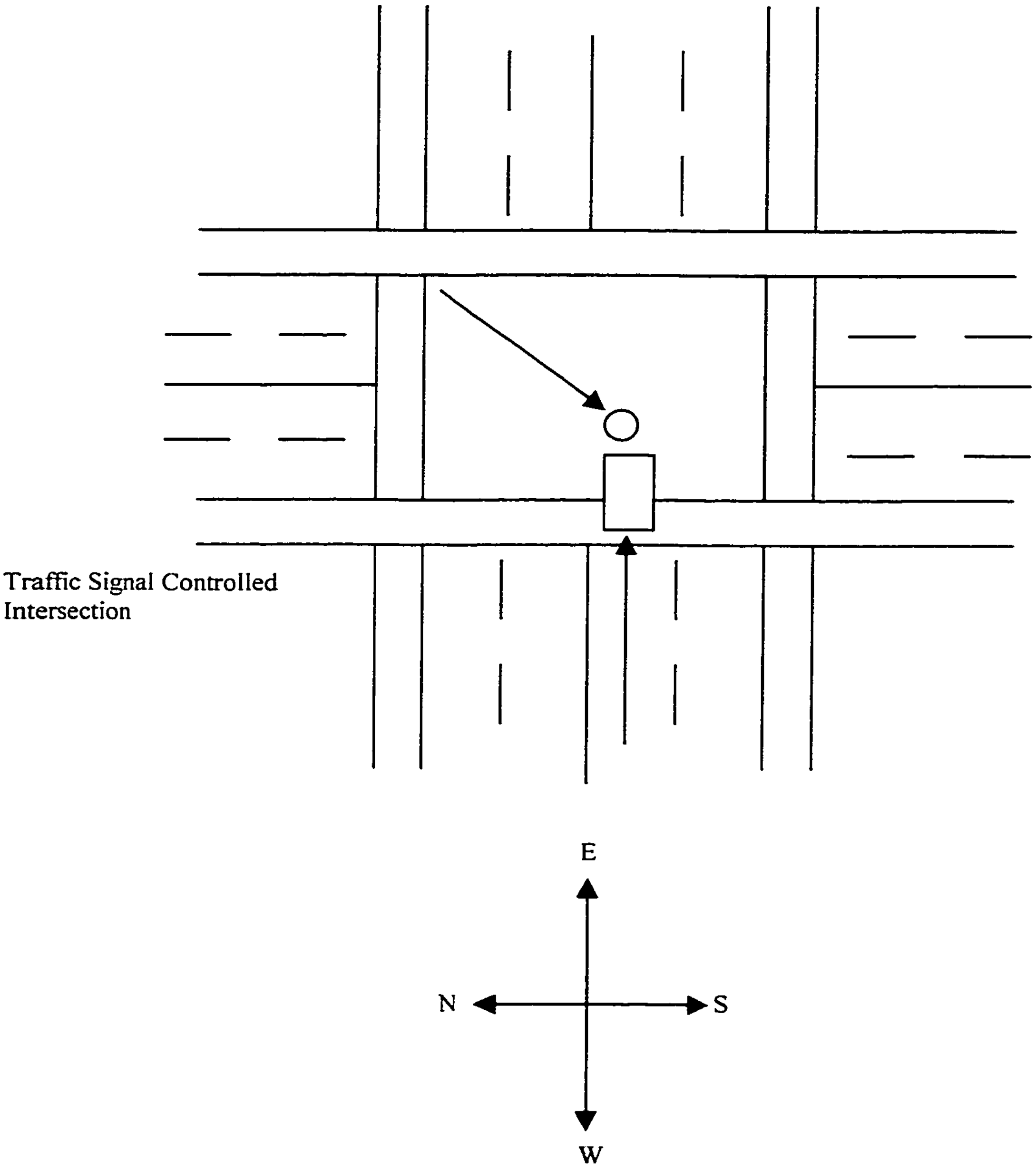
1. Primary Prevention:

The location this collision occurred in is one frequented by many bar and liquor store patrons. This collision occurred 2 blocks south on the same road as Case 1 of this chapter. It is also the scene of past car-pedestrian collisions. Primary injury prevention in this neighborhood is clearly a societal issue due to the nature of the people who frequent it. Engineering methods shown to be effective in reducing car-pedestrian collisions include better illumination of roadways where car-pedestrian collisions are likely to occur (Accident Investigation Quarterly, Winter 1998). Also, wire fencing on the sidewalks separating pedestrians from vehicles will reduce the possibility of pedestrians crossing at locations other than at a proper crosswalk.

2. Secondary Prevention

EMS was called immediately by Police. A trauma team stabilized patient at RAH. Patient was coherent in the ER.

Figure 4.30-Scene Diagram



4.17-Case 16-Plymouth Reliant vs. Pedestrian

4.17.1 Collision Summary

At 16:39 on a cloudy afternoon on March 7, 2000, a 16-year-old male driver of a 1987 Plymouth Voyageur was proceeding in the number two lane of a four-lane road (two lanes in each direction divided by a yellow line). The driver was approaching an uncontrolled intersection with a white reflective crosswalk sign when, according to his police statement, he noticed that the vehicle in the number one lane was stopped and cars behind it were slowing down. The driver of the Voyageur attempted to slow the vehicle down but could not due to the fact that the road was covered with fresh snow and had not been cleaned and sanded. This was evident from the skid marks the vehicle left in the snow. As the vehicle slid to the crosswalk of the intersection, several children came running through the crosswalk in front of the vehicle in the number one lane, and then into the path of the Voyageur. The Voyageur, travelling at a driver estimated 50 km/h, with a bumper height 0.4 meters to 0.55 meters, struck the left side of a 7-year-old male. The impact into the side of the child resulted in a laceration of the liver and a left fractured femur. EMS transported the child to UAH.

4.17.2 Patient Injuries

1. Pedestrian:

Table 4.22-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Fracture left femur	851800.3	Extremities	3	9
Laceration of spleen	544220.2	Abdomen	2	4 ISS=13

4.17.3 Haddon's Matrix

Figure 4.31-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver inattention	• No antilock brakes • No snow tires	• Ice on roads • Poor signage • No pedestrian overpass
Event	• Pedestrian attention • Age • Physical condition	• Speed	• Intersection • Asphalt
Post-event	• Age • Physical condition	• Poor tire traction for stopping	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.17.4 Injury Prevention Measures

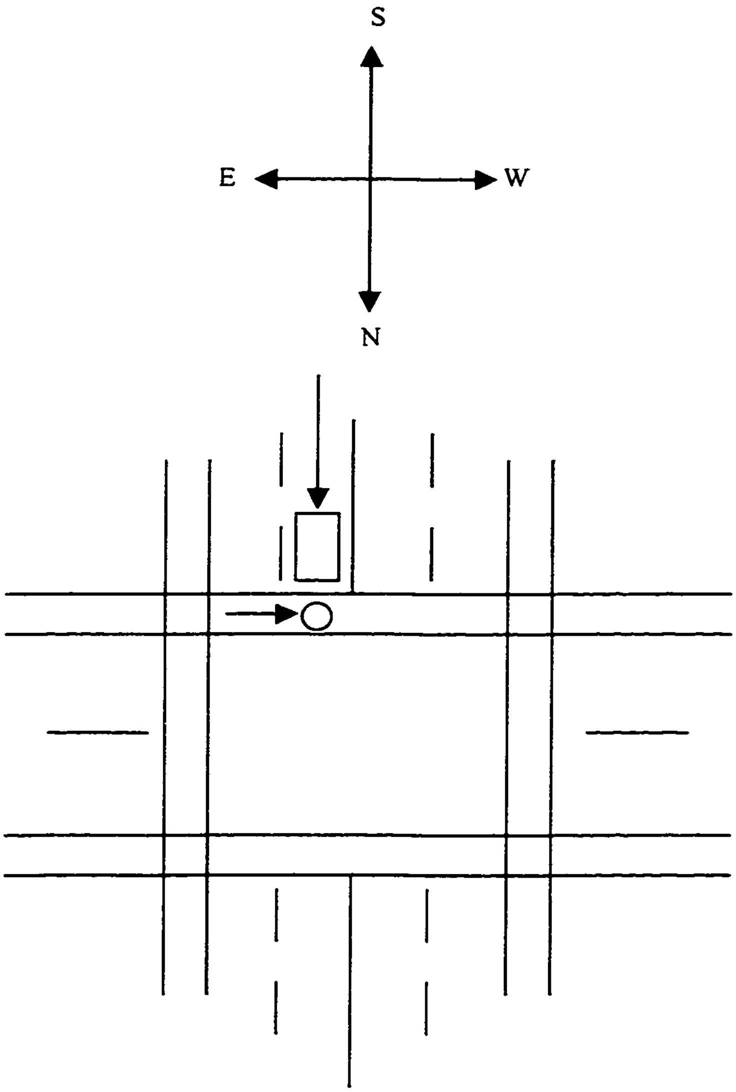
1. Primary Prevention

An injury prevention strategy in this case would be to move the stop line at the crosswalk farther back (Accident Investigation Quarterly, Spring 1998). Had the stop line been further back, the driver and pedestrians may have been able to seen each other better and the collision could have been prevented. Secondly, the road conditions were very slippery, and the driver was unable to stop the vehicle. Road maintenance would have likely allowed the Voyageur to stop before reaching the crosswalk.

2. Secondary Prevention

EMS transported the pedestrian to UAH. A trauma team at UAH treated patient. A cast was put on the leg.

Figure 4.32-Scene Diagram



4.18-Case 17-Pontiac Grand Am vs. Dodge Ram Van and Oldsmobile Cutlass

4.18.1 Collision Summary

On March 14, 2000, at approximately 10:40 on a clear and sunny morning, a 42-year-old male driver of a 1986 Pontiac Grand Am was proceeding northbound on a 60 km/h, four lane road (two lanes in each direction separated by a concrete barrier). The driver, according to witness statements in the police report, was approaching a major traffic signal controlled intersection for which the light was red for him. The unrestrained driver proceeded through the intersection without braking. This was evident by the fact that there were no skid marks, and a mechanical inspection revealed that that brakes were in working order. The Grand Am was struck on the right side of the vehicle at a police estimated 80 km/h by a 1981 Dodge Ram van driven by a 28-year-old male travelling westbound in the number one lane of a four lane road (two lanes in each direction, separated by a concrete barrier). The Grand Am was struck on the right side and spun into a 1986 Cutlass that was in the turning lane waiting to turn eastbound. This resulted in the driver of the Grand Am striking the interior of the vehicle (at a location undetermined by the researchers), resulting in a closed head injury. The Grand Am came to rest in the grass beside the Cutlass. The Cutlass remained in the turning land and the van came to a rest with its rear bumper in contact with the Cutlass.

Damage to the Grand Am was extensive. The front bumper and hood were crumpled (forward section towards bumper-0.3 meters, mid wheel well-0.3 meters, rear portion by A-pillar-0.4 meters), front right headlight and grill smashed. The A-pillar on the driver side (1.45 meters from the front) was bent outward and the driver side door was bent outward. On the initial impact site with the van (right side of Grand Am), the front right quarter panel was crushed into the engine bay, the right A-pillar from the hood to rocker panel was crushed in (A-pillar 0.1 meters), the front right passenger door was crushed in towards the center console (0.41 meters). The body behind the right B-pillar was crumpled to the right rear wheel well. The right B-pillar was crushed in 0.10 meters inward. The right front seat and dash were compacted into the center console.

Damage to the impacting Dodge Ram included bumper crush (maximum at 0.21 meters), the corner of the front quarter panel crushed into the front left tire, the front left quarter panel crumpled into the front left door jam, the hood crumpling, and both headlights breaking. Interior damaged consisted of the steering column bending under the stress of the restrained driver. The left side of the windshield was cracked and stained with blood. This damage corresponded to the head laceration and concussion sustained by the driver of this vehicle.

The driver of the Cutlass was uninjured. The Cutlass sustained a dent to the front left corner of the quarter panel (from initial impact with Grand Am), paint transfer from the Grand Am from the A-pillar to the B-pillar, and a cracked front windshield. There was body crumple behind the left A-pillar (2.9-3.35 meters from the front left corner).

4.18.2 Patient Injuries

1. Driver of Grand Am (42-year-old male):

Table 4.23-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Closed head injury	115099.9	Head/neck		
Right multiple rib fractures	450210.2	Chest		
Right pneumothorax	441414.3	Chest	3	9 ISS=9

4.18.3.1 Haddon's Matrix

Figure 4.33-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Unknown	• Brakes in working order	• Speed limit
Event	• No seatbelt use •	• Speed • No occupant safety cage	• Intersection
Post-event	• Age • Physical condition	• Crush required extication	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

2. Driver of Dodge Ram (28-year-old male):

Table 4.24-Patient Injuries

Injury	**AIS**	**ISS Body Region**	**Highest AIS**	**AIS^2**
Laceration of scalp (10 cm deep)	110600.1	Head/neck		
Concussion	161000.2	Head/neck	2	4 ISS=16

4.18.3.2 Haddon's Matrix

Figure 4.34-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Attention	• Brakes in working order • Center of gravity • Loaded cargo bay affecting handling of vehicle	• Speed limit
Event	• Seatbelt • Airbag	• Speed	• Intersection
Post-event	• Age • Physical condition	• Tire traction proper for stupping	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.18.4 Injury Prevention Measures

1. Primary Prevention

The injuries sustained by the driver of the Grand Am may have been decreased in severity had the driver been wearing a seatbelt. A side and head airbag may have reduced or eliminated the closed head injury he suffered (BMW reference).

