EXAMINING NON-FATAL TRAFFIC AND OTHER INJURY OCCURRENCE AND SEVERITY USING SOCIOECONOMIC AND INDIVIDUAL-LEVEL FACTORS

BY

GEMMA L. BRIGGS

A Thesis submitted to the Faculty of Graduate Studies of
The University of Manitoba
in partial fulfilment of the requirements of the degree of

MASTER OF SCIENCE

Department of Community Health Sciences
University of Manitoba
Winnipeg

ABSTRACT

Background. In Canada, motor vehicle collisions are the leading cause of unintentional injury deaths and second leading cause of injury hospitalization**.** Nationally, serious traffic injury has reduced 35% (1986-2005). Social determinants of health have not been studied with serious traffic injury in adulthood.

Study Aims. To determine whether lower SES (measured by education, income, and employment), is associated with serious traffic and fall injury and injury severity and whether the pattern of association differed between traffic and fall injury. To reveal issues to be made by decision makers regarding at risk groups.

Methods. Combined cycles (1.1, 2.1, and 3.1) of the cross-sectional Canadian Community Health Survey were used. Injuries in the past year 'serious enough to limit normal activities' were studied. Deaths and less serious injuries are not captured. "Transportation accident" was used to represent traffic injury. It does not specify victim type (e.g. driver, bicyclist) yet the category pertains to "automobiles" and published research used it as a proxy for motor vehicle collisions. Power analyses, survey weighting and bootstrapping were executed to prevent biased population estimates. Records with missing data were excluded. Logistic regression models were performed for tests with binary outcomes. Injury severity selected individuals' highest treatment within 48 hours - admitted to hospital, Emergency Department visit, or seeing a health professional.

Results. Socioeconomic variables were associated with serious traffic and fall injury and severity. For serious traffic injury, those with some post-secondary education were at higher risk (OR=1.34; 95%CI 1.08, 1.67) than post-secondary graduates. For serious fall injury, an education by gender interaction resulted. Males who did not complete high school had a higher risk (OR=1.14; 95%CI 1.03, 1.27) relative to post-secondary graduates. With the same reference group, females who completed high school had a lower risk (OR=0.86; 95%CI 0.75, 0.98). For serious fall injury, those in the lowest, versus top, personal income quintile had a higher risk (OR=1.37; 95%CI 1.23, 1.51). Females had a higher risk (OR=1.18; 95%CI 1.03, 1.35) of serious traffic injury relative to males. Youth/young adults had a higher risk of serious traffic injury (OR=1.75; 95%CI 1.50, 2.06) relative to the middle-aged group. The younger group had a higher risk of serious fall injury (OR=1.41; 95%CI 1.25, 1.60) relative to seniors. With serious traffic injury, seniors had a lower risk (OR=0.50; 95%CI 0.37, 0.68) than the middle-aged group. This did not support the literature with young and old at risk for traffic injury. In the two-level traffic severity model, employed, versus unemployed, individuals had a higher risk (OR=1.69; 95%CI 1.12, 2.55).

Discussion. Associations were found between SES variables and serious traffic and fall injury for Canadians 12 years of age and over that were mostly but not always in the direction of lower SES having higher rates. Findings must be interpreted with caution due to sampling bias from missing data removal (27%). Information was not available on culpability or vehicle miles travelled. The traffic injury-SES relationship and SES-traffic severity relationship merit further inquiry in other contexts or with other datasets.

ACKNOWLEDGEMENTS

I thank my thesis advisor, Dr. Michael Moffatt, for his guidance and feedback during my studies. My thesis committee members, Dr. Marni Brownell, Dr. Lawrence Elliott and Dr. Jeanette Montufar contributed diverse perspectives and facilitated my critical thought processing. I wish to thank Dr. Stephen Moses, for his input in the final stages.

I am grateful to Statistics Canada for providing access to the microdata at the Manitoba Research Data Centre. Dr. Ian Clara aided me greatly with the use of data products and valuable insights. Also helpful were Ms. Kelly Cranswick and Dr. Evelyn Forget. I received an RDC Graduate Student Award. I wish to thank Dr. Depeng Jiang and the Manitoba Institute of Child Health for providing statistical assistance.

I benefited from the input of Dr. Lynne Warda, Dr. Sande Harlos, Dr. Caroline Piotrowski, Dr. Kelly Russell, Dr. Colleen Metge, the WRHA Research and Evaluation team, Dr. Kerry-Jane Galenzoski, Ms. Lorraine Avery, Mr. Shawn Feely, and Ms. Wendy French. Mr. Feely provided ongoing motivational support. I thank my close friend, Dr. Glenn Stalker for his feedback, statistical help, and enthusiasm for mini-breaks.

My family and good friends were supportive. These include my mother, my sister and her family, Ms. Zoe Green, Ms. Carolanne Dupasquier, and Ms. Darryl Park. Administrative and scholastic support was received from Ms. Theresa Kennedy, Ms. Robin Shreiber and Dr. Robert Tate. Lastly, I wish to thank my father, Professor Emeritus, Dr. Colin Briggs who served as 'ghost' committee member, proofreader, note-taker, and cheerleader.

DEDICATION

I dedicate this work to my parents who supported me greatly throughout my studies.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

I. INTRODUCTION

1.1 Problem Context and Background

Injuries are the fourth leading cause of death and a significant contributor to hospitalization for all Canadians.[1-3] Nationally, motor vehicle traffic crashes result in the highest number of unintentional injury deaths and are the second leading cause of injury hospitalization, preceded by falls.[4, 5] For individuals 15-34 years of age, traffic injury is the leading cause of death and hospitalization.[6] In 2011, Canadian motor vehicle collision statistics included 2,006 fatalities, 10,443 serious injuries, and 166,725 total injuries.[7] The total cost of treating transport incidents in Canada is estimated at $3.7 billion annually, for motor vehicle incidents costs are $1.93 billion annually (2004 data).[8] The above categorization includes pedal cyclists, pedestrians, motor vehicle incidents, ATV/snowmobile users and an undefined category of "other". Transport incident costs amount to one fifth of the national economic burden of injury ($19.8B) which includes direct and indirect (e.g. lost productivity) health care costs.[8]

Transport Canada data evidence significant declines in the burden of road traffic injury between 1986-2005 with a 28% fatality reduction, a 35% decrease in serious injuries, and a 21% reduction in total injuries.[9] A wide range of effective traffic injury prevention strategies exist and are being employed, yet current efforts are not enough to eradicate traffic injury. Motor vehicle traffic continues to present a significant injury burden. Novel strategies are needed to further reduce the individual, societal and economic toll of traffic injury.

1.1.1 Examining Socioeconomic Status

The key Whitehall II study described health inequalities and the consequences of income inequality on health in Britain.[10] Study subjects were members of the British Civil Service and social gradients were evidenced for numerous diseases across work class. Mortality was higher among those in the lower job grades compared to those with higher level positions. Canadian research includes in the study of health inequalities the variables of income, education and employment.[11] Currently, the relationships among socioeconomic status, serious traffic injury and traffic injury severity have not been studied extensively. A study of cardiovascular disease risk factors found higher education may be the best socioeconomic status predictor of good health.[12] Income and occupation were not significantly associated with risk factors in that study. Research on injury and SES has largely considered injury as a general category versus focusing on specific mechanisms such as traffic injury. Also, children and adolescents have been the main focus of this research. A rare study examining youth, driving and SES showed that young drivers from low SES areas had nearly twice the relative risk of hospitalization from a crash compared with young drivers from high SES areas, controlling for rural residence and exposure.[13]

1.1.2 Falls as a Comparison Group

Studying socioeconomic status for a specific injury cause in a non-child population for all Canadians is a new research area. It was therefore desired to examine how the social determinants of health impact not only traffic injury cases but another injury mechanism, results may be similar or different. Comparing falls and traffic injury means a large portion of the injury burden is being investigated; comparisons can be made regarding whether SES variables are solely associated with traffic injury or whether crossover exists. Also, the results for interaction terms can be compared or contrasted across mechanisms. Falls were selected as there are similarities among the two injury mechanisms, together they account for the highest incidence of traumatic brain injury[14] and are the largest causes of unintentional injury hospitalizations as reported by the Canadian Institute for Health Information (CIHI).[15] For falls, the subpopulations most at risk are older adults and children.[16, 17] The latter are not examined in this project.

Relationships between socioeconomic status and serious traffic and fall injury have been found to differ. Research on falls and SES has demonstrated that being of lower socioeconomic status increased the probability of a fall in the preceding 12 months among community dwelling older adults.[18] In the elderly, low income, low education, and poor access to services all increase one's propensity for acquiring chronic health conditions which are risk factors for falls.[19]

A Swedish study of falls and traffic injuries in individuals less than 20 years of age showed socioeconomic status differences in traffic injury were greatest for 15-19 year olds, yet outcomes were not significant for fall injury.[20] Another study of individuals less than 20 years of age and injury showed an SES gradient by year for motor vehicle-related hospitalizations, with stepwise increases over time, while for falls the significant gradient by time relationship was inconsistent.[21] An Ontario study of childhood injury and poverty found that the most impoverished children experienced higher rates of injury, including fall injuries.[22]

1.2 Study Purpose

The purpose of this study was to establish the relationship among the social determinants of health and serious traffic and fall injury and separately, the severity of each. The research project included the study of individuals from age 12 throughout adulthood. The goal was to reveal issues to be considered by decision makers regarding the personal and societal burden of serious traffic injury and injury severity.

1.3 Scope

This project does not encompass all levels of traffic injury research. Factors pertaining to the vehicle and road environment, while important components of the study of traffic injury, cannot be assessed by current methods and are therefore not discussed within this project. The age span studied is individuals 12 years of age and older, therefore children less than 12 years of age are excluded. The use of a national survey enables all Canadian jurisdictions to be represented. All levels of severity are not included as fatal injury, less serious injury, and individuals in care are not captured.