The injuries sustained by the driver of the Dodge Ram would have likely been reduced had the vehicle been equipped with a front airbag.

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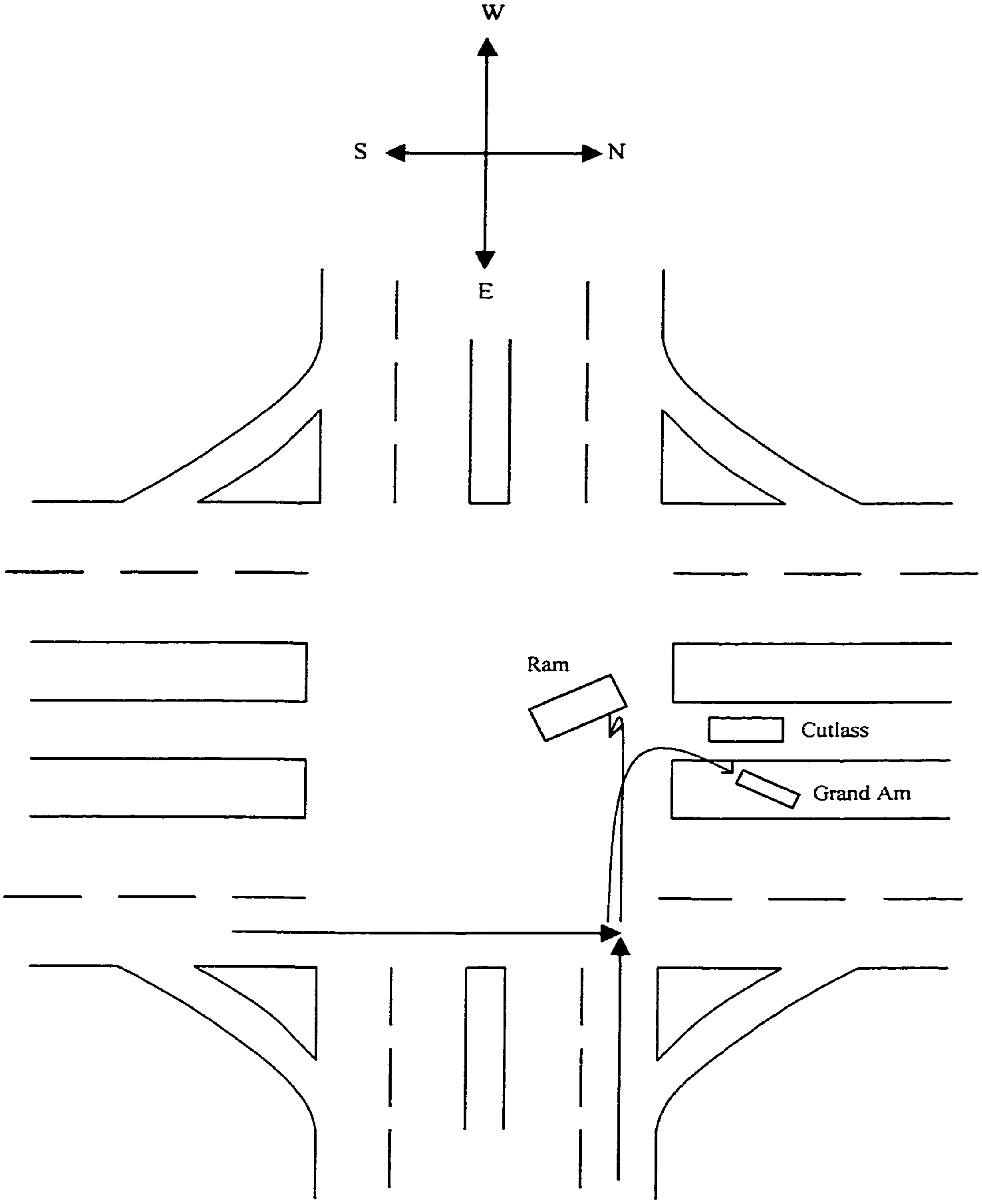
2. Secondary Prevention

EMS transported all three drivers to RAH. The drivers of the Dodge Ram and the Cutlass were seen by an emergency physician and released. The driver of the Grand Am was admitted to ICU.

Figure 4.35-Scene Diagram



4.19-Case 18-Mazda 626 LX vs. Light Post

4.19.1 Collision Summary

On March 17, 2000 at 15:51 during a clear and sunny day, a17-year-old male driver was travelling at a police estimated 100 km/h entering eastbound into the City of Edmonton in the number four lane of a one way four lane road. The Mazda 626 that he was driving approached a traffic signal controlled intersection for which, according to witness statements in the police report, the light was green for eastbound traffic. The driver began to change into the number two lane, but saw that there was a vehicle stopped at the intersection in that lane. The driver then attempted to get into the number one lane, which is an exit southbound. The number one lane merges away from the number two lane, and is separated by an island which also supports the traffic light. The driver of the Mazda was unable to negotiate the turn into the number one lane and the vehicle jumped the island and smashed head-on into the traffic light pole.

There were four occupants in the vehicle including the driver. The driver and the 17-year-old male front passenger were both wearing seatbelts. The driver was transported to UAH and the front passenger to Misericordia Hospital. The right rear female passenger, a 17-year old unrestrained female, and the left rear passenger, an 18-year-old unrestrained female passenger, were both transported to UAH.

The left rear passenger died in hospital. The mechanism of her injuries appear to be as follows: The 18-year-old female first crashed into the right front passenger seat. The chair was bent forward and to the right. She then continued forward and smashed into the front windshield. The windshield had a spiral in it with hair evidence as well. There was a second spiral with hair evidence in front of the right front passenger, which corresponds to his head also striking the glass. The 18-year old female sustained one more collision. A VCR sitting on the rear shelf of the back seat was thrown upon impact and hit the back of her head. The VCR had a dent in it the shape of a head.

The vehicle sustained severe frontal crush to the front center bumper and engine bay. The driver's side floor pan was pushed into the driver's seat. The whole left dash intruded into the passenger compartment. The left rocker panel at the driver's side was bent downward, corresponding with the intrusion of the floor pan. The steering column was bent downwards. The left front roof over the driver's area was bent down into the occupant compartment.

4.19.2 Patient Injuries

1. **Left rear passenger (18-year-old female):**

Table 4.25-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Closed head injury (Diffuse axonal injury)	140628.5	Head/neck	5	25
Scalp laceration	110600.1	Head/neck		
Ventricular tachycardia				
Abrasions of ankles	810202.1	Extremities	1	1 AIS=25

4.19.3.1 Haddon's Matrix

Figure 4.36-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Unknown	• Brakes in poor condition	• Speed limit • No breakaway pole
Event	• No seatbelt use by rear passengers	• Speeding	• Light post
Post-event	• Age • Physical condition	• VCR in rear struck occupant	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

2. **Right rear passenger (17-year-old female):**

Table 4.26-Patient Injuries

Injury	**AIS**	**ISS Body Region**	**Highest AIS**	**AIS^2**
Facial abrasions	210099.1	External		
Right femur fracture	851800.3	Extremities	3	9 ISS=9

4.19.3.2 Haddon's Matrix

Figure 4.37-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Attention	• Brakes	• Speed limit
Event	• Seatbelt	• Speed	• Light post
Post-event	• Age • Physical condition	• Extrication	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

3. Driver (17-year-old male):

Table 4.27-Patient Injuries

Injury	**AIS**	**ISS Body Region**	**Highest AIS**	**AIS^2**
Abrasions left cheek	212202.1	External	1	1
Abrasions left neck	310202.1	External		
L1 spinous process fracture	650618.2	Abdomen	2	4
L1 transverse process fracture	650420.2	Abdomen		
L2 spinous process fracture	650618.2	Abdomen		
L2 transverse process fracture	650618.2	Abdomen		ISS=5

4.19.3.3 Haddon's Matrix

Figure 4.38-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Speeding • Erratic driving	• Brakes in poor condition	• Speed limit • No breakaway pole
Event	• Wearing seatbelt	• Speed • No occupant safety cage	• Light post
Post-event	• Age • Physical condition	• Extrication due to frame damage	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

Note: The injuries sustained by the front right passenger were not investigated because the patient was not transported to UAH or RAH.

4.19.4 Injury Prevention Measures

1. Primary Prevention

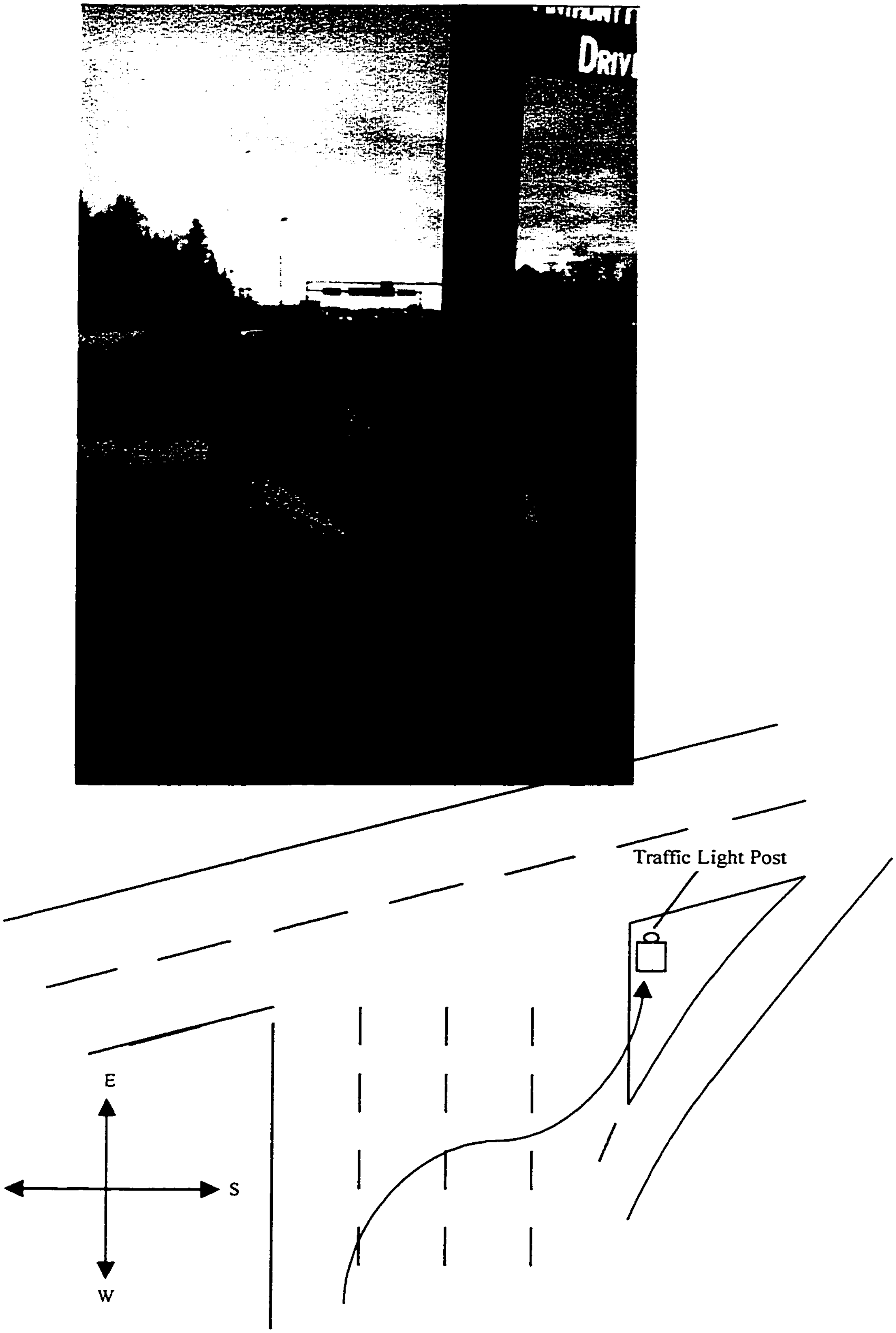
The fatal injuries sustained by the 18-year-old female could have been prevented had she been wearing a lap and shoulder belt. This is another example of the importance of seatbelt usage. The VCR on the back shelf was not properly contained, and should have been kept in the trunk. Newton's First Law states that an object will continue in motion unless acted on upon by an external force. Sadly, in this case, it was the back of her head that stopped the VCR. A breakaway pole would have decreased the severity of the crash.

The female in the right rear passenger may have had less severe injuries had the vehicle been travelling slower.

2. Secondary Prevention

The driver and rear passengers were all transported to UAH. The 18-year-old female died in hospital. The driver was admitted to the neurotrauma ward and released several days later after observation. The 17-year-old female had surgery to set her fractured femur.

Figure 4.39-Scene Diagram



4.20-Case 19-Toyota Van vs. Pedestrian

4.20.1 Collision Summary

On March 25, 2000, at approximately 22:20 on a clear night, a 50-year-old driver of a 1987 Toyota van was stopped in a westbound direction at an uncontrolled intersection. According the driver's statement in the police report, the driver began turning left southbound into the number two lane of a four-lane road (two lanes in each direction separated by a yellow line). As she turned into the number one lane, she saw a 45-year-old male walking his dog 10 meters after the intersection (not in a crosswalk). The woman, proceeding at a driver estimated 20 km/h attempted to apply the brakes, but instead pressed the accelerator and struck them man. A speed analysis was not possible due to lack of skids on the road. The van, with a bumper height of 0.42-0.54 meters, and a hood height of 0.55-1.18 meters above the ground, struck the man and dragged him under the bumper. The man left handprints on the hood of the vehicle, 1.1 meters above the ground. The pedestrian was struck on the left side of the bumper of the vehicle. A bystander helped the driver of the vehicle reverse the van in order to free the pedestrian.

The van was equipped with metal studded tires for snow traction.

4.20.2 Patient Injuries

1. Pedestrian:

Table 4.28-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Closed head injury	115099.9	Head/neck		
Basal skull fracture	150200.3	Head/neck	3	9 ISS=9

4.20.3 Haddon's Matrix

Figure 4.40-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver' s night vision • Pedestrian jaywalking	• Improper tires	• No pedestrian overpass • Poor lighting • Heavy traffic location
Event	• Age	• Bumper height • Speed	• Street, not at crosswalk • Asphalt
Post-event	• Age • Physical condition	• Decreased stopping ability due to studded tires	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.20.4 Injury Prevention Measures

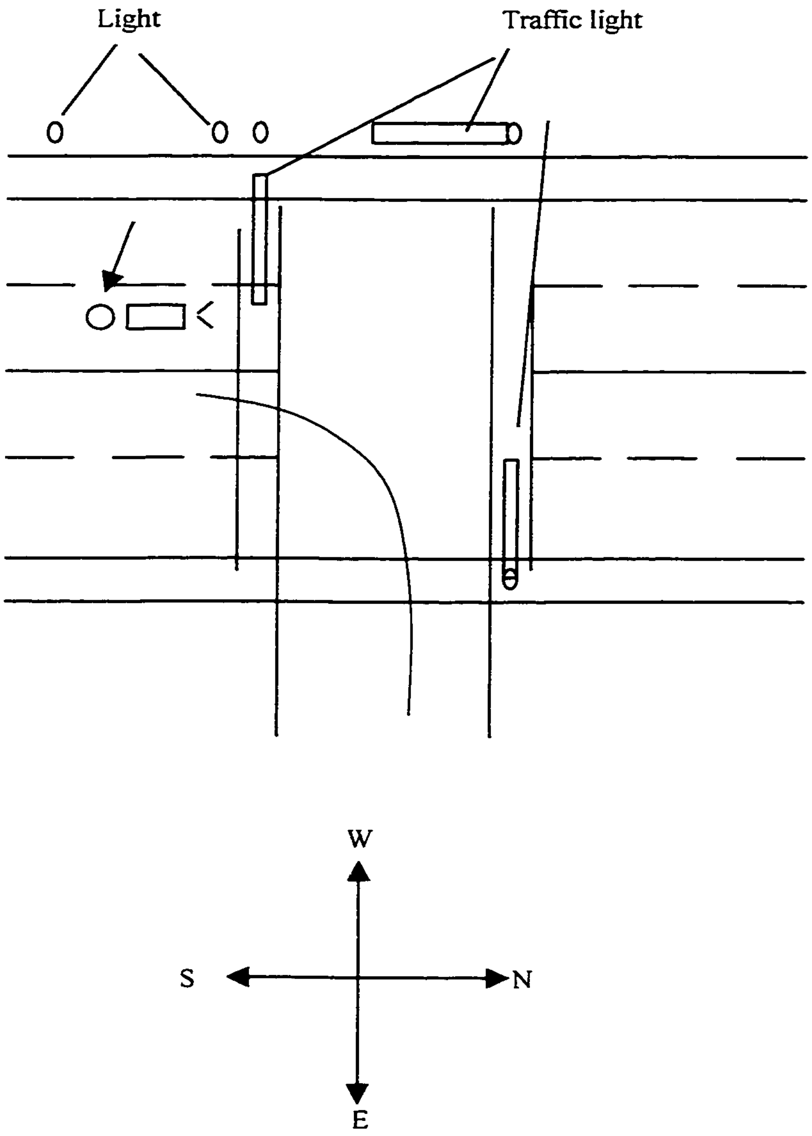
1. Primary Prevention

In this case, the pedestrian was jaywalking. If the pedestrian was crossing at the intersection, which has light posts on each corner, perhaps the driver would have seen the pedestrian and had time to react. Also, according to the driver in the police statement, the driver stepped on the accelerator instead of the brake pedal. Driver reaction contributed to the collision occurring.

2. Secondary Prevention

EMS transported the pedestrian to RAH. Trauma team treated patient at RAH. Patient was admitted to ICU.

Figure 4.41-Scene Diagram



4.21-Case 20-GMC Sierra 1500 vs. Light Post

4.21.1 Collision Summary

On April 2, 2000, at approximately 15:00 on a clear and sunny afternoon, an 18-year-old male driver of a 1995 GMC Sierra 1500 truck and this 21-year-old female passenger were travelling southbound at a high rate of speed in the number two lane of a four lane road (two lanes in each direction separated by a yellow line). Due to the lack of skid evidence, police were unable to determine the velocity of the truck. According to witness statements in the police report, as the truck approached a traffic light controlled intersection, the left front wheel of the truck hit an elongated pothole. The driver lost control of the vehicle and it turned in a southeast direction. The left front quarter panel of the truck struck a traffic light post in the southeast corner of the intersection. The vehicle then spun counterclockwise and came to a stop.

The vehicle sustained severe damage. The left front quarter panel was completely destroyed and the left front of the hood crumpled inwards. The left A-pillar was bent to the rear of the vehicle and the left door bent into the occupant compartment. The dashboard on the left side of the vehicle was pushed into the left front seat, which was pushed right into the rear seat. The floor pan also intruded into the occupant compartment. The rear window also broke as a result of the force of the crash. To have an idea of the amount of intrusion occurred on the left side, the right front seat measured from the middle of the seat to the dash was 0.85 meters. On the driver's side this measurement was 0.45 meters. The driver's side airbag deployed in this crash. Both driver and passenger were restrained.

4.21.2 Patient injuries

1. Driver:

Table 4.29-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Abrasion left cheek	210202.1	External	1	1
Contusion lower lip	210402.1	External		
Contusion left hip	850602.1	Extremities	1	1
Abrasion left knee	810202.1	Extremities		ISS=2

2. Passenger:

Table 4.30-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Contusion right elbow	750610.1	Extremities	1	1
Contusion right knee	850802.1	Extremities		AIS=1

4.21.3 Haddon's Matrix

Figure 4.42-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver drinking • Stolen vehicle	• Brakes in working order	• Pothole in road
Event	• Airbag • Wearing Seatbelt	• Speed	• No breakaway light post • Intersection
Post-event	• Age • Physical condition	• Dashboard intrusion	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.21.4 Injury Prevention Measures

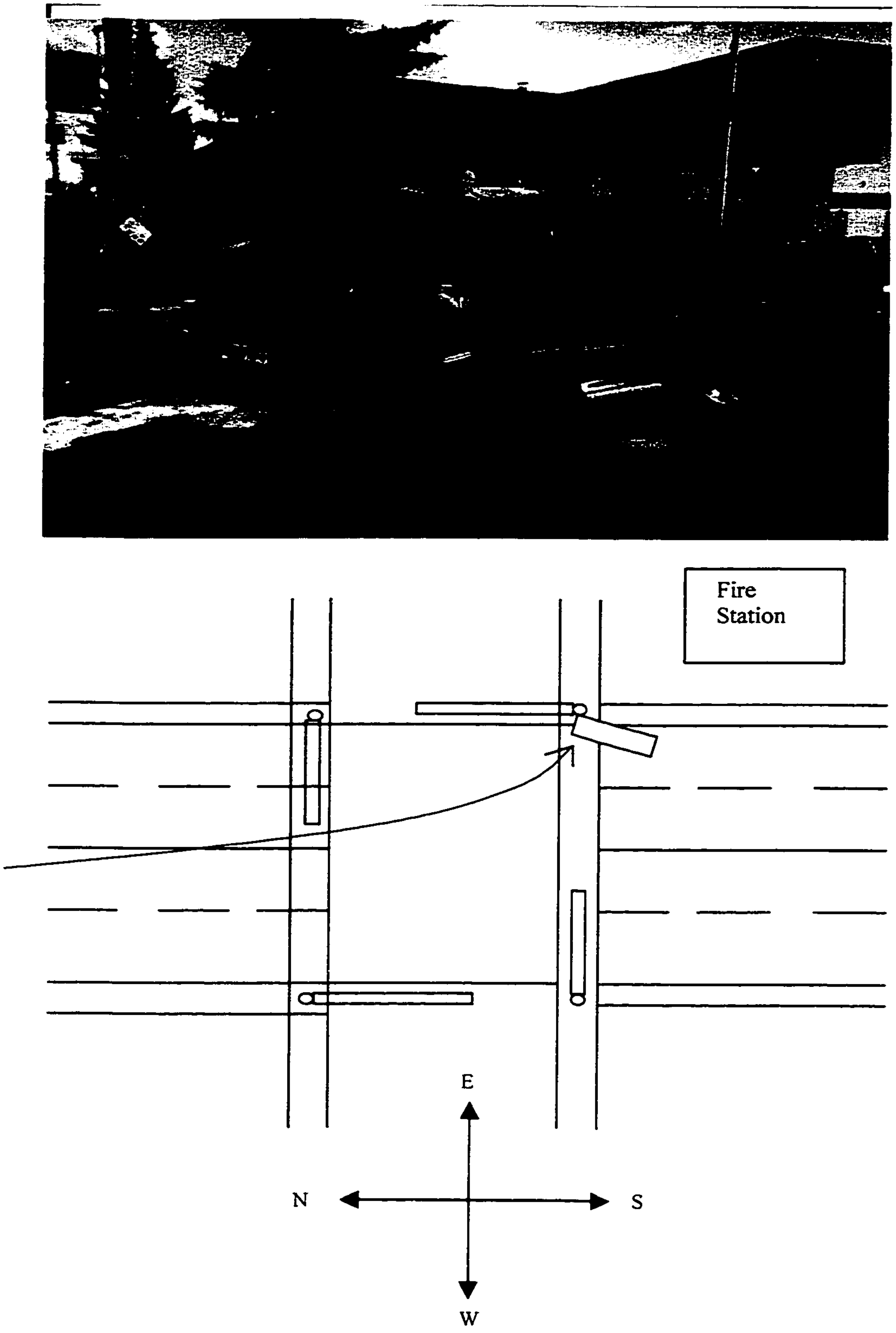
1. Primary Prevention

The injuries in this case were a result of vehicle speed, driver experience, the pothole in the road, and the intrusion of the dashboard into the occupant compartment. These injuries could have been prevented had the driver been following the speed limit and had the pothole in the road been repaired. The driver was also under the influence of alcohol. A breakaway light post may have decreased the severity of the crash.

2. Secondary Prevention

The collision occurred right beside a fire hall. Firefighters rushed out to tend to the injured driver and passenger. The driver was found slumped over the steering wheel unconscious and not breathing. Firefighters restored his breathing and EMS transported him and the passenger to UAH. The driver and passenger were examined by an emergency physician and released the same day.