1.4 Objectives

This research project had the following objectives:

1. To provide the first assessment of the association between individual-level socioeconomic variables and serious traffic and fall injury for Canadians from youth to adulthood.
2. To compare serious traffic and fall injury with regard to the social determinants of health in terms of frequency and severity.
3. To determine the personal variables (e.g. age, gender) and behaviours (e.g. health behaviours, risky traffic behaviours) that play a role in serious traffic and fall injury.
4. To clarify the relationship of non-SES predictors to serious traffic and fall injury severity.

1.5 Research Questions

The following research questions result from the objectives:

- Do individual level socioeconomic variables relate to traffic injury incidence in Canadians 12 years of age and over? Specifically, is there an association between serious traffic injury and income, education and employment?
- Is there an association among the social determinants of health and serious traffic and fall injury?
- Do sociodemographic, individual and behavioural variables play a role in serious traffic and fall injury occurrence and injury severity?

1.6 Hypotheses

It was hypothesized that:

- Socioeconomic disparities would be present for traffic injury in a national survey population. SES disparities were expected across the three age bands of 12-34 years, 35-64 years and 65+ years. Lower SES was expected to be associated with higher injury rates in these age groups.
- Individual level factors would be influential in predicting serious traffic and fall injury and injury severity.
- Traffic injury severity would differ by age group, gender and SES with interactions among variables. Lower SES was expected to be associated with higher levels of severity.

Relationships are expected among serious traffic and fall injury and socioeconomic factors. Research on SES, serious traffic and fall injury, and injury severity are exploratory, especially given the population under study.

1.7 Significance of the Problem Studied

Preventing injuries with higher levels of mortality, morbidity, and economic burden would reap the greatest benefit. This study provides a novel approach as it addresses SES and serious traffic injury with the addition of falls as a comparison group, from youth throughout adulthood. Injury severity is included as a factor which is rarely studied given that most research focuses on the primary prevention of traffic injury.

The public health approach tackles an injury problem via four steps: defining the problem, identifying risk factors, selecting and testing an intervention and finally implementation and evaluation.[23] This project focuses on the identification of risk factors with the goal of influencing decision makers regarding relevant intervention and policy directions.

1.7.1 Informing Strategies and Their Impact

Determining the strategies that are most effective for lowering injury loss is key.[24] Results of this research have the greatest capacity to aid in the construction of traffic injury risk profiles, provide knowledge relevant to general traffic injury reduction strategies, and clarify the relevance of SES to prevention planning. Identifying subgroups at greatest risk of serious traffic and fall injury and severity can inform the need to target these groups. The World Health Organization (WHO) states that road traffic injury prevention efforts should involve ascertaining the road users most affected and what the main risk factors are.[25]

1.7.2 Socioeconomic Status and Traffic Injury

Confirming differences in traffic injury by socioeconomic status can aid in targeting efforts and highlight the importance of such factors in strategic planning to reduce the burden of serious road traffic injury. This is relevant to identifying sub-groups most at risk and considering these groups when designing all interventions. Not doing so can undermine the effectiveness of strategies.[26] Mackay and colleagues (1999) stated that the SES of the target population should be taken into account for all injury prevention program strategies.[27] The discovery of interactions among SES and other predictor variables is expected to present new information applicable to reducing traffic injuries among adolescents and adults. The co-occurrence of risks is known to increase the likelihood and severity of injury.[28]

Evidence of a socioeconomic gradient in traffic injury risk where each one-level reduction in SES is associated with a greater likelihood of serious traffic injury could inform the need for a macro-level strategy that focuses on reducing socioeconomic disparity. It may not be possible to reduce traffic injuries in subpopulations until underlying inequalities are addressed. Reducing health inequalities by raising socioeconomic standing in the population is advantageous. A Swedish study showed that 25% of traffic injuries to young drivers could have been prevented had all young people had the injury rate of teens with highly educated parents.[29] A blanket approach to improve the health of Canadians by increasing SES in the lower groups could be implemented. This would raise the standing of individual yet may increase traffic injury risk if more gain access to motor vehicles. An experiment called "Mincome" was initiated in Dauphin, Manitoba in the 1970s where wages were increased to a minimum level and the working-poor were boosted financially. In its five years 1,000 families were helped by this program and research has been conducted regarding long-lasting effects.[30] Clearly, macro-level SES-level changes or specific targeting of at-risk groups can be beneficial.[31]

Obtaining results that support the research hypotheses can aid in identifying new factors underlying serious traffic injuries. In some areas, not finding support for the proposed hypotheses may also be informative. Research findings can provide evidence for priority setting, program planning, policy development and the effective allocation of health resources.[32] Those who understand the problem of traffic injury and the population in which it occurs are best able to suggest interventions.[33] Hypothesized results align with the target groups and contributing factors within Transport Canada's Road Safety Strategy 2015 (www.ccmta.ca/crss-2015). Also, data pertaining to traffic injury severity will provide insight into treatment patterns and contributing factors.

1.7.3 Traffic Injury Prevention Policy

The WHO states that many players are involved in the development of road injury prevention policy. These include: police, NGOs, special interest groups, professionals, the media, government and legislative bodies (e.g. transport, public health, education, justice, finance), users/citizens and industry.[25] Results of this research project should be relevant to many of these groups in their development of policies for traffic injury prevention. Outcomes from this project will help policy makers in selecting target groups.

1.7.4 Strengths of this Research Project

This research project has several strengths, including:

- Studying the social determinants of health in a dual-injury context from youth to end of life
- Comparing and contrasting serious traffic and fall injury when examining SES

- Using an understudied age group (adults) to investigate serious traffic and fall injury and severity with a novel Canada-wide approach.
- Examining SES as it pertains to traffic and fall injury severity in Canada
- Having a large sample size for executing statistical plans

2. BACKGROUND

2.1. Framing the Problem

"Road traffic injuries are a major but neglected public health challenge."

-World Health Organization (2004)

Injury has been described as an "invisible epidemic" as the toll is large in terms of morbidity, mortality and societal economic costs yet the amount of resources assigned to this problem is rather small in comparison to other health issues with a smaller burden.[34] Also, there is the ubiquitous use of the term "accident" to describe injuries (e.g. "motor vehicle accident") which coincides with the view that they occur by happenstance. This leads to a failure to acknowledge that injuries are predictable and preventable.

Another key issue pertains to injury severity and the amount and type of available data. Much information has been recorded for deaths and hospitalizations which are more severe yet less has been captured for Emergency Department visits, health professional visits and injuries not requiring medical treatment. Figure 1, The Injury Pyramid, illustrates that as one progresses from the bottom to the top of the triangle the severity of injury increases. In contrast, the frequency of injury occurrence increases as one moves from the top to the bottom. A study of general injuries found that 64% of those who sustained a serious injury in the past year sought medical treatment within 48 hours and 8% were admitted to hospital.[35]

Figure 1. The Injury Pyramid

2.2. Situating the Problem within an Established Framework

Dr. Willliam Haddon Jr., an injury prevention epidemiologist in the 1960s, conceptualized injuries as resulting from a transfer of energy that the body cannot tolerate (e.g. mechanical, thermal, chemical, electrical, lack of energy).[36] He viewed injury as stemming from the interaction of the host, agent, and environment.[37-39] His three-by-three matrix of event timing (pre-event, event, post-event) and interacting factors (host, agent, environment) provided cells where risk factors could be described or interventions proposed.[37-39] Environmental factors included both the physical and socio-cultural environment (i.e. norms, values, laws).[40]

Haddon viewed events leading to injury as distinct from the injury itself and therefore worthy of a focus for prevention.[41] The pre-event stage permitted the implementation of primary prevention strategies.[23] An assessment of factors contributing to injury severity relates to the event stage which had not been studied from a social determinant of health perspective. Table 1 illustrates existing strategies to prevent traffic injury.

Table 1. Primary Traffic Injury Prevention Strategies by Factor Type

	Host (Individual)	**Agent (Vehicle)**	**Environment**	
			Physical (Roads)	**Socio-cultural**
PRE-EVENT	-restraint use -drive sober (no alcohol or drugs) -appropriate speed -no distractions -no aggressive driving	-air bags -crumple zones -back up indicators -stability control -anti-lock breaks -daytime running lights -mechanical integrity -park assist	-wider lanes -fewer obstacles -breakaway areas -good lighting -bike lanes -cross walks	-speed limits -restraint laws -DUI laws -Graduated Licensing

2.3. Summarizing the Research Evidence

2.3.1 Host: Individual

Human factors have been determined to be the largest contributor to traffic crashes. Highway safety research concluded that driver errors are the main contributing factor in approximately 85% of motor vehicle collisions.[42]

2.3.1.1. Sociodemographics

<u>2.3.1.1.1. Health Determinants</u>

Directing attention to vulnerable sub-populations can be a beneficial use of scarce resources. The Population Health Approach includes determinants of health that are linked to health problems yet not considered health problems themselves.[43] Exposure to different combinations of these determinants impacts how people experience health, which is relevant to their socioeconomic status. Controlling health determinants, including socioeconomic factors, could contribute more to improving health than expanding the health care system.[44] Similarly, it has been stated that these health determinants are much more expansive than the medical system.[45] The relevance of a health determinant to an issue depends on its prevalence and effect size.[43]

The Public Health Agency of Canada listed the following determinants as influential in population health,[46] (an asterisk is placed beside those incorporated in this project):

- Biology and Genetic Endowment
- Culture*
- Education*
- Health Services
- Income and Social Status*
- Personal Health Practices and Coping

Skills*

- Employment/Working conditions*
- Gender*
- Healthy Development
- Physical Environments
- Social Environments
- Social Support Networks

2.3.1.1.2. Social Determinants of Health

Raphael summarized the social determinants of health that stemmed from a 2002 York University conference examining such factors across the lifespan. The following determinants resulted[47] (an asterisk is placed beside those incorporated in this project):

- Aboriginal status*
- Early life
- Education*
- Employment and working conditions*
- Food security
- Healthcare services
- Housing
- Income and its distribution*
- Social safety net
- Social exclusion
- Unemployment and employment security

The social determinants of health have been stated to directly impact the health of people and populations.[47] These determinants often interact with one another to cumulatively affect health. Marmot and Wilkinson (2006) stated that action on these social determinants was needed to reduce health inequalities.[48]

2.3.1.1.3. Socioeconomic Status

Socioeconomic status provides a means for explaining the health inequalities that occur within and between populations. This term has been defined as "encompassing possession of material and social resources (such as income and education) and rank or status within a social hierarchy in relation to access to and consumption of goods, services, and knowledge" (p. 151).[43] SES has been measured most often using the variables of income, education and employment, alone or in combination.