Figure 4.43-Scene Diagram



4.22-Case 21-Dodge Ram 2500 vs. 1994 Pontiac Grand Am

4.22.1 Collision Summary

On April 21, 2000 at 7:58 on a clear and sunny morning, a 53-year-old male driver of a 1994 Pontiac Grand Am was proceeding eastbound in the number two of four lanes on a one way off ramp towards an intersection. The off ramp intersects with a five lane northbound road controlled by a traffic light. A witness travelling behind the Grand Am stated in the police report that the traffic light was red for the eastbound traffic. He also stated that the sun was rising at that time and in the view of eastbound traffic. The Grand Am driver did not brake or stop at the intersection and entered into it. The Grand Am was struck on the front right door (2.8 meters from the rear corner, with maximum penetration of 0.34 meters) and in the front right quarter panel (3.6 meters from the rear corner and 0.37 meters above the ground, with maximum penetration of 0.32 meters) by a 1996 Dodge Ram 2500. The 51-year-old restrained driver of the Dodge was travelling in the number two lane, at a driver estimated 50 km/h. Police were unable to perform a speed analysis on either vehicle because neither vehicle braked prior to the collision, therefore not leaving any skid evidence. The Dodge, with a front bumper height of 0.45 to 0.85 meters, struck the Grand Am and spun in a clockwise direction. The Dodge came to rest in the northwest corner of the intersection, crashing into a concrete overpass barrier, which is designed to protect vehicles from falling onto the freeway below. The Dodge sustained a front bumper crush of 0.1 meters, and body damage to the entire left side of the vehicle due to the crash with the concrete barrier. The Dodge's driver side airbag inflated during the initial collision, with the driver suffering stiffness after the collision. The Grand Am spun in a counterclockwise direction and cam to rest in the number three lane of the northbound road, approximately ten meters from the intersection. A bystander, who tended to the driver, found the driver of the Grand Am in the front passenger seat. The driver received a contusion of the frontal lobe when his head made contact with the interior of the vehicle. The researchers were unable to verify where this contact occurred during the investigation. In addition to the right front door and right front quarter panel damage, the right A-pillar buckled up, the front hood buckled up in the center, and the windshield was cracked. The driver of the Grand Am was not wearing a seatbelt.

4.22.2 Patient Injuries

1. Driver of Grand Am:

Table 4.31-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Contusion right frontal lobe	140602.3	Head/neck	3	9
Pneumothorax	441414.3	Chest	3	9 ISS=18

4.22.3 Haddon's Matrix

Figure 4.44-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver inattention	• Brakes in working order	• Sun
Event	• Not wearing seatbelt	• Speed	• Red light • Intersection
Post-event	• Age • Physical condition	• Tires in proper condition for stopping	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.22.4 Injury Prevention Measures

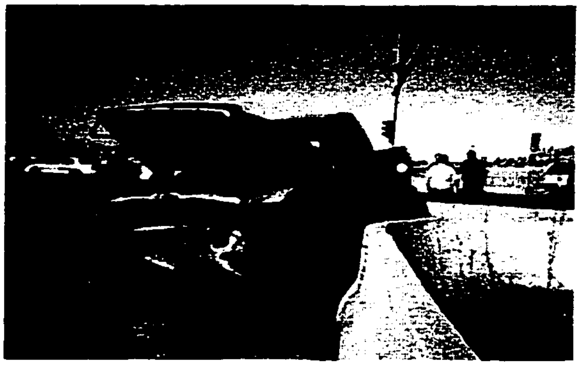
1. Primary Prevention

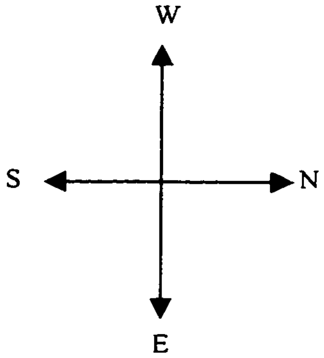
The injury sustained by the driver of the Grand Am may have been decreased in severity had the driver been wearing his seatbelt. The driver was thrown to the right side of the vehicle during the impact, and sustained an injury to the right frontal lobe. The driver of the Dodge Ram was uninjured.

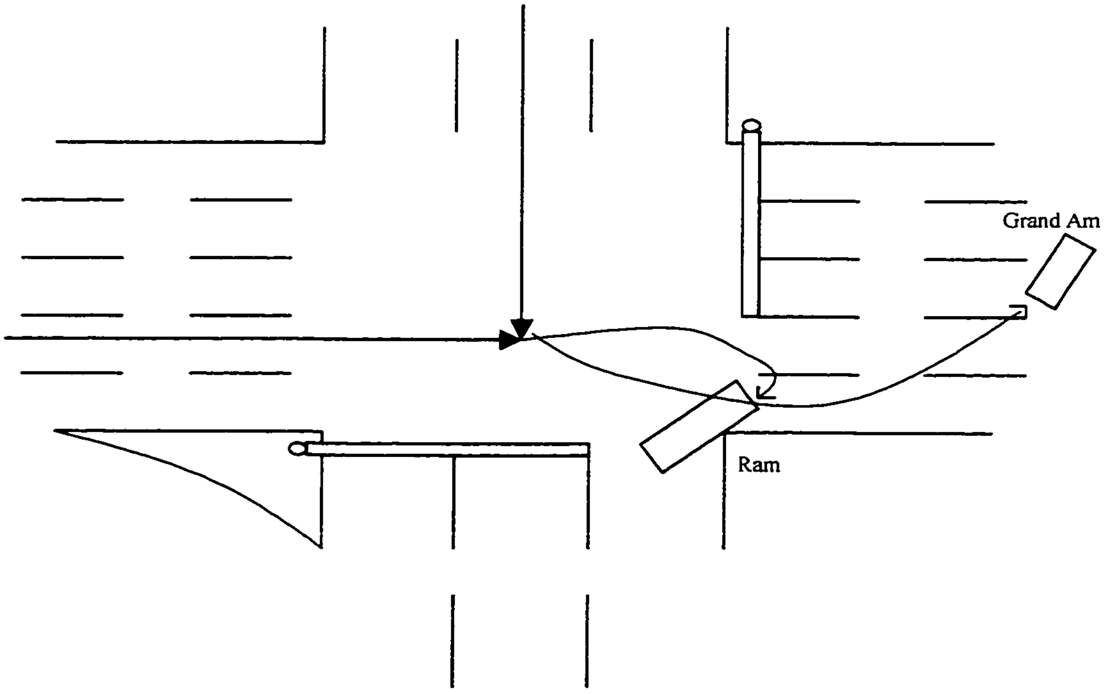
2. Secondary Prevention

EMS transported the driver of the Grand Am to UAH. Trauma team at UAH initially treated patient. Patient was admitted to ICU.

Figure 4.45-Scene Diagram







4.23-Case 22-Ford F-150 vs. Pedestrian

4.23.1 Collision Summary

On April 26 at 21:45, a 76-year-old male driver of a 1996 Ford F-150 truck was making a left turn northbound from a four-lane road (two lanes in each direction separated by a concrete divider) at an uncontrolled intersection. The intersection is lighted by a gas station on the northwest corner of the intersection, and a street light on the northeast corner of the intersection. As the driver was completing the left turn into a residential area, he stated in the police report that he noticed a pedestrian crossing the street in a northwest direction towards the gas station several meters away from the intersection. Upon seeing the pedestrian, the driver swerved left and depressed the brake to the maximum. The truck, with a front bumper height of 0.52-0.8 meters above the ground, and a leading edge of the hood of 1.22 meters above the ground, struck the pedestrian, who suffered a left fractured fibula and tibia. There was no damage to the vehicle and the driver was unhurt. A bystander called 911 and EMS transported the pedestrian to RAH.

4.23.2 Patient Injuries

1. **Pedestrian:**

Table 4.32-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Left fibula fracture	851800.3	Extremities	3	9
Left tibia fracture	853404.2	Extremities		ISS=9

4.23.3 Haddon's Matrix

Figure 4.46-Haddon's Matrix

Phase **Factor**

	Host	**Vehicle**	**Environment**
Pre-event	• Driver reaction time • Driver inattention • Pedestrian jaywalking	• Brakes in working order	• No stop sign in intersection
Event	• Pedestrian age • Physical condition	• Low speed • High bumper height	• Intersection • Asphalt
Post-event	• Age • Physical condition	• Brakes and tires in proper working condition for stropping	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.23.4 Injury Prevention Measures

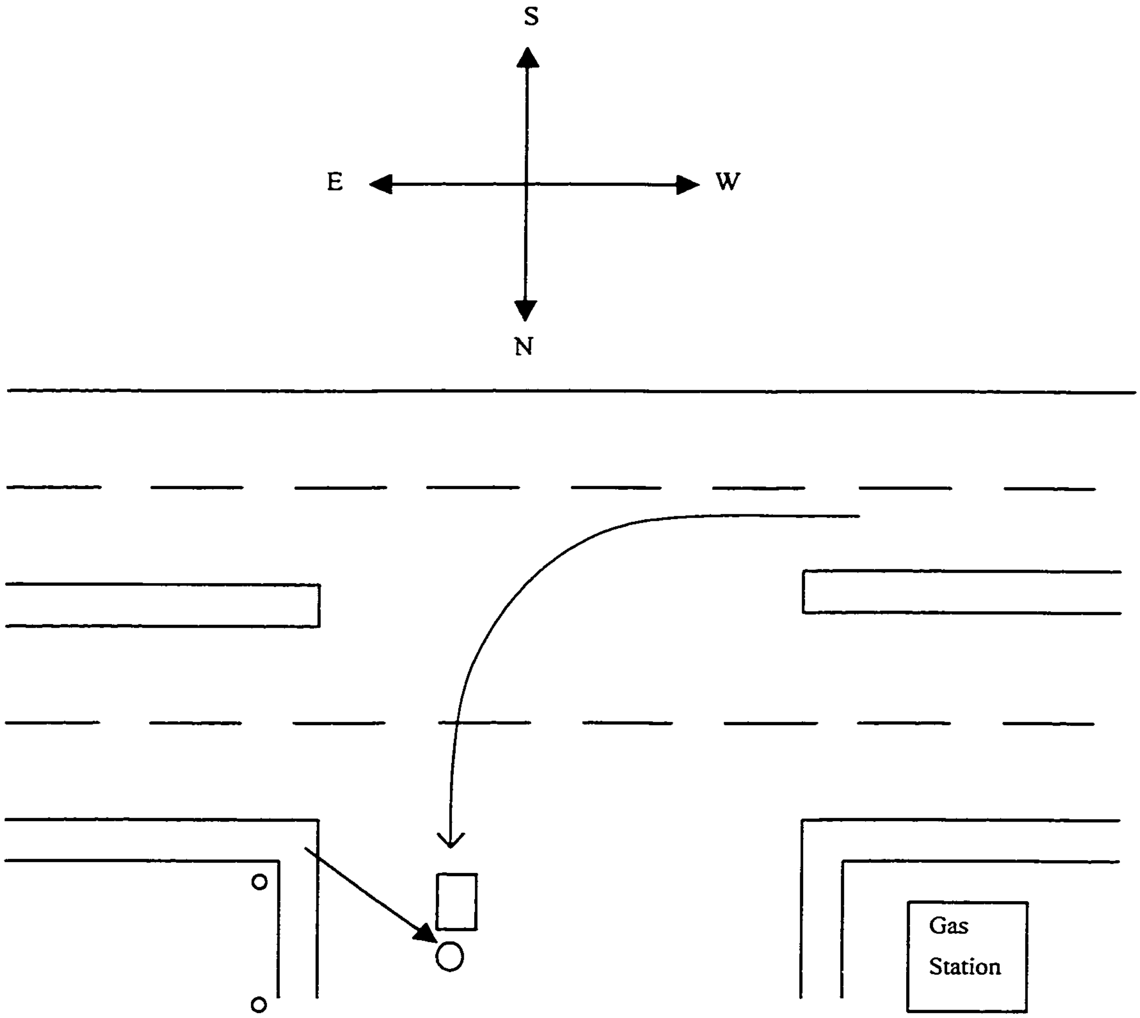
1. Primary Prevention

The location in which this collision occurred is lighted by the bright lights of the gas station in the northeast corner of the intersection, and by the light in the northeast corner of the intersection. The collision, and in turn the injury, could have been prevented had the driver been more alert and looking for crossing pedestrians when making the left turn. Research at the Institute for Improved Highway Safety shows that substituting four-way stop signs for traffic signals at low-volume intersections reduces pedestrian crashes by 24% (Accident Investigation Quarterly, Spring 1998). Perhaps had a stop sign been in place for the male driver, he would have had time to see the pedestrian before crossing.

2. Secondary Prevention

EMS transported patient to RAH. An emergency physician put a cast on the left leg of the pedestrian, who was then released from the hospital.

Figure 4.47-Scene Diagram



4.24-Case 23-Plymouth Voyageur vs. Pedestrian

4.24.1 Collision Summary

On April 27 at 21:49 on a clear night, a 32-year-old male driving 1986 Plymouth Voyageur mini van was proceeding southbound in the number two lane of a four-lane road (two lanes in each direction separated by a yellow line). The driver stated in the police report that he had just passed through a traffic signal controlled four-way intersection for which the light was green for him when a pedestrian walking westbound appeared in front of the van. The pedestrian was not crossing at the intersection, but was approximately 10-15 meters past the traffic light. Upon seeing the pedestrian, the driver stated in the police report that he swerved left and applied maximum pressure on the break pedal. The vehicle, travelling at a driver estimated 50 km/h, struck the pedestrian on the front right side of the bumper and hood. The bumper height of the van was 0.4-0.55 meters above the ground with the leading edge of the hood 0.9 meters above the ground. The van hit the pedestrian on his right side. The impact caused the pedestrian to sustain severe abdominal injuries, which resulted in his death at the hospital. The impact with the pedestrian caused a 0.13-meter crumple on the front hood.

The pedestrian rode up the right side of the hood, hit the antenna on the right side of the front quarter panel, and landed in the number one lane. The driver, who was restrained, was not injured in the collision. EMS was called and transported the pedestrian to UAH.

4.24.3 Patient Injuries

1. **Pedestrian:**

Table 4.33-Patient Injuries

Injury	AIS	ISS Body Region	Highest AIS	AIS^2
Closed head injury	115099.9	Head/neck		
Traumatic abdominal injury	515999.9	Abdomen		
Fractured pelvis	852600.2	Extremities		
Fractured femur	851800.3	Extremities	3	9 ISS=9

4.24.3 Haddon's Matrix

Figure 4.48-Haddon's Matrix

Phase **Factor**

	Host	Vehicle	Environment
Pre-event	• Driver attention • Driver reaction time • Pedestrian jaywalking	• Brakes in working order	• No pedestrian overpass
Event	• Age • Physical condition	• Speed • Bumper height • Hood height	• Intersection • Asphalt
Post-event	• Age • Physical condition	• Brakes and tire traction in proper working condition for stopping	• 911 emergency number • EMS • Trauma care systems • Rehabilitation systems

Adapted from Haddon, 1980

4.24.4 Injury Prevention Measures

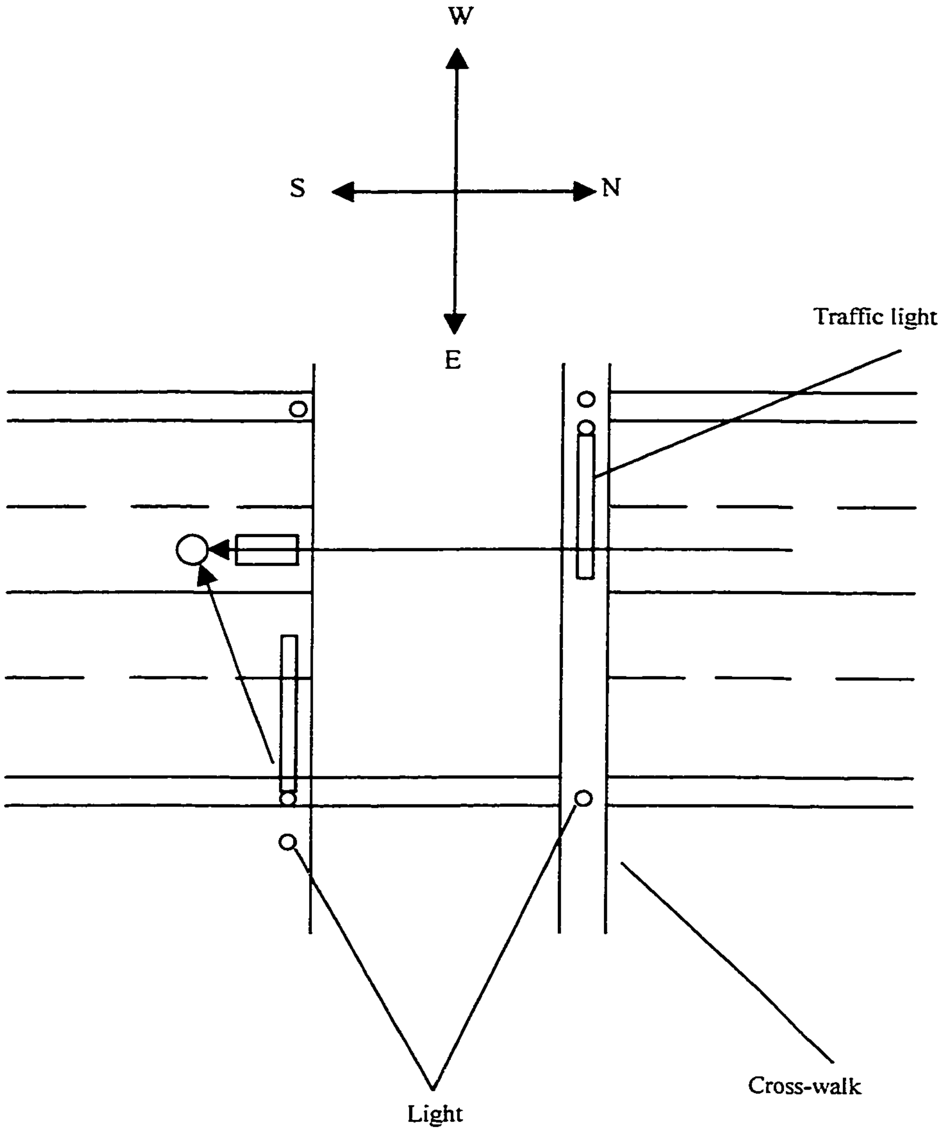
1. Primary Prevention

This is the second pedestrian collision on this road that has been involved in this study. Several other cases involved in this study have been in the vicinity of this location. The injury could have been prevented in this case had the pedestrian crossed at the intersection when the signal gave him the right of way.

2. Secondary Prevention

EMS transported the patient to UAH. The trauma team at the UAH stabilized the patient before a trauma surgeon performed exploratory surgery. The pedestrian died at 02:30 from his injuries.

Figure 4.49-Scene Diagram



4.25 Case Summary Statistics

Table 4.34-Hospital and Mean Injury Severity Score

Hospital	Mean Injury Severity Score
University of Alberta	13.08
Royal Alexandra	9.25

Table 4.35-Gender and Mean Injury Severity Score

Gender	Mean ISS
Male	9.39
Female	13.55
Both	10.97

Table 4.36-Driver Gender and Seatbelt Use

Gender	Belted	Unbelted	Unknown
Male	18	3	2
Female	3	2	1
Total	21	5	3

Figure 4.50-Mean Injury Severity Score and Collision Type

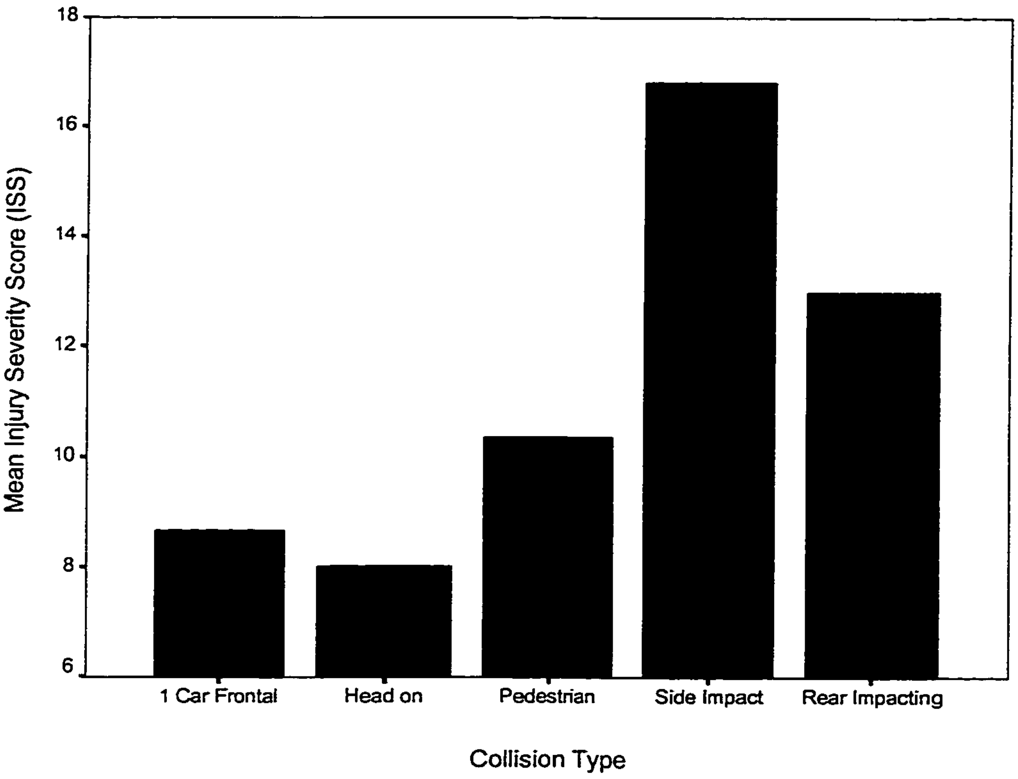


Table 4.37-Collision Type and Number of Injuries by Body Region

Collision Type	Body Region 1	Body Region 2	Body Region 3	Body Region 4	Body Region 5	Body Region 6	Total
	Head/neck	Face	Chest	Abdomen	Extremities	External	
Frontal	3	0	0	4	8	5	**20**
Head on	2	0	3	0	6	1	**12**
Pedestrian	13	4	3	2	23	0	**45**
Side impact	5	0	5	4	1	0	**15**
Rear impact	3	0	0	0	5	0	**8**
Total	**26**	**4**	**11**	**10**	**43**	**6**	**100**

CHAPTER Five
Conclusions and Future Directions

5.1 Conclusions

The objective of this study was to design a model that studies the biomechanics of motor vehicle collision injury in a collaborative manner. The background analysis described the need for studying injury biomechanics. Injuries are a major public health issue in the province of Alberta. Safety organizations need the collection of data pertaining to how *injuries* occur in order to prevent them from occurring in the first place, or at the least, decrease the severity and consequences of this injury once it has occurred.

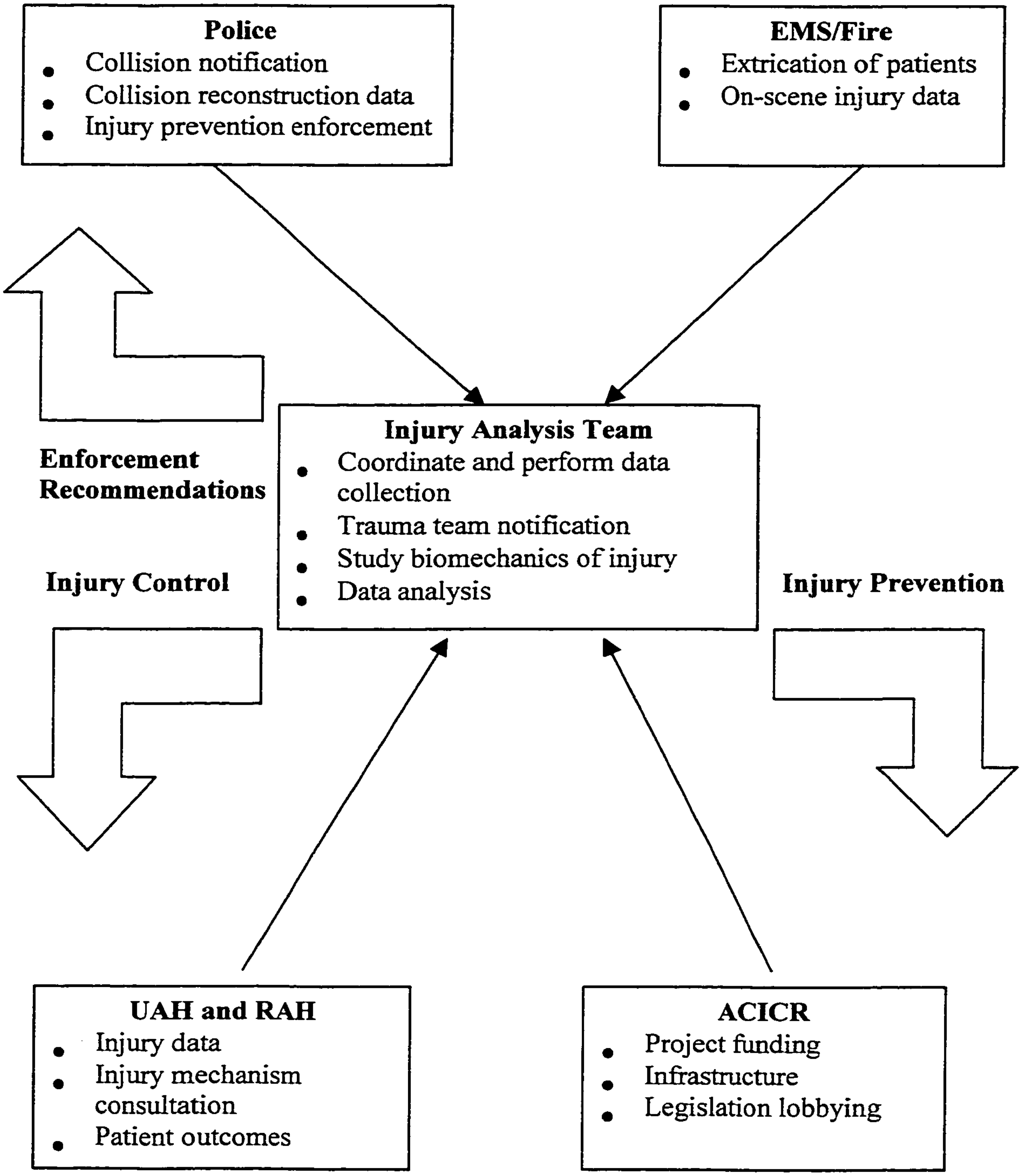
The program design, represented in Figure 3.2, described the model design and how it is theoretically supposed to function in a collaborative manner. The collaboration approach of the study described who the key organizations were and what their roles in a biomechanics study would be. This included a framework of collaboration, which was used to form the network. Finally, the Implementation phase described the pilot study in which the researchers began collecting data on motor vehicle collision injuries.