The impact of SES on injury has not been determined for adults nor for serious traffic and fall injury. Results of a systematic review (six studies) were that a higher risk of general injury existed for children in low SES categories, yet evidence was not strong.[27] Similarly, a study using the first cycle of the Canadian Community Health Survey (CCHS) demonstrated that SES was inversely associated with general injury, therefore low levels of SES were associated with greater injury rates.[49] In Manitoba, higher rates for injury mortality and injury hospitalization have been found for children residing in deprived versus economically advantaged areas.[50] In contrast, a study of adolescents (15-19 years of age) using the first cycle of the National Population Health Survey (NPHS) found injury rates to be directly related to SES (more common in high SES groups).[26] This could have resulted from increased access to dangerous devices (e.g. cars, off-road vehicles). A few studies investigated traffic injury outcomes and SES. Braver in the US, found that not completing high school predicted occupant deaths.[51] A New Zealand study found educational level and occupational status were both inversely related to driver injury risk.[52] For children, socioeconomic variables measured at the individual level play a role in traffic injury occurrence.[53-55] Most results depict an inverse relationship among SES and examined outcomes.

2.3.1.1.4. Income, Education and Employment

The amount of income and education one accumulates and the type of work performed can impact one's health and well-being. It was clear that these concepts are related to one another and that in general, more is better (e.g. more lucrative occupations, higher education). Those with less due to their position in society were disadvantaged as they had to stretch limited resources and focus more on basic needs. More often in injury research, income is used as the primary measure of SES. In a study from Alberta, payment status categories for provincial health insurance were used. This study examined childhood injury and determined high risk groups to be males, those in urban centres, those on social assistance, and children with Treaty status.[56] In Ontario, children and adolescents in the lowest income areas had a 40% greater likelihood of injury (Emergency Department or hospital admission) compared with those in the highest income area.[57] A Manitoba study showed that motor vehicle collisions were the leading cause of childhood injury mortality which was significantly correlated with income.[58] Here, higher injury mortality was associated with lower levels of income. A study of parental employment and child (0-15 years) injury fatalities found that having parents who never worked or were unemployed long-term was associated with a thirteen times greater risk of injury death from all external causes, relative to children with parents in higher managerial/ professional occupations.[59]

The use of multiple SES measures can be beneficial. Research using the first cycle of the CCHS demonstrated that adult males with an income less than $60,000 was associated with work injury, yet not education.[60] In a Canadian study on adolescence, a low level of household education, low family income and being foreign born were inversely associated with injury.[61] In Sweden, youth 16-23 years of age who were unskilled workers, or who had self-employed parents, parents who were farmers, and parents that had only compulsory schooling had an increased risk of driver injury relative to high SES and those with highly educated parents.[29]

2.3.1.1.5. Socioeconomic Gradients

A socioeconomic gradient in health status has been defined as:

> "The phenomenon that health status is lowest in the least privileged socioeconomic groups, whether 'privilege' is defined in terms of income, occupation or education, and that it increases in a monotonic fashion as one goes up the socioeconomic categories" (p.83).[62]

Therefore, like a ladder, people on a lower rung of the gradient were less healthy than those one rung above, and even less healthy than those two rungs above. The general health of a population is determined by the steepness of a socioeconomic gradient as steeper ones indicate greater inequality.[63] For overall health, a gradient has been identified in terms of disease development when considering the most privileged to the least privileged groups.[64] Early evidence of socioeconomic gradients came with the Whitehall I & II studies by Marmot and colleagues; these long-term follow up studies showed that many-cause mortality is steeply inversely associated with social class, as measured by grade of employment.[10] The relationship between lower family SES and poorer child health was evidenced as a gradient that did not vary with age.[65] In Sweden, a socioeconomic gradient was discovered for 15-19 years olds who drove and rode in motor vehicles, showing an inverse relationship among SES and traffic injury.[66] In Canada, an Emergency Department study of childhood injuries evidenced a socioeconomic gradient for injury visits among five classes of areas differing in poverty level.[22] Researchers have concluded that a social gradient in health persists which is present across the lifespan.[63]

2.3.1.2. Culture

It has been recognized that culture adds diversity to a population yet in some cases being of a particular culture can lead to marginalization. First Nations populations have been found to be at greater risk of motor vehicle injury and death compared to the general population.[67] Aboriginal people are at a higher risk of being victims of motor vehicle crashes due to the greater distances they have to travel for regular activities, and their isolation from emergency facilities.[68] Population-based research conducted in Calgary found that Aboriginal Canadians had five times the risk of sustaining motor vehicle crash injuries relative to non-Aboriginal Canadians (ages 16+).[69] Motor vehicle collision rate ratios were higher among urban Aboriginal men (RR 3.51, 95%CI 2.32-5.32) compared to urban non-Aboriginal adults who were 25+ years of age.[70] Rates were also higher for urban Aboriginal women (RR4.13, 95%CI 2.46-6.93) relative to their non-Aboriginal counterparts. Traffic injuries occurring in Canada’s Aboriginal communities have not been well captured.

2.3.1.3. Demographic Factors

2.3.1.3.1. Age

For driver age and motor vehicle injury, it has been determined that adolescent and older drivers have the highest risk of death.[71] Drivers 16-20 years of age and 75+ years of age had a greater chance (per vehicle-miles traveled (VMT)) of being in a fatal or non-fatal crash, compared with other age groups.[72] In Canada, motor vehicle crashes were the primary cause of hospital admission among 15-34 year olds.[73]

Nationally, teen drivers (16-19 years) have been over-represented in traffic victim data.[9] Teens comprised 5% of licensed drivers yet they accounted for double that proportion of driver deaths (10%) and 13% of seriously injured drivers.[74] When exposure (VMT) was taken into account, young drivers had seven times the risk of a fatal motor vehicle injury relative to non-elderly drivers. Teen drivers have been implicated in 11% of nighttime crashes and 19% of the fatal crashes between 10:00 p.m. and 6:00 a.m.[75] Teens' heightened crash risk has been attributed to their novice driving status, alcohol use, lack of maturity, passenger distraction, and risk-taking.[25, 72, 76-78] Yet teens' novice status was not a sufficient explanation for the teen driver problem as other new drivers did not have as high a risk of injury or death.[78, 79] Teens tended to be more aggressive drivers and less apt to identify and react to hazardous situations.[77, 80] Passengers had a greater [6-fold[81]] risk of death when traveling in vehicles driven by adolescents versus drivers aged 30-59.[81, 82] For teen drivers there was a 'dose-response' relationship – the more passengers the higher the fatal crash likelihood.[83, 84]

Graduated Driver Licensing (GDL) programs for young/new drivers restricted many of the high-risk behaviours that increase teen crash risk.[85] These programs protected young drivers from experiencing hazardous situations when learning to drive[86] and have contributed to lower crash rates and injuries in young drivers.[25, 87, 88] A review of GDL programs demonstrated reductions for all types of crashes among all teen drivers.[87] Most Canadian provinces and territories have introduced GDL programs yet they differ in their components, restrictions and age requirements.[89] A Canadian Pediatric Society report stressed that policy improvements are warranted in some jurisdictions.[90] An assessment of the impact of individual GDL components to determine key regulations (e.g. exit tests) for traffic injury reduction in young and new drivers was needed.[87, 91] Studies have found night driving rules and teen passenger restrictions to be effective.[79, 92] Also, zero tolerance laws regarding alcohol use prior to driving were found to lower injuries and collision likelihood in young drivers.[93] Parents were able to influence young drivers via vehicular access and rule enforcement.[94]

Compared to 30-59 year old drivers, older drivers (75+) had three times the risk of driver deaths and their passengers had 2.5 times the risk of fatal injury.[81] For similar levels of collision severity, seniors had a greater chance of dying relative to younger drivers, likely on account of physical frailty and medical issues.[95-97] Seniors 65+ years of age were more likely than teens to be in intersection crashes (especially left turns), and to be found at fault for them.[98] Older drivers' increased risk for a fatal motor vehicle crash may stem from compromised sight, loss of psychomotor skills and reduced cognition.[99] Side effects resulting from prescription and over-the-counter drugs also posed a problem for these drivers.[72, 100] Driver license renewal policies that mandate vision tests among older drivers have reduced the fatal crash risk for this age group. Another strategy to prevent injuries among elderly drivers is physician counseling.[101] Physicians can assess patients' driving competence and screen for impairments which heighten the risk of traffic injury[102] (e.g. poly-prescription side effects).[99] For these individuals, cognitive dysfunction and physical impairments often impeded the driving task.[100] With current population shifts, the proportion of elderly drivers is likely to increase in the near future.[42, 96]

2.3.1.3.2. Gender

Male drivers were more likely to be involved in fatal speed- and alcohol-related crashes relative to female drivers.[72] Men were also more likely to be hospitalized for traffic injury than women.[103] They have been recorded as driving more aggressively and exhibiting anger more readily, behaviours which have placed them at greater risk of traffic crashes and injury.[104] Men accounted for two-thirds of unrestrained occupants and were more likely to have higher blood alcohol contents (BAC).[105, 106] Young male drivers were at greatest risk for traffic crashes and injury.[77] In countries that are part of the Organization for Economic Co-operation and Development (OECD) driver fatality rates for young males were up to three times greater than those of young women.[107] In contrast, research in Canada has found that a larger proportion of females reported being in a motor vehicle collision.[108]

2.3.1.3.3. Immigrant Status

Only one study was found relevant to immigrants and traffic. In this study, Latin immigrants were as likely or more likely to wear seat belts compared to whites.[109] The other comparison groups were Mexican Americans, Central American/South American, Puerto Ricans and Cubans.[61] This represents a new area of research with serious traffic injury as the main outcome.