A goal of this study was to collaborate with police, Emergency Medical Services, University of Alberta Hospital and Royal Alexandra Hospital emergency physicians, and

Office of the Chief Medical Examiner. Primarily, the model is designed to promote primary injury prevention by making recommendations to the police in terms of enforcement policies by sharing with the police what are factors that are causing serious injuries. It was an observation of this study that seatbelt enforcement is one aspect that the police should consider when planning their injury prevention strategies. As described in Chapter Two, seatbelts have a major impact in injury etiology. It was also an observation that 52% of the cases studied involved pedestrian collisions. Clearly, it is recommendation that police should target enforcement towards pedestrian safety. Enforcing areas with high car-pedestrian collision rates can do this. The researchers have noted specific locations.

The model was also designed to promote secondary injury prevention (decreasing the severity of the injury once it has occurred) by sharing collision information with emergency physicians in the trauma room while they were treating the patient. This was most successfully performed in Case 10 when the researcher described the collision scenario to the emergency physician who decided to investigate further upon hearing the extent of the trauma the patient suffered.

Figure 5.1-Injury Investigation Model



5.1.1 Evaluation

The study used a collaboration framework to construct a model of collaborative injury biomechanics analysis. For a program to function, an evaluation must be performed in order to ensure that objectives of the member organizations are being met, and for the member organizations to assess processes, outcomes, and impacts of the coalition. This thesis only evaluated the model itself. Each member organization will have to conduct its own evaluation to assess its impact in the coalition, and if they are benefiting from being part of the information sharing network.

Police Evaluation

In evaluating their participation in the network, police will have to consider the following:

- Are Traffic members calling the researchers to *all* cases that they investigate?
- Are the researchers interfering negatively at crash scenes?
- Are the researchers helping in crash investigations?
- Are enforcement recommendations made being implemented by Traffic members?
- Are the injury rates changing in locations where enforcement has been emphasized?

Trauma Center Evaluation

In evaluating their participation in the network, Chiefs of Staff at the two trauma center emergency departments will have to consider the following:

- Are trauma physicians benefiting in terms of diagnosing injuries faster, and more accurately, now that they receive data on what type of crash occurred, and what speeds were involved?
- Are the researchers interfering with physicians in the trauma room? Are they taking up too much of the physicians time?
- Are digital photos of the scene easy to access in the trauma room?

Model Evaluation

Evaluation of the model considered the four factors that were used in designing the model:

1. Use of existing data sources must be maximized.
2. Appropriate analysis systems must be in place.
3. The model must be feasible and sustainable.
4. The model must have general applicability.

1. Use of existing data sources must be maximized.

This criterion of the model was met. All of the information required to see how the injury occurred was readily available. Police shared data on the crash analysis with the researchers, and physicians shared data on patient injuries. This included access to the patient file, and all diagnostic test results as requested by the researchers. These data sources were already in place and functioning, and did not require further financial expenditure to setup or access.

EMS data, including extrication details, patient condition at the scene, and stabilization procedures, were already routinely collected, so once again, no addition expenditure of resources were required to access this data source.

2. Appropriate analysis systems must be in place.

The police already perform collision analysis. In this model, the expert collision reconstructionists shared their analysis of the crash with the researchers. However, the issue of data reliability arises when comparing the three Traffic crews of EPS. Each crew collects different amounts of data. For example, one crew consistently made measurements of vehicle compartment intrusions, where another did not. Therefore, for reliable, consistent results, the researchers will require training in collision reconstruction to conduct their own investigation, in collaboration with police, to collect data on injury mechanism.

The system for clinical investigation of injuries is already in place at the trauma centers, therefore, an additional analysis system is not required. However, to elucidate how the injury occurred, a reconstruction of the injuries using computer analysis software will assist the researchers. This software is discussed later in this chapter.

3. The model must be feasible and sustainable.

This research has shown that the model is feasible since data pertaining to how the injury occurred is accessible by researchers. The research has also shown that the network functioned in a manner that allowed for the sharing of data. The model, however, can only be sustained by outside funding. The ACICR, injury control infrastructure, can support this type of research, which is in accordance with its mandate.

4. The model must have general applicability.

This model can be applied to study MVC injuries in any locale. However, only metropolitan centers will have a trauma center dealing with serious MVC injuries. RCMP will have the ability to reconstruct collisions in rural areas, but data on injuries will have to be accessed from which ever trauma center the patient has been transported to. Researcher applying this model in rural areas will need to get ethics approval to conduct these studies from the nearest trauma centers and from the regional health authority (Alberta).

5.1.2 Pros of Model

1) The design of a model that collaborates with police expert collision reconstructionists allows for the direct notification of researchers. This is beneficial because it permits the researchers to arrive at the scene of an injury collision in order to collect injury-causing data before any of the evidence is destroyed or vehicles moved from the scene. Working with the police also allows sharing of collision factors such as speed and direction of vehicles prior to impact.

2) Collaborating with trauma physicians is beneficial to both the researchers and the physicians. The researchers benefit by the fact that they get firsthand data on what injuries occurred. Collecting data retrospectively from hospital charts is not always feasible or easily accessible. For example, the researchers would have to go through medical records, which takes extra time. Also, researchers would not be able to document injuries through digital means, such as a camera, retrospectively. This data, which could be used for injury reconstruction purposes, must be collected as soon as possible. Physicians benefit from the model because they receive collision data from the researchers pertaining to the scene. This allows them to narrow their investigation when treating the patient. As described in Chapter two, there are general injuries that can be expected from specific types of crashes. It was an observation of the researchers that emergency room admission forms of injured motor vehicle collision patients in most cases simply read "MVA", or motor vehicle accident. If the physician knows what type of injuries to expect, preferably before the patient even arrives, then valuable time can be saved when treating the patient.

3) The model in general allows for the study of injury mechanisms. Injury should be treated as a disease. For example, epidemiologists determined the link between smoking and cancer. This resulted in smoking prevention campaigns. Similarly, studying what factors lead to injury can allow for the prevention of this disease.

4) By incorporating the Alberta Center for Injury Control and Research into the model, this allows for the researchers an infrastructure from which to work from. This includes access to injury control experts, as well as the potential to promote motor vehicle safety at the community level through ACICR activities.

5.1.3 Cons of Model

1) Due to the fact that an inclusion criteria for this model involves only those cases involving the traffic section of the Edmonton Police Service, some injury cases will be missed. Car crashes occur everyday, resulting in many patients being injured. These injuries could prove to be serious in the near future but may have not shown signs of seriousness in the emergency department. Therefore, some serious injury cases will be lost when strictly relying on the notification by the Traffic Section.

2) The model relies on the notification of researchers by the EMS Traffic Section. However, the police sometimes forget to call the researchers, or call them during their investigation. Calling the researchers midway into the investigation results in the loss of time for the researchers to arrive at the scene, and in some cases, arrive when the investigation is nearing completion. Researcher notification by police dispatch will correct for this. It is also important for the investigator to have collision reconstruction training so that the police are not hindered. The police are concerned with why the collision occurred, and who is at fault. The investigator will be trying to study why the injury occurred.

3) Assuming that making enforcement recommendations to the police will have an affect on decreasing the number of motor vehicle collision injuries is simply that, an assumption. Future research will have to evaluate if there is a correlation between targeted enforcement and injury rates, before and after the implementation of this model.

5.1.4 Collaboration Findings

This was a collaborative project in which the researchers were responsible for combining data collected by police and emergency physicians. The researchers were a hub for the transmission of data between the researchers, police, and emergency physicians. The researchers would collect crash data from the police and share with it the emergency physicians to elucidate possible injuries sustained by the patient. The researchers would then share injury data with the police to target enforcement for injury prevention. The researchers also acted as a facilitator between the police and emergency physicians. In cases where the police came with the researchers to the trauma center, the officer accompanied the researcher into the trauma room so that he or she could learn about the injuries. This allowed for meetings between the physicians and the police. It fostered an environment where member organizations got to know each other on a personal level. It also showed the member organizations how they were contributing to the collaboration.

Having the researchers, police, and emergency physicians meet in the trauma room together was advantageous because it allowed for the meeting of the groups on a regular basis. Each group had different interests in the investigations, but had the same goal of understanding how the injury occurred so that they could be prevented. The main objective of the police was to investigate why the *crash* occurred. However, the Traffic Section administration and investigators stated that they want to participate in public health because they realize that MVC injury is predictable and preventable and that they have a role in preventing these injuries through enforcement. There is also a stigma in the community that the Traffic Section is a money making section within the EPS. The fact that the Traffic Section was described in the media as "supporting scientific research" in regards to this project reinforced their commitment to the model. One sergeant commented that the researchers "give us more support than city hall". This collaboration was successful because the data collection process did not interfere with the normal activities of member organizations.

There were no turf protection issues because of the nature of investigations carried out by collaboration members. The police conduct scene investigations. Participating in this model did not change that. When the researchers were on scene, the police were in charge of the scene. In the trauma room, the physicians were responsible for the clinical investigation of the injuries. Participating in this model did not cause any turf problems for physicians because neither the researchers nor the police were involved in the clinical investigations. The researchers and police shared data with the physicians, and that was the extent of the interaction. Dr. Francescutti, an emergency physician, was not involved in any of the clinical interventions in the trauma center, therefore, the issue of turf protection was not an issue with the physicians.

Prior to having the member organizations commit to the model, the researchers attempted to conduct a meeting with both emergency physicians and police officers. The meeting was scheduled, but only a handful of physicians attended. This was due to the shift work nature of emergency medicine and policing. Instead, the researchers met individually with the Chiefs of the Staff of the Emergency Departments and with the administrations of Traffic Section and RCMP to discuss the project and how it would be implemented and what protocols would be required. Once the project was implemented, the researchers gave presentations at Emergency Department rounds at the Royal Alexandra Hospital so that the emergency physicians were updated with how the program was being implemented and what exactly the researchers were looking for. Similar presentations were made at ED staff meetings at the University Hospital.

5.1.5 Sustainability of the Coalition

In terms of financial sustainability of the program, several funding requests have been submitted to community agencies. Meetings were held with the Director of Emergency Medical Services and the Director of Government and Consumer Affairs of the Alberta Motor Association. These groups are awaiting the results of this thesis and are considering funding this program. In terms of the sustainability of the program itself, the researchers are in talks with Emergency Medical Services to have EMS personnel conduct the injury investigations. Dr. Francescutti will be taking a three-month sabbatical in 2001 in which he will ride along with EMS personnel to test the feasibility of EMS conducting the investigations with the police and researchers. It makes sense for EMS personnel to be conducting the research because they are the first to arrive on the scene, even before the police in some instances. EMS personnel can collect scene data pertaining to the injuries and extrication, as well as be able to transmit scene photos to the ED even before the patient arrives. The EMS personnel can then return to the scene after transporting the patient to the ED in order to investigate with the police how the injury occurred. This is feasible because in many cases, the EMS personnel have already transported the patient to the trauma center before the Traffic Section has begun their investigation. Upon completing the scene investigation, the EMS personnel can return to the trauma center to document the patient injuries.

Another issue related to sustainability is how the researchers can use the data collected to stimulate injury prevention. One technique is the use of economics (Francescutti, 1997). If each injury event was evaluated in terms of direct and indirect costs, and whom it was costing, this may be able to stimulate injury control directed at MVC injuries (Personal Communication, Dr. Garnet Cummings, Chief of the Emergency Department, Royal Alexandra Hospital, June 2000).

5.2 Future Directions

5.2.1 Investigator Training

A person that will act as an injury investigator will need training in both biomechanics of injury, as well as collision reconstruction. It is a recommend that the person fulfilling this role has training for the biomechanics from the Association for the Advancement of Automotive Medicine (AAMC). Although there are other organizations that teach biomechanics, the AAAMC courses in biomechanics and injury scaling (ICD-9 and AIS) are implemented in accordance with the Essentials and Standard of the Accreditation Council for Continuing Medical Education in the United States through the joint sponsorship of Program of Continuing Education University of Maryland School of Medicine. Also, the injury scaling techniques are required when documenting injury, so it is advantageous to have training from the same organization.

The person who will act as the investigator will have a background in collision reconstruction. However, there are courses offered by several institutions, which could be taken to refresh the investigator's skill sets. Texas A&M University in College Station, Texas, offers several courses in traffic and biomechanics investigation through the Texas Engineering Extension Service (Law Enforcement and Security Training Division). These courses offer standardized training in a university setting and are appropriate for injury research.