2.3.1.4. Risk Behaviours

Smoking and heavy alcohol use in daily life were not as directly linked to the driving task but were considered relevant acts in which people choose to engage. An assessment of a propensity to behave in ways that put one's health at risk was considered valuable. Data from the 1.1 cycle of the CCHS, for adolescents 12-24 years of age, showed risk-taking (current smoking or heavy alcohol use) to be positively associated with injury occurrence.[61] Here, an increased risk of serious injury was apparent for current smokers and adolescents consuming alcohol in the past year. The relationship among behavioural factors and traffic injury was not known. In a study of work injury, daily smokers had a greater likelihood of work injury versus occasional or non-smokers; and heavy alcohol consumption was associated with a higher likelihood of work injury.[60] A study of traffic safety behaviours in adolescents found that light and heavy patterns of cigarette smoking were significantly associated with not buckling up one's seat belt.[110] The negative consequences of smoking were known to be broad (e.g. poor health, cancer) and quitting smoking had numerous benefits for the individual. Researchers who found a link among health risk behaviours and injury in adolescents stated that multi-factorial interventions targeting the risk-taking behavior was needed.[61] Smoking or heavy alcohol consumption often served as a symptom of an overall risky lifestyle. Health behaviour change interventions have been found to be effective in primary care settings.[111] Recent research highlighted the use of behavioural science theories in efforts to change behaviour to increase the effectiveness of health promotion-based strategies.[112]

2.3.1.5 Traffic Risk Behaviours

Factors known to increase a driver's risk of being involved in a motor vehicle crash included law violation, driver inattention, and the condition of the driver (e.g. intoxication).

2.3.1.5.1. Speeding

Speeding is a form of aggressive driving with other types including weaving between lanes, running red lights, and tail-gaiting. Speeding encompasses driving either faster than the posted speed limit or too fast for conditions.[113] It has been directly linked with collision likelihood, injury likelihood, injury severity, and fatality risk.[71, 114] An exponential relationship has been identified with increased crash rates as speed increased.[115] In Canada, speed was listed as a contributing factor in 24% of fatal crashes (1996-2001).[74] In the US, removing the National Maximum Speed Limit (55mph) resulted in a 17% increase in death rates.[116] Transport Canada reported that serious speed-related injuries increased 22% between 1996-2001.[74] Use of speed enforcement detection devices has been shown to decrease traffic crashes and injury.[117] Stationary speed enforcement and red light camera devices have reduced injury crashes 17% and 12% respectively.[49]

2.3.1.5.2. Restraint Use

Seat belts were introduced as an active pre-event intervention by the motor vehicle occupant for self-protection. Seat belt use lowered the risk of injury, injury severity and fatality in a crash.[23] In Canada, approximately 1,000 lives have been saved by seat belts annually.[118] Non-use of seat belts was found to be a key risk factor for motor vehicle occupant injury,[25] with a risk of ejection from the vehicle. In Canada, unbelted occupants were listed as a contributing factor in 30% of traffic fatalities (1996-2001).[74] Unbelted occupants often became projectiles seriously injuring their fellow vehicle occupants who opted to buckle up. Enforcement of seat belt laws has led to a 20% increase in seat belt use.[49]

2.3.1.5.3. Driver Inattention

Driver inattention has been described as "a delay in recognition of information needed to safely accomplish the driving task" (p. 14).[72] Trying to complete other tasks while driving was found to compete with staying alert and attentive.[119] Driver distraction consists of visual, auditory (e.g. cell phone), biomechanical (e.g. tuning radio), or cognitive (e.g. arguing with a passenger) components.[72] Studies by the National Highway Traffic Safety Administration (NHTSA) estimated that 25-30% of police-reported collisions resulted from driver inattention.[120, 121] Teen drivers (16-20 years) had the highest involvement rates in crashes resulting from driver inattention.[72] Cellular telephone use can put drivers at greater risk of at-fault and rear-end crashes relative to non-use by drivers.[122] In Canada, the use of hand-held cell phones by drivers has been banned in British Columbia, Saskatchewan, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, Quebec, and Manitoba. The United Nations Secretary General stated that driving using hand-held cell phones increased one's risk of a crash four-fold.[123] Driver drowsiness was considered to be a form of driver inattention as tired drivers exhibit behaviours similar to inattentive drivers.[72] Crash risk was found to increase 14-fold for drivers who felt they were falling asleep.[124]

2.3.1.5.4. Being Under the Influence of Alcohol or Drugs While Driving

Alcohol impacts behaviour by lowering inhibitions, impairing judgment and raising levels of aggressiveness and risk-taking.[71] Having a positive blood alcohol concentration (BAC) is associated with a higher risk of fatality, more severe injuries, and greater crash likelihood.[125-129] In Canada, impaired drivers were listed as a contributing factor in 33% of traffic fatalities (1996-2001).[74] Compared with sober drivers, those driving under the influence of alcohol were much more likely to be male, in a single-vehicle crash, unrestrained, ejected, and driving faster.[130] Even a low blood alcohol concentration impairs driving ability[128] including lowered performance for skill tasks.[71] Relevant to reducing alcohol-related crashes and their injuries, random and selective breath testing sobriety checkpoints were effective.[131] Policy changes to control access to alcohol and restrictions to pricing and promotion were also effective in lowering impaired driving.[132] Drug use also contributed to collision risk, particularly benzodiazepines, cocaine, amphetamines and opioids with multi-use common.[133]

2.3.1.6. Self-Rated Health

Research on self-rated health has identified associated variables and validity has been assessed. One study that involved injuries and health status concluded that as self-rated health status decreased an increased injury risk was found, yet this pertains to injuries in general.[134] Other research has shown that individuals with poorer health status have an increased odds of being in a motor vehicle collision.[108] Another study that examined the perception of combined categories of fair and poor health found it was strongly associated with age, sex, SES, smoking, obesity and infrequent exercise.[135]

2.3.2 Physical Environment

2.3.2.1. Living Areas – Urban/Rural

Traffic fatalities have been found to occur more often on rural roads compared with urban roads.[136] The proportion of traffic deaths in rural areas has far exceeded the amount attributable to the extent of road travel that occurs in rural areas (exposure).[137] With rural roads, driver behaviour is a key factor in outcomes. In Canada, rural roads were listed as a contributing factor in 48% of traffic fatalities (1996-2001).[74] In British Columbia, a study spanning six years found rural populations experienced a three-fold rise in relative risk of traffic fatality and a 50% rise in relative risk of hospitalization.[138] Increased speed was identified as a contributing factor for rural crashes.[139] Other potential contributing factors include the tendency for rural drivers to travel farther, often on inferior road surfaces, relative to urban drivers.[139] Greater distance to medical assistance may contribute to deaths.[136]

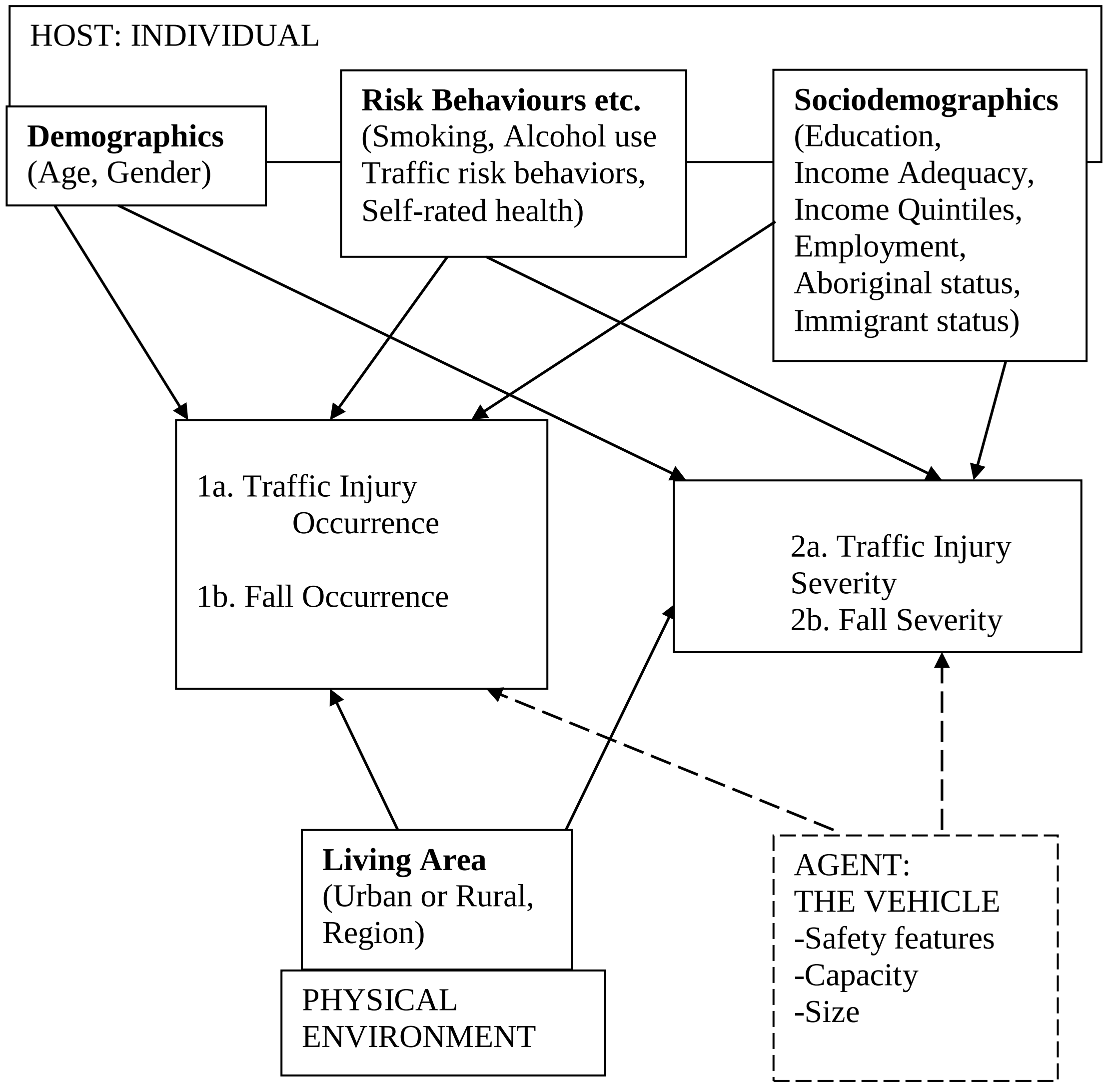
2.3.2.2. Living Areas – Region

A study using the first cycle of the CCHS demonstrated a lower injury risk for general injuries in Quebec and Nunavut relative to other areas.[35] In a study on traffic injury per 100,000 population, lower rates were found in Newfoundland and higher rates in British Columbia.[140]

2.4. Conceptual Framework

The research project is summarized in the following conceptual model. Variables that are incorporated are relevant to SES, individual factors and both primary and secondary prevention. The relationship between the host and environment variables on traffic injury, falls, traffic injury severity and fall injury severity was examined. The vehicle was included in the conceptual framework as it represents the agent in Haddon's framework and plays a role in traffic injury occurrence and severity. Vehicular characteristics cannot be examined within the current project.

Figure 2. Conceptual Model: Haddon's Matrix Applied



3. METHODS

3.1. Study Design

Secondary analysis of three combined cycles of the Canadian Community Health Survey, a federal Statistics Canada survey, was undertaken. Secondary data analysis accesses data that were previously collected. Advantages of using secondary data are time-saved from collecting raw data, a wealth of information is often available, and in general large sample sizes result. A disadvantage of secondary data analysis is that the researcher did not provide input into the questions posed. CCHS data were employed with the goal of identifying factors associated with serious traffic and fall injury, and serious traffic and fall injury severity.

3.2. Data Source: The Canadian Community Health Survey

The Canadian Community Health Survey is a cross-sectional population-based survey that acquires a new sample for each cycle with each one representing a cross-section of the nation. The survey is a collaborative effort of Statistics Canada, Health Canada and the Canadian Institute for Health Information. The CCHS was created to gather timely cross-sectional health-related data at sub-provincial levels including estimates of health determinants, health status and health system utilization.[141] These data have applications for health surveillance (e.g. incidence rates) and provide a snapshot of what is occurring within a large population.[142] The information can be used to aid in the development of public policy, to guide analytic studies for evaluating the determinants of health, and to collect social, demographic and environmental correlates of health.[141] Data were collected with the use of computer assisted telephone interviewing over a 12 month period for each cycle.

3.2.1 Reliability and Validity of the CCHS

Questions within the CCHS are tested repeatedly either prior to survey administration or when acquiring data for the parent survey from which the CCHS questions are derived. Evidence of test-retest reliability assessments conducted by Statistics Canada in advance of survey administration are provided. The injury module was taken from the National Population Health Survey, a longitudinal health survey. The demographic and sociodemographic questions were replicated from the Census of Populations. None of the questions included in this research pertain to established scales and therefore scale-based validity and reliability testing do not apply. Many other investigators have drawn inferences from the CCHS data for their health research.[60, 61, 143-147]

Statistics Canada (www.statcan.ca) states that three methods were used to validate the CCHS data: comparing estimates of health indicators with the prior version with differences analyzed, publishing analytical articles on specific themes permitting a specific area assessment, and external validation by sending share files to jurisdictions for the examination of data and any anomalies.

3.2.2 Joining Cycles

Approximately 130,000 individuals were sampled per X.1 cycle and each biennial cycle utilized an independent sample.[142] This research project combined data from X.1 cycles where the injury module was mandatory. The X.2 cycles were smaller population-based examinations of a specific health area (e.g., 1.2 - Nutrition) and therefore they not part of this research. Combining the X.1 surveys for the first three cycles (1.1 (2001), 2.1 (2003), 3.1 (2005)) would triple the number of respondents, without compromising the independence of observations. Statistics Canada developed guidelines for joining the three X.1 versions of the CCHS which include a need to weight these data to account for changes to the sampling frame from cycle to cycle.[148] The sampling frame is a key component of survey sampling relevant to ensuring a representative sample from the population.[43] Complex sampling designs and possible sampling frame inconsistencies from cycle to cycle are key issues that must be addressed. Joining strategies can include use of separate estimates, then a weighted average of these; or a pooled estimate.[149] The possibility of adding more recent cycles of the CCHS to the current three being used was investigated. In the next cycle (2007/8) the injury module was optional and not selected by many jurisdictions so data were limited. The following 2009 cycle reinstated the injury module as mandatory yet only collected a half cycle of data. It was therefore not beneficial to add these more recent cycles.

3.2.3 Population and Sample

CCHS data provided health and socio-demographic data from nationally representative population-based samples of household residents 12 years of age and over. It excludes individuals residing on Indian Reserves, Canadian Forces Bases (CFB) and in some remote areas of Quebec and Ontario.[142] Fatal injuries and extremely serious non-fatal injuries (e.g. resulting in residence at permanent treatment facilities or personal care homes) are excluded. The homeless, and the poor who do not have a telephone are also not captured.

A multi-stage stratified cluster design combined with random sampling was used to obtain a representative sample of the Canadian population.[150] Here, multi-stage sampling is taken from a frame of clusters initially with a sample of units selected from the first-level (i.e. sub-sampling) and this can break down further.[151] Homogeneous strata are formed first and samples of clusters are drawn from each stratum; the dwelling serves as the final sampling unit with households drawn per cluster.[142]

3.3. Key Variables

3.3.1 Outcome Variables

The injury question within the CCHS pertains to injuries that occurred in the past year that were 'serious enough to limit normal activities – for example, a broken bone, a bad cut or burn, a sprain or a poisoning', not including repetitive strain injuries. Respondents who report an injury are asked further questions relevant to "the most serious injury" they experienced in the past year. Questions include total number of injuries in the year, month of most serious injury, the injury cause, the injury type (e.g. sprain, concussion), main body part injured, the activity when injured, and place of injury.

3.3.1.1. Traffic Injury

The type of injury question includes a category called 'Transportation Accident' which was used as the main outcome variable for this project. A more specific term such as ‘motor vehicle collision’ (MVC) would have been preferable. It was helpful that the descriptor used in the interview script was “transportation (automobile) accidents” as this served to confirm injuries pertained to passenger vehicles. A research study that assessed self-reported motor vehicle collision injuries using the identical NPHS data characterized “transportation accidents” as “MVC”.[152] Clearly a significant limitation of these data is that the term “transportation accident” does not allow one to distinguish whether victims were drivers, passengers, pedestrians or cyclists. The Canadian Motor Vehicle Traffic Collision Report 2011[7] states the proportion of serious injuries and fatalities by victim type. Nearly 70% of serious injuries reported were motor vehicle occupants.

Table 2. Percentage of Serious Injuries and Fatalities by Road User Class 2011

Road User Class	Serious Injuries	Fatalities
Drivers	47.3	51.5
Passengers	21.8	19.3
Motor Vehicle Occupants	69.1	70.8
Pedestrian	13.5	15.7
Motorcyclists	10.6	8.4
Bicyclists	3.9	2.6
Not Stated/Other	2.9	2.5

Questions within the CCHS on where the injury happened and what activity was being engaged in prior to injury were examined to see if they would provide further clarification of the type of transportation injury sustained. The ‘place of injury’ variable had the category of ‘street, highway, sidewalk’ which was applied to the study of road traffic injury.

3.3.1.2. Fall Injury

The CCHS includes a pre-screening question regarding whether the injury was the result of a fall and if so, “how” the individual fell. The latter is used for descriptive purposes only. Serious fall injury was included as a secondary outcome variable assessing the same predictors as used for serious traffic injury. Main effects and interaction terms that reach significance for serious traffic and fall injury were compared.

3.3.1.3. Injury Severity

Prior to the development of a composite measure for severity a full literature search was conducted with the assistance of a health science librarian to find previously used categorizations of injury severity. Scales were found (e.g. Injury Severity Scores, Glasgow Coma Scale) yet they were medical in nature and did not relate to data within the CCHS. In the absence of a readily available measure, a medical doctor with specialization in injury recommended the following four-level composite measure, listed from highest to lowest severity: admitted to hospital, visited the Emergency Department (ED), saw a health professional, or used self-management. The severity variable was derived from responses to questions regarding where individuals sought treatment within 48 hours of injury and whether they were admitted to hospital.

3.3.2 Predictor Variables

Three of the four main SES variables below were included in all models, only one of the two income variables was used in each model. The other main variables and the exploratory variables were added to the models so long as bivariate tests were significant.

Table 3. Categorization of Predictor Variables

Factor	
Main Variables	**Exploratory Variables**
Educational Level	Heavy Alcohol Use
Personal Income Quintiles	Immigrant Status
Income Adequacy	Self-rated Health
Employment	Smoking Status
Gender	
Age Group	
Region	
Urban/Rural	
Aboriginal Status	

3.3.2.1. Education Attainment

Highest level of education attained was grouped into four categories: less than secondary school, secondary school graduation, some post-secondary, post-secondary graduation. This information was taken from the CCHS response categories within the demographic information questions.