Engineering Dynamics Corporation of Beaverton, Oregon, USA, offers a 3-D software program called HVE (Human-Vehicle-Environment) which simulates crashes after data input. HVE models humans, vehicles, and the environment and allows for the studying of the interaction of the three. Graphical Articulated Total Body (GATB) is an HVE compatible simulation software which can be used by researchers to analyze how humans are injured in car crashes. This is a graphical version of the software developed by the U.S. Airforce to study the biomechanics of pilots in flight. The human is modeled with 15 segments connected with 14 joints to produce 48 degrees-of-freedom for each person modeled. These software programs will allow for the reconstruction of how the injury occurred. (Personal Communication, Engineering Dynamics Corporation, 2000)

5.2.2 Secondary Prevention in the Emergency Department

The most rapid and efficient method to send photos of the scene and extrication to the emergency physicians will be through digital technology. Photographing the scene with a digital camera, and then electronically mailing them to the emergency department via a cellular phone connection can do this. In order to do this, both trauma centers will need to purchase a desktop computer that will be used solely for receiving scene data. An average computer in year 2000 dollars can be purchased for $1500 Canadian. Any email program such as Eudora will suffice to carry out the task of receiving scene pictures and text. The computers will need to be connected to a constant Internet connection, which both trauma centers have. The local area administrator can open an email account to support the program. The computers should be equipped with a firewall in order to prevent hackers from accessing any confidential data. Firewalls are available on the Internet (www.zonelabs.com).

From the scene, the researcher will require a laptop computer ($2000 Canadian) with a cellular compatible modem, a cellular telephone (Nokia 2160, $240 Canadian per year with Rogers AT&T), and a digital camera (Nikkon, $1300 Canadian). Upon arriving at the scene, the researcher will analyze to see what type of crash occurred, and then send photos of the scene and extrication, along with a pre-prepared text which describes what injury physicians can expect the patient will have. The whole purpose of this is to maximize the critical time that emergency physicians must use when treating motor vehicle collision injuries.

5.2.3 Delayed Injuries

The researchers did not follow up patients after being released from the ED or ICU. However, patient follow up is important for elucidating delayed injuries (Personal Communication, Dr. Garnet Cummings, Chief of the Emergency Department, Royal Alexandra Hospital, June 2000). Researchers should conduct patient follow-ups at regular intervals in order to study if any delayed injuries were discovered resulting from the crash.

5.2.4 Driver Interview

This study interviewed drivers for background information on drivers when possible. The researchers used a modified form designed by Dalkie (Dalkie, 1993). Since this model involves attending the scene of a crash, this gives the researchers an opportunity to gain insight into why the collision occurred. Researchers can utilize proven qualitative interview methods to study trends amongst drivers involved in car crashes. Rothe (Rothe, 2000) described qualitative methods for interviewing drivers that can be applied to injury control research. This included performing unstructured, semi-structured, structured, and focus group interviews. Each has its advantages and disadvantages and should be used according to the research situation. For example, Rothe described a semi-structured interview strategy used for a large study on young drivers who were involved in injury collisions. Rothe described asking a question, and then a follow up probing question. For example, one question was "What was going on in the car just before the accident"? The probing questions were "Were you talking to a passenger"? "Listening to the radio"? "Smoking"? "Lost in thought"? "Do you think this contributed to the accident?" The advantages of semi-structured interviews are that they lead the interviewee into providing greater depth and breadth for answers (Rothe, 2000).

Rothe also describes two methods for sequencing questions when interviewing in a qualitative manner (Rothe, 1993). The funnel approach moves from general questions, to specific questions, with each succeeding question related to the preceding one and narrowing in focus as the questions are asked. The pyramid approach involves asking questions from the specific to general, with each succeeding question be related to the preceding one.

Although the primary goal of the model is to understand how injuries occur, understanding why the collision occurred will allow for the designing of prevention strategies. Rothe's methodology allows for an avenue of understanding of researching why the crash occurred in a manner that does not restrict the interviewee to yes or no answers. Rather, by structuring interviews in such a manner that the interviewee has a forum to give descriptive answers, qualitative data analysis can be employed to look for trends that would not be possible using quantitative methods. By combining data on why the crash occurred, and why the injury occurred, a combination of prevention strategies can be considered.

The researchers of this study did not employ qualitative methods when interviewing the drivers. However, future investigators should consider using a qualitative questionnaire that will give greater insight into the crash itself, and not just the cause of the injury.

5.2.5 Joining CIREN

Joining CIREN will allow the researchers access to a common injury mechanism database shared by eight universities. The CIREN administration will also train researchers in collision reconstruction and in injury biomechanics. However, the main setback to joining CIREN is the financial commitment. As of May, 2000, CIREN requires $500,000 US per year for up to a 5-year commitment (minimum two years). If funding can be achieved, joining CIREN will allow for a collaboration of medical and engineering researchers in many specialties and the linking of laboratories.

5.2.6 A Research Tool

This research was undertaken to design a tool for understanding how injuries occur in the City of Edmonton and surrounding area in a collaborative manner. Now that the tool is in place, future research can be performed to understand why these injuries are occurring. The thesis was undertaken to be a model for other communities to be able to perform collaborative research. Collaboration with trauma centers, police, EMS, and the medical examiner's office allows researchers rapid access to information. An important outcome of this model will be to see if making recommendations to the police, and providing crash details to the trauma centers will have an impact on injury control.

References

Alberta Motor Association. Mission Possible: Integrated Traffic Safety Initiative for Alberta. AMA Mission Possible Campaign. Edmonton, 1996.

Alberta Center for Injury Control and Research. Personal communication. 1997 Injury Statistics. Edmonton, 1998.

Accident Investigation Quarterly (Spring 1998). Pedestrian Accident Countermeasures 15.

Accident Investigation Quarterly (Winter 1998). Engineering Methods to Reduce Urban Crashes. 18,48.

American College of Surgeons on Committee on Trauma (1997). Advanced Trauma Life Support for Doctors. Instructor Course Manual. 417-438.

Barss, P., Smith, G., Baker, S., Mohan, D. (1998). Injury Prevention: An International Perspective. Epidemiology, Surveillance, and Policy. New York, New York. Oxford University Press

Burgess, A.R., Dishinger, P.C., OQuinn, T., & Schmidhauser, C.B. (1995). Lower-Extremity Injuires in Drivers of Air-bag Equipped Automobiles-Clinical and Crash Reconstruction Correlations. Journal of Trauma-Injury and Critical Care, 38(4), 509-516.

Cummings, Garnet (June 2000). Personal Communication.

Dalkie, H.S. (1993). The Development and Application of A Model to Investigate Road Safety Issues. P.hD. University of Manitoba;

Davies, J.C., & Manning, D.P. (1994a). Data collected by MAIM intelligent software: The first fifty accidents. Safety Science, 17(3), 219-226.

Davies, J.C., & Manning, D.P. (1994b). MAIM: The concept and construction of intelligent software. Safety Science, 17(3), 207-218.

Dembert, M.L. (1984). The accident injury matrix and its use in diving injury investigations. Aviation Space & Environmental Medicine, 55(12), 1143-1147.

Francescutti L.H. (1997). Injury Control: Are You Accountable? Canadian Journal of CME. 109-119.

Gennarelli, T.A., Champion, H.R., Copes, W.S., & Sacco, W.J. (1994). Comparison of mortality, morbidity, and severity of 59,713 head injured patients with 114,447 patients with extracranial injuries. Journal of Trauma, 37(6), 962-968.

Gooder, P., & Charny, M. (1993). The difficulties of investigating motor vehicle traffic accident mortality in a district. Public Health, 107(3), 177-183.

Green, R.N., German, A., Nowak, E.S., Dalmotas, D., & Stewart, D.E. (1994). Fatal injuries to restrained passenger car occupants in Canada: crash modes and kinematics of injury. Accident Analysis & Prevention, 26(2), 207-214.

Injury Prevention Center (University of Alberta) (1993). Injury Prevention Workshop Facilitator Handbook.

Kong, L.B., Lekawa, M., Navarro, R.A., McGrath, J., Cohen, M., Margulies, D.R., & Hiatt, J.R. (1996). Pedestrian-motor vehicle trauma: an analysis of injury profiles by age. Journal of the American College of Surgeons, 182(1), 17-23.

Kullgren, A., Lie, A., & Tingvall, C. (1995). Crash pulse recorder--validation in full scale crash tests. Accident Analysis & Prevention, 27(5), 717-727.

Loo, G.T., Seigel, J.H., Dishinger, P.C., Rixen, D., Burgess, A.R., Addis, M.D., OQuinn, T., McCammon, L., Schmidhauser, C.B., Marsh, P., Hodge, P.A., & Bents, F. (1996). Airbag protection versus comparment intrusion effect determines the pattern of injuries in multiple motor vehicle crashes. Journal of Trauma-Injury and Critical Care, 41(6), 935-951.

Maynard, F.M., & Krasnick, R. (1988). Analysis of recreational off-road vehicle accidents resulting in spinal cord injury. Annals of Emergency Medicine, 17(1), 30-33.

Micik, S., Miclette, M., (1985). Injury Prevention in the Community: A Systems Approach. Pediatr Clin North Am, 32(1), 251-265.

Midha, R. Epidemiology of brachial plexus injuries in a multitrauma population. NEUROSURGERY 40(6), 1182-1188. 6-1997.

Miltner, E., & Salwender, H.J. (1995). Influencing Factors on the Injury Severity of Restrained Front Seat Occupants in Car-to-Car Head-On Collisions. Accident Analysis & Prevention, 27(2), 143-150.

Miltner, E., Wiedmann, H.P., Leutwein, B., Hepp, H.P., Fischer, R., Salwender, H.J., Frobenius, H., & Kallieris, D. (1992). Liver and Spleen Ruptures n Authentic Car-to-Car Side Collisions With Main Impact at Front Door or B-Pillar. American Journal of Preventive Medicine, 13(1), 2-6.

National Committee for Injury Prevention and Control (NCIPC), (1989). Injury Prevention: Meeting the Challenge. New York, NY. Oxford University Press.

Nikkel, K. (1998). BMW's Safety Breakthrough:Head Airbags. Motor Trend, 50(1), 28.

Niemcryk, S.J., Kaufmann, C.R., Brawley, M., & Yount, S.I. (1997). Motor vehicle crashes, restraint use, and severity of injury in children in Nevada. American Journal of Preventive Medicine, 13(2), 109-114.

Oppe, S. (1992). A comparison of some statistical techniques for road accident analysis. Accident Analysis & Prevention, 24(4), 397-423.

Osberg, J.S., & Di, S.C. (1992). Morbidity among pediatric motor vehicle crash victims: the effectiveness of seat belts. American Journal of Public Health, 82(3), 422-425.

Pimble, J., & O'Toole, S. (1982). Analysis of accident reports. Ergonomics, 25(11), 967-979.

Redmond, P., Barton, D., McQuillan, R., & O'Higgins, N. (1990). An audit of road traffic accident victims requiring admission to hospital. [Review] [10 refs]. Irish Medical Journal, 83(4), 133-136.

Rosman, D.L., Knuiman, M.W., & Ryan, G.A. (1996). An evaluation of road crash injury severity measures. Accident Analysis & Prevention, 28(2), 163-170.

Rothe, J.P. (1993). Qualitative Research: A Practical Guide. Heidelberg, ON: RCI/PDE Publications.

Seigel, J.H., Masongonzalez, S., Dishinger, P.C., Cushing, B., Read, K., Robinson, R., Smialek, J., Heatfield, B., Hill, W., Bents, F., Jackson, J., Livingston, D., Clark, C.C., Norwood, S.H., Parks, S.N., Hawkins, M.L., Reath, P.B., & Gregory, J.S. (1993). Safety Belt Restraints and Compartment Intrusions in Frontal and Lateral Motor-Vehicle Crashes-Mechanisms of Injuries, Complications, and Acute Care Costs. Journal of Trauma-Injury and Critical Care, 34(5), 736-759.

Sharma, J.A. (1999). Analysis, Design, and Development of A Sustainable Community Fire Station-Based Injury Control and Research Centre. M.Sc. University of Alberta.

Sjogren, H., & Bjornstig, U. (1991). Injuries to the elderly in the traffic environment. Accident Analysis & Prevention, 23(1), 77-86.

Stoop, J.A. (1995). Accidents - In-depth analysis; towards a method AIDA?. Safety Science, 19(2-3), 125-136.

Veridian Engineering (March 2000). Personal Communication.

Vilenius, A.T., Ryan, G.A., Kloeden, C., McLean, A.J., & Dolinis, J. (1994). A method of estimating linear and angular accelerations in head impacts to pedestrians. Accident Analysis & Prevention, 26(5), 563-570.

Internet Sites

Association for the Advancement of Automotive Medicine
www.carcrash.org/biominfo.html

Alberta Infrastructure www.tu.gov.ab.ca

Calspan Corporation, www.calspan.com

CIREN www.umich.edu/~ciren

The George Washington University Ashburn Virginia
www.ncac.gwu.edu/pubs/lower/lower.html

National Highway Transportation Safety Administration www.nhtsa.dot.gov

University of Maryland School of Medicine

Som1.ab.umd.edu/NSCforTrauma/index.htm

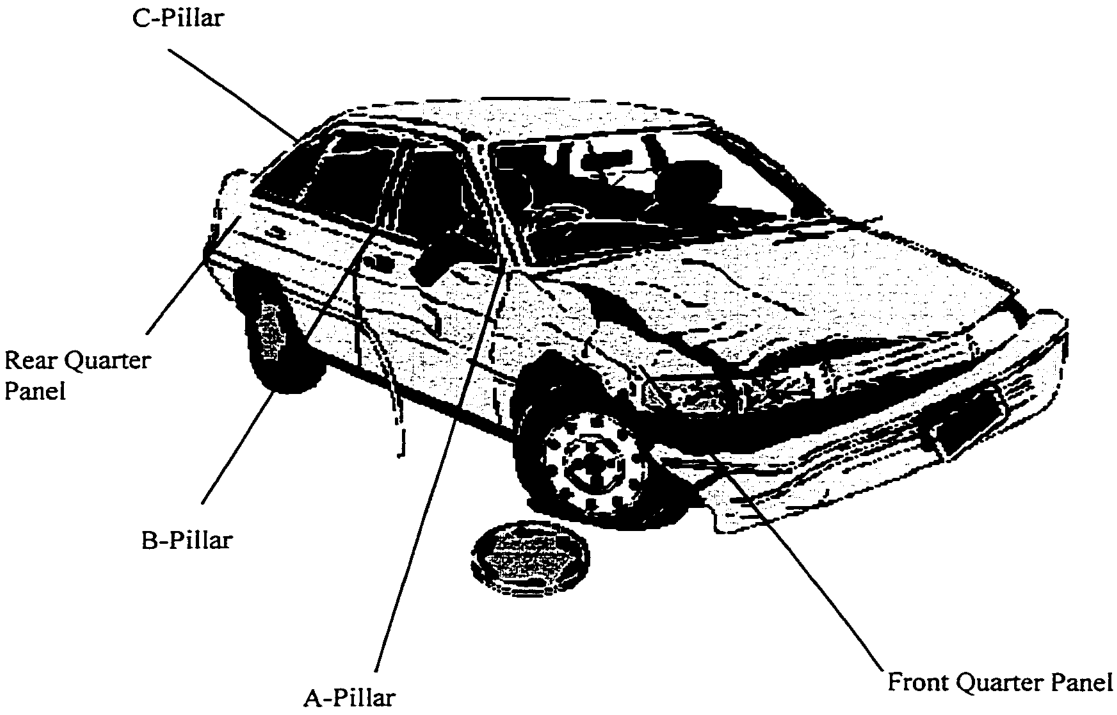
Som1.ab.umd.edu/NSCfor Trauma/presents.htm

Som1.ab.umd.edu/NSCfor Trauma/papers.htm

Som1.ab.umd.edu/NSCfor Trauma/research.htm

www.zonelabs.com

Appendix A


C-Pillar
Rear Quarter Panel
B-Pillar
A-Pillar
Front Quarter Panel

Model of a Generic Injury Analysis Investigator

Principal Investigator:
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Purpose:
The purpose of this research project is to study injuries. This is a graduate thesis project. We will use data already collected by the police and hospital staff. This project will study injuries caused by car crashes. This information can help healthcare researches to design prevention programs to decrease the number of injuries caused by car crashes.

Background:
Injury is one of the most neglected areas of public health. Injuries affect all of us. Three and a half million people around the world die every year because of injuries. Seventy eight million people around the world are disabled every year because of injuries. Injuries are the number one cause of death in people aged 1 to 44. Billions of dollars are spent in the treatment of injuries. Motor vehicle collisions alone cost $3.55 billion dollars in Alberta. But, because injuries are predictable and preventable, their numbers can be decreased through injury control and prevention. Every day three Albertans die from injuries.

A benefit of this study will be collection of data that will allow design of prevention programs to decrease the number of injuries. Those people involved in a crash involving injury will be recruited. We hope that this study will provide an example of how to study injuries.

Procedures:

1. If you are involved in a motor vehicle crash and enter a hospital in the city of Edmonton between July 1, 1999 and June 1, 2000, the investigator will offer you an information sheet about this research. You will also be given a consent form to see if you are willing to take part in this study.

2. You should read this information sheet first. After you read this entire information sheet, you can choose whether or not you want to sign the consent form. Your treatment in the Emergency Department will not be affected by your choice.
3. After signing the consent form, or deciding not to, you should return the information sheet and consent form to the researcher. If you did not sign the consent form, you are done. Thank you for your time. If you did sign the consent form, you will be given a copy both the information sheet and the consent form. You will also be asked questionnaire about the crash and some information about yourself. This questionnaire will help to determine background information to the crash. Only the researchers will have access to this information.

Note: The entire procedure should not take more than 15 minutes of your time.

Risks:

There are no risks to you by participating in this study.

Confidentiality:

Only the investigators of this study will have access to the answers you give. The standard medical guidelines of confidentiality will be observed for this study.

Freedom to Withdraw:

You are free to withdraw from this project at any time. You do not have to give a reason for withdrawing. Withdrawing from this project will no effect on the care you receive while in the Emergency Department

Contacts:

You can make comments about this project. The project investigators can be contacted at the phone numbers above. Concerns may also be addressed to the "Patient Concerns Office of the Capital Health Authority" at 492-9790. This office has no affiliation with the project investigators.

Title of Project: **Model of a Generic Injury Analysis Investigator**
Principal Investigator(s): Dr. Louis H. Francescutti, MD, Ph.D., MPH
Assistant Professor, Dept. of Public Health Sciences & Division of Emergency Medicine,
University of Alberta Phone (780)-492-6546
Chair to the Advisory Board of the Alberta Center for Injury Control and Research
Co-Investigator(s): M Naseem Hoque, B.Sc.

Part 2 (to be completed by the research subject):

Do you understand that you have been asked to be in a research study?	Yes	No
Have you read and received a copy of the attached Information Sheet?	Yes	No
Do you understand the benefits and risks involved in taking part in this research study?	Yes	No
Have you had an opportunity to ask questions and discuss this study?	Yes	No
Do you understand that you are free to refuse to participate or withdraw from the study at any time? You do not have to give a reason and it will not affect your care.	Yes	No
Has the issue of confidentiality been explained to you? Do you understand who will have access to your records?	Yes	No
Do you want the investigator(s) to inform your family doctor that you are participating in this research study? If so, please provide your doctor's name:	Yes	No

____

This study was explained to me by: ______________________________

I agree to take part in this study. ______________________________

______________________ Signature of Research Participant	________________ Date	______________________ Witness
______________________ Printed Name		______________________ Printed Name
______________________ Signature of Family Member/Parent or Legal Guardian	________________ Date	______________________ Witness
______________________ Printed Name		______________________ Printed Name

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

______________________________ ________________
Signature of Investigator or Designee Date

On-Scene Collision Report

Injury Analysis Team Collision Number________ Police Collision Report Number_______________

1. Vehicle Number _____ of _____ involved.
2. Collision location____
3. Weather conditions____
4. Time of collision_____________________________________
5. Date of collision______________________________________
6. Constable of ride along________________________________
7. Shift hours of ride-along_______________________________
8. Time of dispatch______________________________________
9. Time of arrival_______________________________________
10. Police Collision Reconstructionist expert__________________
11. Make of vehicle_______________________________________
12. Model year__________________________
13. Ownership Self Rental Family member Other
14. Number of occupants_________________
15. Number of seat belts in vehicle_________
16. Driver gender Male Female
17. Driver belted Yes No
18. Front passenger gender Male Female
19. Front passenger belted Yes No
20. Left rear passenger gender Male Female
21. Left rear passenger belted Yes No
22. Center rear passenger gender Male Female
23. Center rear passenger belted Yes No
24. Right rear passenger gender Male Female
25. Right rear passenger belted Yes No

26. (Mini-vans) Third row left rear passenger gender Male Female

27. (Mini-vans) Third row left rear passenger belted Yes No

28. (Mini-vans) Third row center rear passenger gender Male Female

29. (Mini-vans) Third row center rear passenger belted Yes No

30. (Mini-vans) Third row right rear passenger gender Male Female

31. (Mini-vans) Third row right rear passenger belted Yes No

32. Velocity of vehicle prior to impact ______________ KM/H

33. Vehicle impacting or impacted

34. Angle of impact ____

35. Location(s) of impact on vehicle____

36. Length of vehicle (Bumper to Bumper)____

37. Width of vehicle (Side to Side)____

38. Height of front bumper from ground____

39. Height of hood from ground____

40. Height of rear bumper from ground____

41. Height of trunk from ground____

42. Depth(s) of Intrusion into vehicle compartment:

Length from rear_________ Height from ground_________ Width into vehicle_______________

43. Depth of crush into A-Pillar___________ B-Pillar______________ C-Pillar_________________

44. Depth of crush of vehicle front____________ rear______________

45. Intruding objects__________________________________

46. Intruding objects Road way based Stationary based Moving vehicle based

47. Occupant(s) injured as result of intrusion Driver Front Center Front Right Rear Left

Rear Center Rear Right Third row Left Third row center Third row right

48. Occupants(s) requiring EMS Driver Front Center Front Right Rear Left

Rear Center Rear Right Third row Left Third row center Third row right

49. Hospital of admission UAH RAH

CollisionNarrative

Physician Interview/Chart Review Form

Injury Analysis Team Collision Number_______ Police Collision Report Number_____________

1. **Date: dd_______mm_______yy________**

2. **UAH RAH**

3. **Trauma Team Leader/ER Physician____**

4. **Hospital I.D.**

   ____

5. **Interviewer Dr. Louis Hugo Francescutti M. Naseem Hoque**

6. **Time of arrival of patient to ED______________ AM PM**

7. **Injured Driver Center front passenger Front right passenger Left rear passenger**

   Rear center passenger Right rear passenger Third row left passenger Third row center passenger

   Third row right passenger Pedestrian

8. **Vehicle #___________**

9. **Gender Male Female**

10. **Age _______________**

11. **Injuries diagnosed:**

____

____

____

____

____

____

____

____

____

____

____

____

12. Interventions

13. Prognosis/Outcomes

Motor Vehicle Driver Interview Form
Injury Analysis Team Collision Number______ Police Report Collision Number_______

1. Date of birth______dd_______mm______yy 2. Height________ 3.Wieght__________

4, Marital Status_____________ 5. Gender____________

6. Hand preference Right Left 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 license ____________

10. Type of vehicle driver training None, self taught Rural Urban
Friends, family
Formal course Company providing course ___________
Year completed ___________

11. Age first began to operate a automobile/small truck? _________

12. Age first licensed to operate a Motor Vehicle? _________

13. Age first owned a Motor Vehicle? _________

14. Number of Motor Vehicle's Presently Owned? _________

15. Type of Motor Vehicles Presently Owned?
Sedan 1/2Ton truck 3/4 Ton truck Mini van Sports car 4 Wheel drive vehicle
Station wagon Compact Motorcycle

16. Primary use of vehicle To and from work Recreation/family Both

17. Number of days per week vehicle driven _________

18. Number of days per week driven on road of collision _________

19. Was a seat belt worn during collision? Yes No

20. How often do you wear your seatbelt? Always Most of the time Sometimes Almost never
Never

21. If not always, Why not? Uncomfortable Forget Don't have one Don't believe in seat belts
Medical reason Other

22. Purpose intended for trip? Work Recreational event Shopping Social

23. Length of intended trip? ____

24. Familiarity with roadway of collision? Commuter Often user Sometimes Seldom First

25. Distance from Place of Residence to Scene of the collision? ______________

26. Eye Correction Used? ___________

27. Any Alcohol Consumed Prior to the Accident (specify)________________________________

28. Any Drugs or Medication Involved (specify) ________________________________

29. Collision Narrative____

30. Vehicle in Lane #_________of ___________through lanes before collision

31. Estimated Speed_____________

32. Vehicle control operations before collision: None________ Braking______________

Downshifting________ Other ___________

Upshifting/Accelerating ________________

33. What were you doing just before the collision?
Eating Drinking Smoking Changing a CD or Tape Interacting/Arguing with a passenger
Daydreaming Locating item in vehicle Using a cellular phone or CB radio

34. Any Evasive Maneuvers? Accelerating__________Steering__________________

35. Were brakes applied? _______________ Partial or Full? _____________________

36. Total braking distance? ______________ 37. Passenger interference? ___________

38. Vehicle airborne? ___________________ 39. Distance________________________

40. Headlights On Off 41.Evasive action by other vehicle? _____________

42. If Treated, Where Treated UAH RAH

43.Vehicle Safety Equipment:
Driver Side Airbag Passenger Side Airbag Door Airbags Airbag Curtain

ABS Front ABS Rear