3.3.2.2 Income Adequacy

This was a derived ten-level variable computed by Statistics Canada for cycle 3.1. Each survey respondent is assigned to a decile via the use of an algorithm using total household income and accounting for the number of household dwellers. Therefore, people who reside in similar income households with different numbers of household dwellers might be in different income adequacy groups. For cycles 1.1 and 2.1 these deciles were back-filled as they were calculated retrospectively using formulas provided by Statistics Canada.

3.3.2.3. Income Quintiles

This variable was generated electronically by SPSS. The software was programmed to divide the personal income variable into five equivalent quintiles each accounting for 20% of the sample. Here, respondents were asked "What is your best estimate of your total personal income, before taxes and deductions, from all sources in the past 12 months". This variable is relevant to statistical power as the income adequacy variable has 10-levels which may not reach statistical significance. However, personal income was not always reported so missing data were present.

3.2.2.4. Employment

For employment three categories were available for use: individuals who were employed, not currently employed, and permanently unable to work.

3.2.2.5. Aboriginals Living Off-Reserve

The proportion of Aboriginals relative to Non-Aboriginals experiencing serious traffic and fall injury was examined. Coding of cases was based on a prior study of non-fatal injuries that used the 1.1 and 2.1 combined cycles of the CCHS, comparing injuries for non-Aboriginal and Aboriginal Canadians, with the latter specific to people living in households in non-reserve areas.[146] Respondents were asked "To which ethnic or cultural group(s) did your ancestors belong" - those who selected "North American Indian", "Inuit" or "Métis", were collectively categorized as "Aboriginal". Those who did not state their cultural or racial background were excluded and those who did not state that they were Aboriginal were considered not to be.

3.3.2.6. Gender

Gender is included as a demographic variable with the categories of male and female. The goal of determining whether results from this study align with prior research was tested. Results were stratified by gender to examine differences between males and females where applicable.

3.3.2.7. Age

Respondents were asked to provide their age in years. Age was incorporated in the models predominantly as a categorical variable. The categorical breakdowns were youth/young adults (12-34), general adults (35-64), and seniors (65+). Statistical tests were conducted to examine whether a curvilinear relationship existed among age and key outcome variables. The testing of a curvilinear relationship necessitated the creation of age as a squared variable in the model. Therefore, the value of age was multiplied by itself for each respondent. When age squared was included in the model the continuous variable age also had to be present. Models were compared to examine whether age functions better as a continuous or categorical variable.

3.3.2.8. Place of Residence

Data did not specify a crash location so place of residence of each case was used. Cycle 1.1 uses a five-category breakdown of rural/urban while the other two cycles employed a seven category breakdown. A six-category breakdown was employed as one of the seven categories was “missing”. The new variable had one level absent for cycle 1.1’s five-level categorization.

3.3.2.9. Region of Residence

Little is known regarding differences in serious traffic and fall injury and severity rates across Canada. Conducting analyses by province led to too many category levels. Efforts were made to classify injuries on a larger scale by region of the country. Prior research is replicated which divides the country into the groupings of Atlantic, Quebec, Ontario, the Prairies and British Columbia.[153] A sixth category was added to include residents of northern territories.

3.3.2.10. Immigrant Status

Immigrants were defined as individuals not born in Canada or Canadian by parentage; they were compared to their non-immigrant counterparts. This research was exploratory given the lack of concrete evidence linking serious traffic and fall injury and immigrant status.

3.3.2.11. Health Behaviours

The CCHS contains questions on health risk behaviours which were used to determine individuals' risk-prone or risk-averse nature. Data regarding the variables of smoking status and heavy alcohol consumption were employed. Smoking categories were arrived at by following a schema devised by Fransoo et al. (2009) for CCHS data.[154] Three levels resulted: former smokers (daily and occasional), non-smokers (never smoked), and current smokers (current daily, current occasional). Former smokers were included as smoking rates have reduced in recent decades and these individuals may still represent an at risk group. For alcohol use, respondents were asked "Thinking back over the past week, did "you" have a drink of beer, wine, liquor or any other alcoholic beverage?." If yes, the respondent was asked to state how many alcoholic beverages were consumed in that week. For women, 10 or more alcoholic beverages per week was considered heavy alcohol consumption, and for males 15 or more alcoholic beverages per week defined heavy drinking.[155]

3.3.2.12. Self-Rated Health

Respondents were asked to rate their health on a scale ranging from poor, fair, good, very good, and excellent. Self-rated health was included as a two-level variable of "poor/fair" versus "good/very good/excellent". This was based on categorizations in prior research.[156] This is a new area of research and is very exploratory in nature.

3.3.2.13. Traffic Risk Behaviours

Two modules relevant to road safety have been included within single cycles of the CCHS. Samples were small given that each occurs in only one of the three cycles, and because modules were optional so not all regions included them. In cycle 1.1 there was a "Driving Under the Influence Survey" with questions pertaining to driving or riding with someone who had two or more drinks and use of a designated driver. The "Driving and Safety Survey" was a module included in cycle 2.1. It surveyed general driving behaviours and impaired driving or riding with an impaired driver. Topics such as seat belt use, hands-free cell phone use, driving when tired, speeding tendencies, and aggressive driving were examined. A variable entitled "risky driving" was derived from content provided within this module. Responses were summed for risky driving behaviours and a categorization of whether the individual had engaged in none, one or "two or more" risky driving behaviours was created. The driving and safety survey module included questions on motorcycle and off-road vehicle use and that content was not used.

3.4. Interactions

3.4.1 Traffic Injury and Fall Outcomes

The following two-way interactions were investigated among predictor variables and outcomes of serious traffic and fall injury:

- Education x Income Adequacy

  -One study found that those who attended secondary school for less than two years were 2.3 times as likely to have had a driver injury (resulting in hospitalization or death) relative to those who attended university or polytechnic.[52]
  -Higher injury mortality was associated with lower levels of income.[58] While this study involved children it is expected to be relevant to older age groups.
  -It was predicted that the effect of income inadequacy would be greater for those with less education versus those with more education
  -There may not be sufficient power to examine this four-level by 10-level relationship; if this is the case education by income quintiles will be substituted.

- Gender x Education
  -Research has shown that young male drivers have a greater risk of traffic injury than any other age group.[77]
  - This interaction tests the prediction that the effect of education will be greater for males than for females.

- Gender x Aboriginal Status
  - Male drivers are more likely to be involved in fatal speed-related crashes, alcohol-related fatal crashes, and speed-related deaths than female drivers.[72]
  -Aboriginal people are at higher risk of motor vehicle collisions than non-Aboriginal people.[157]
  -The prediction that the effect of Aboriginal status will be greater for males compared with females was investigated.

- Age x Gender
  -An age-gender interaction is expected as young male drivers have a greater risk of traffic injury than any other age group.[77]

-The prediction that the effect of age will be greater for males than for females was examined.

- Urban/rural x Alcohol use

  -When fatal motor vehicle crashes were assessed it was found that the injury fatality rate was nearly three times higher in rural versus urban areas.[136]
  -The heavy alcohol use variable is exploratory as all evidence pertains to drinking just prior to driving versus patterns of overall alcohol consumption and how that may impact crashes.
  -The prediction that the effect of rural dwelling will be greater for those who consume high amounts of alcohol relevant to those who are not heavy drinkers was assessed.

- Smoking x Alcohol Use

  -In a study of motor vehicle drivers attending a trauma centre, smokers were more likely to have a history of previous motor vehicle trauma than non-smokers.[158]
  -As stated above, the alcohol use variable is included for exploratory purposes.
  -The prediction that the effect of smoking will be greater for those who consume alcohol in high levels relative to non-heavy drinkers was examined.

- Age x Risky Driving Behaviours

  -For both men and women the stated use of seat belts increased with age.[159]
  -Teens' heightened crash risk has been attributed to their novice driving status, alcohol use, lack of maturity, passenger distraction, and risk-taking.[25, 72, 76-78]
  -The prediction that the effect of risky driving behaviours will be greater for younger traffic injury victims versus older ones was examined.

3.4.2 Severity Outcome

- Age x Education

  -The prediction that the effect of education will differ for younger and older traffic injury victims was investigated.

- Gender x Education

  -The prediction that the effect of gender will be greater among individuals with higher education compared to those with lower education was examined.

- Age x Gender

  -The prediction that the effect of age will be greater for males than females was tested.

3.5. Analytic Plan

3.5.1 Data Preparation and Programming

Steps were taken to ensure data were complete and appropriate adjustments were made prior to conducting statistical analysis. SPSS 17.0 was used for coding, data cleaning, and generating descriptive data. The SUDAAN software program was used for bivariate tests, logistic and multinomial modeling all of which applied the bootstrapping technique.

3.5.2 Missing Data

The best approach to missing data is to reduce the likelihood of having missing values in the data planning and collection steps. It has been well established that "missing data can result in biased estimates of the association between an exposure *X* and an outcome *Y"* (p. 1).[160] It is important to determine the type of missing data and whether data were missing at random or not.[161] It is preferred that cases be missing at random versus systematically, to not yield biased estimates.[162] [163] For instance, if disadvantaged groups more commonly refuse to answer questions or provide invalid responses, and these cases are all deleted, the sample would be skewed to higher income groups. Also, the data would not be missing at random. Statistical procedures exist for diagnosing the type and extent of missing data within a dataset.[164] The type of missing data most likely found in this study was "item non-response", characterized by a respondent failing to provide a proper response to one or more survey items.[165] Missing data can impact the interpretation of findings regarding data quality (re: reliability and validity), the strength of the research design, and the validity of findings.[164, 166] Reliability pertains to the replication of results and their generalizability to different individuals or groups.[43] For this study, the extent of missing data was clarified for all key predictor variables. Data were also screened for outliers not falling within the accepted range of each variable.[167]

3.5.2.1. Evaluating Missing Data Solutions

Missing data can be dealt with via several strategies each of which tends to have benefits and drawbacks. The three main solutions that were considered for these data were use of complete cases, missing value imputation, and weighting.

3.5.2.1.1. List-wise Deletion/Complete Cases

Omitting entire cases with missing data and performing analyses on only the remaining complete cases is a popular strategy for dealing with missing data.[164] A systematic review of 262 epidemiological studies containing missing data showed that 81% used “complete case analysis”.[168] Pitfalls of this approach are the elimination of potentially useful data which results in a smaller sample, and less statistical power to detect effects, both of which can introduce bias.[166] [164] A key assumption is that the sample that remains is a true random sample of all eligible cases.[169] It is advantageous to use this strategy when the proportion of missing data in the database is fairly low.[170]

3.5.2.1.2. Imputation

Imputation involves back-filling missing results by substituting estimated values for missing ones. Many different statistical procedures are used to arrive at the estimated values; some employed a multiple imputation method (i.e. introduce random variation, trials conducted, use multiple datasets).[160] The multiple imputation method accounts for the uncertainty of estimates[171] and can result in less bias relative to other techniques.[169] Substituted variables in simple imputation may include the overall variable mean, a subgroup mean or a regression estimate. Imputation can lead to biased parameter and standard error estimates as "artificial" data are treated as real data. This method may falsely boost statistical power, artificially increase R-square, and reduce variability.[172]

3.5.2.1.3. Applying Weights

With the weighting method, one applies a statistical weight to compensate for the pattern of missing data. More weight may be applied to the cases that are missing. Determining what weights to use can be a complicated endeavor as can applying the weights using standard statistical software.[165] Also, having other weights already applied to a large dataset can impact the introduction of new weights to address the missing data problem.

The strategy selected to address the missing data problem in this study, following consultation with many statistical texts, journal articles on methodology/statistics, and a biostatistician, was to use only complete records. A reduced sample was arrived at by binary coding the data for ten key variables as missing or non-missing and then removing the incomplete cases. The ten key variables used were education, income adequacy, employment, age group, gender, Aboriginal status, urban/rural residence, region, smoking status, and self-rated health.

3.5.2.2 Statistical Comparison of Reduced and Removed Samples

It was necessary to determine how much distortion or bias resulted from using a reduced sample to conduct all analyses for this project. At this stage, the removed cases cannot be re-imputed as access to the data has expired. To quantify the impact of removing missing cases chi-square tests were conducted contrasting the "missing" (yes/no) variable against each predictor and outcome. Non-significant results are preferred indicating that the reduced and removed samples do not differ significantly and bias is not present. A significant result points to a need to evaluate the extent of the difference and its relevance to drawing real inferences from the data.

3.5.2.3 Probing Statistically Significant Results for SES Variables

Whether the reduced sample data were significantly different from similar national population data collected around the same time was assessed. The Statistics Canada website (www.statcan.gc.ca) was searched for comparable population-based data. Differences among datasets were compared by calculating confidence limits per variable category and determining whether proportions overlap. It was preferred that confidence intervals overlapped indicating that the reduced sample data was representative of the population. The following formula was used to compute confidence intervals (CI):[173]

Figure 3. Confidence Interval Formula

$$p \pm 1.96 \times \sqrt{\frac{p(1-p)}{n}}$$

Small p is the sample proportion, and n is the sample size. The square root section is the standard deviation of the proportion and its standard error. Formulas were developed in Microsoft Excel to tabulate this information and arrive at low and high 95% CIs.

3.5.3 Bootstrapping

Standard methods of statistical analyses can rarely be directly applied to complex sample survey data.[174] Sampling weights were employed as the design is non-random. Weighting accounts for the differential likelihood of selection among individual respondents.[175] It provides a remedy for the violation of the assumption of 'independence' (of observations) and not having an equal probability of selection (via simple random sampling[176]). In national population-level surveys the weighting of estimates is necessary to avoid generating biased population estimates,[142, 167] and to allow generalization of obtained results to the entire population.[177] The final weights assigned to each respondent reflect unequal selection probabilities and adjust for non-response and stratification.[176]

Weighting of CCHS survey samples facilitates obtaining a nationally representative sample and representative subpopulations.[141] The sample weight applied to each case was "the (estimated) number of individuals in the population which the person represents" (p. 159).[178] Bootstrapping was carried out as a final step to improve the accuracy of variance estimation when employing a complex survey design. It involved the calculation of a mean point estimate using a large number of different weights with a variance and 95% confidence intervals per estimate. Non-overlapping point estimate intervals are viewed as statistically significant differences, and a coefficient of variation was also generated.

Bootstrap variance estimates were used to counteract bias in terms of the statistic being an accurate parameter estimate and for determining variance.[179] This method accounted for the complexities of the survey design and the various adjustments conducted when weighting. A set of bootstrap weights was available per sampling weight to calculate the variances.[180] The coefficient of variation (CV) that was computed indicates the quality of the estimate obtained. A CV from 16.6 to 33.3% should be interpreted with caution, and those exceeding 33.3% with extreme caution.[181]

3.5.4 Sample Size Calculations

Analysis of large databases provides the benefit of having a large representative sample available.[177] It is important to verify that the sample size was adequate to perform proposed analyses.[175, 177] Power and sample sizes calculations were performed after consultation with a statistical expert and reviewing statistical manuals.

3.5.4.1 Main Statistical Models

Descriptions of predictor variables included in the main analysis are listed in Table 4A. Power analyses involved calculating the number of respondents needed per condition of the dependent variable. To accomplish this, the number of levels per variable minus 1 was calculated and the result was multiplied by 10; this was carried out per variable, and then results summed across all predictors. Interactions were calculated as [(k-1)(k-1)]*10 so a gender by education interaction would add (1)(3)=3x10=30 cases to the total.

Table 4A. Traffic & Falls - Individual-Level Predictor Variables

Variable Name	# Levels-1	N per variable
Age (12+) - categorical with three levels, and continuous	2	20
Gender – two levels	1	10
Highest Education Obtained – four levels	3	30
Income Adequacy – ten levels	9	90
Income Quintiles – five levels	4	40
Employment – three levels	2	20
Aboriginal status - two levels	1	10
Region – six levels	5	50
Immigrant Status – two levels	1	10
Urban/Rural Residence – six levels	5	50
Heavy Alcohol Use – two levels	1	10
Smoking status – three levels	2	20
Self-rated health – two levels	1	10
Risky driving behaviours – three levels	2	20
	Total	390

Table 4B. Traffic & Falls Interactions

Education x Income Adequacy	(3)(9)=27	270
Gender by Education	(1)(3)=3	30
Gender by Aboriginal Status	(1)(1)=1	10

Age x Gender	(2)(1)=2	20
Urban/rural x Heavy Alcohol Use	(5)(1)=5	50
Smoking x Heavy Alcohol Use	(2)(1)=1	20
Age x Risky Driving Behaviours	(2)(2)=4	40
	Total	440
Total main effects & interactions		830

Sufficient cases existed to test all interactions and main effects for this project. Based on the 830 minimum, traffic and fall injury outcomes, and control cells had more than enough cases. The lowest was the serious traffic injury outcome which had 2,342 cases in the reduced model, far more than required.

3.5.4.2 Severity Model

Predictor variables included in the severity analysis are listed in Table 5A. The number of interactions and main effects to be tested was reduced due to lower sample sizes for outcomes.

Table 5A. Severity - Individual-Level Predictor Variables

Variable Name	**levels-1**	**x10**
Age (12+) - categorical with three levels, and continuous	2	20
Gender – two levels	1	10
Highest Education Obtained – four levels	3	30
Income Quintiles – five levels	4	40

Employment – three levels	2	20
Aboriginal status – two levels	1	10
Heavy Alcohol Use – two levels	1	10
Smoking status – three levels	2	20
Self-rated health – two levels	1	10
Risky driving behaviours – three levels	2	20
	Total	190

Table 5B. Severity – Interactions

Age x Gender	(2)(1)=2	20
Age x Education	(2)(3)=6	60
Gender by Education	(1)(3)=3	30
	Total	110
Total main effects & interactions		300

The severity model had enough cases to be valid.

3.5.5 Data Analyses

3.5.5.1 Preliminary Analyses

Serious traffic and fall injury and severity outcomes were examined for each predictor variable using chi-square tests. Also, variables from the driving survey modules were tested against the outcome variables via chi-squared tests. Means and other descriptors were performed with age as a continuous variable. The strategy used for these bivariate tests followed recommendations within the SUDAAN software manual. Injury severity was examined using either the ACMH or TCMH chi-square test, as the outcome variable was ordinal with three levels.

Table 6. Type of Chi-Square Test Conducted

Row Variable Type	**Column Variable Type**	**Type of Chi-Square Test Used**
Nominal	Nominal	Chi-square test (standard)
Nominal	Ordinal	CMH ANOVA Wald-F (ACMH)
Ordinal	Ordinal	CMH Trend Wald-F (TCMH)

3.5.5.2 Logistic Regression Models

Logistic regression was appropriate as the outcome variable had two levels, the presence or absence of a serious traffic or fall injury. The contribution of individual-level SES measures in addition to the demographic, socio-demographic and health content available within the surveys was assessed. Logistic regression was used to predict serious traffic injury, serious fall injury, road traffic injury, neck/back injury, and a two-level severity outcome. Interaction terms that were arrived at by considering the research questions and power calculations were included in the models first. Main effects that pertained to each interaction variable were included in the models yet not examined individually if the higher order interaction was significant. Socioeconomic status variables were included in every model regardless of significance in the bivariate tests. If both personal income quintiles and income adequacy were significant in the chi-square tests a decision was made in terms of which variable was the best fit.

Multicollinearity was examined prior to running the main models by conducting correlations among the main SES variables and the Aboriginal status variable. Spearman's correlation coefficients were assessed to ensure variables were not too closely related. For two variables to be "too closely related" they would be characterized as having a "strong" (0.60-0.79) or very strong (0.8-1.0) association in either the positive or negative direction.[182]

3.5.5.3 Multinomial Logistic Regression Models

Multinomial logistic regression was carried out for the analysis of injury severity. Data were filtered to include only cases of serious traffic or fall injury. Included cases must have sought treatment within 48 hours of injury. The multinomial method is an extension of binary logistic regression which applies to outcome variables that have more than two levels.[183] SES, personal and behavioural variables were included in the severity models.

3.5.6 Limitations

3.5.6.1 Validity of Survey Data

The data collection instrument and variable list were carefully examined to determine how study variables were operationalized.[177] Validity pertains to whether one has truly measured what one thinks was measured.[43, 184] It is preferred that results be generalizable to the population or a subset of the population.[185] Concerns with CCHS validity include the fact that some subpopulations of Canada were not adequately represented so it may not be a valid measure of Canadian attitudes. However, research has demonstrated that approximately 98% of the population 12+ years of age is represented in the CCHS.[150] Another issue was the fact that data were derived from self-report, which can involve difficulties with recall bias, question interpretation, and socially appropriate response bias. Recall bias should be fairly minimal as survey respondents are only asked about events occurring within the past year. A serious injury in the past year should be salient if it was serious enough to limit one's normal activities. The other self-report concerns are more difficult to detect.

3.5.6.2 Association not Causation

The cross-sectional nature of the survey does not allow for the assessment of causation. In these designs individual responses on predictor and outcome variables were obtained at a single point in time.[186, 187] Risk factors can be concluded to be associated with outcomes but not with their incidence or duration.[43 177] The estimated effect of a given factor based on the direction and degree of its correlation with the outcome of interest can be determined.[24]

3.5.6.3 Broad Traffic Outcome Variable

The main outcome variable utilized was not sufficiently specific for the researcher's goals and therefore only broad conclusions can be drawn. In employing secondary data one does not have input in the questions posed and phrasing used. The outcome is described as traffic injury in the absence of knowing the type of victim injured.

3.5.6.4 The Severity Spectrum

Severity of injury spans from little severity to fatalities. This research did not address injuries less than “serious enough to limit your normal activities”. In addition, mortality was not captured and those “in care” are not polled. In care patients refers to those in geriatric hospitals, long-term care facilities and rehabilitation centres. Therefore the middle of the severity spectrum was the focus. Also, as previously stated Aboriginals living on-reserve were not captured.

3.5.6.5 Quantifying and Minimizing Bias

The decision to include only complete cases in the study was further examined to determine if the sample excluded differed from the selected sample. Efforts to align the remaining sample with population-based data aided in confirming whether the sample was representative. Use of other methods to address missing data could not be applied for this project as access to the project data files at the Statistics Canada Research Data Centre had expired.

3.6. Ethical Considerations

Voluntary, informed consent was acquired from participants by the primary survey administrator at the time of the interview. For large national surveys conducted by Statistics Canada a detailed sampling and interview protocol was followed. The protocol for this project was reviewed and approved by the Health Research Ethics Board at the University of Manitoba.

4. RESULTS

4.1. Data Preparation

4.1.1 Reduced Sample

There were between 760-1085 (0.7%) ‘transportation accidents’ per CCHS survey cycle with each cycle having 130,000-135,000 respondents. Once the three CCHS X.1 cycles were joined with relevant weights applied the result was 2,743 cases sustained a transportation accident of 400,055 respondents. Standardized weights were applied to each cycle to account for its individual sampling frame. For missing data, the best course of action was determined to be the use of complete cases once options were compared. In the end, 292,588 respondents remained with 2,342 experiencing a serious traffic injury, 27% of cases were excluded. A study of Canadian Emergency Department data focusing on pediatric injuries removed 17% of cases to have only complete records.[22]

4.1.1.1 Comparing Included and Excluded Data

Chi-squared tests assessed differences among the removed and remaining data for all key predictors and the two outcome variables (see Table 7). With the exception of immigrant status, all tests were found to be significant which was not the desired result. Several tests failed to generate a chi-square value yet the p value was significant. Finding differences suggests that the remaining sample was not representative of the entire sampled population.

Table 7. Missing and Non-Missing Content Compared

Factor	Chi-Sq	p, df
Outcome Variables		
Serious Traffic Injury	X2=19.10	p=0.0000, df=1
Serious Fall Injury	X2=303.46	p=0.0000, df=1
Main Variables		
Education	X2 (ACMH)=*****	p=0.0000, df=1
Personal Inc. Quintiles	X2 (ACMH)=*****	p=0.0000, df=1
Income Adequacy	X2 (ACMH)=*****	p=0.0000, df=1
Employment	X2=421.70	p=0.0000, df=2
Gender	X2=265.73	p=0.0000, df=1
Age Group	X2 (ACMH)=851.60	p=0.0000, df=1
Region	X2=100.23	p=0.0000, df=4
Urban/Rural	X2=35.70	p=0.0000, df=4
Aboriginal Status	X2=5.22	p=0.0228, df=1
Exploratory Variables		
Heavy Alcohol Use	X2=132.43	p=0.0000, df=1
Immigrant Status (ns)	X2=3.03	p=0.0825, df=1
Self-rated Health	X2=782.81	p=0.0000, df=1
Smoking Status	X2=1828.81	p=0.0000, df=2
Survey Variable		
Cycle	X2 (ACMH)=215.14	p=0.0000, df=1

4.1.1.1.1 Proportions of Missing Data

Table 8 illustrates data proportions for relevant categories across all variables in the study. For variables where only a few levels were presented (e.g. region) the absent levels had more even distributions across the reduced, removed and total groups.

Table 8. Percentage of Overall, Reduced and Removed Results

Variable	Overall Percentage	Reduced Percentage	Removed Percentage
Traffic Injury	0.8%	0.8%	0.6%
Fall Injury	5.2%	4.6%	7.0%
Education			
-Post sec grad	47.8%	53.2%	29.7%
-Some high school	26.6%	20.0%	48.6%

Income Adequacy	Even split	Skewed levels 5-10	Skewed levels 1-4
Income Quintiles	Level 4 lowest 17% Level 5 peak 23%	Skewed levels 3-5	Skewed levels 1-2
Employed	68.5%	70.1%	59.1%
Age Group			
-Middle aged	49.3%	56.4%	27.8%
-Seniors	14.3%	9.4%	29.1%
Gender (males)	49.3%	50.3%	45.9%
Region			
-Ontario	38.7%	39.4%	36.5%
-British Columbia	13.4%	12.7%	15.3%
Urban/Rural			
-Urban core/SUC*	71.2%	71.8%	69.4%
Current Smokers	23.6%	25.7%	16.9%
Heavy drinkers	8.5%	8.9%	6.7%
Poor/fair health	11.5%	10.3%	15.3%
Aboriginals	3.3%	3.2%	3.4%
Cycle	Even split	Even split	26.8% c1, 37.2% c2 36% c3

*SUC – Secondary Urban Core

4.1.1.1.2 Missing Data Distributions and Impacts

Given that SES was the focus of this project missing data in those key variables was unfortunate. For instance, the education variable had higher proportions of individuals with some high school for the removed compared with the remaining sample. For all SES measures, not having a representative sample poses threats to the validity of predictions and the stability of analyses. It would have been preferable to have a reduced sample that was more representative of the overall sample in order to better test for SES differences in outcomes. It was not desirable that the more disadvantaged were eliminated as part of the removed sample. More serious traffic injury cases were included in the analysis which was beneficial, however, fewer serious fall injury cases were present. For age, a deficit identified was the low percentage of seniors in the reduced sample. This is not optimal when one wants to study seniors as an at-risk group.

4.1.1.2 Comparisons of Reduced and National Population Samples: SES Variables

After determining that there were differences among the remaining and removed samples when chi-square analyses were performed, for nearly all predictors and all outcomes tested, the next step was to compare SES variables for the reduced sample data and national data collected around the same time period. It was preferable that all levels of the key SES variables have overlapping confidence intervals with the selected national data.

4.1.1.2.1. Education Data Compared

Study data variables included the highest level of educational attainment achieved per respondent. National population data obtained for educational attainment had seven levels and therefore categories had to be collapsed for comparison. Category levels of "Apprenticeship, or trades certificate or diploma" and "College, CEGEP or other non-university certificate or diploma" comprised "some postsecondary education". The "post-secondary graduation" category focused on university completion. Here, "University certificate, diploma or degree" was combined with "University certificate or diploma below the bachelor level". Data from the 2006 Census Community Profiles for Canada were employed for the national portion.

Table 9. Confidence Interval Results for Educational Attainment

	Study data		**National data**	
	low 95%CI	**high 95%CI**	**low 95%CI**	**high 95%CI**
Less than secondary school	0.1968	0.2033	0.2373	0.2830
Secondary school graduation	0.1774	0.1840	0.2550	0.2557
Some post-secondary education	0.0836	0.0905	0.2810	0.2817
Post-secondary graduation	0.5297	0.5347	0.2557	0.2661
Total sample size	293,171		25,664,220	

For the Census data, results were derived from a 20% sample which is the citizens who completed the long form survey. The national data were for individuals 15 years and over whereas the study data pertains to those age 12 and higher. Educational attainment results were interpreted with some caution as study and national CIs did not overlap.

4.1.1.2.2. Personal Income Quintile Data Compared

National population data obtained for individual income had many more levels than the five within the study data. Collapsing the categories enabled these two datasets to be more directly compared yet some categories did not map onto the study categories exactly (e.g. 1-10,999 study level versus 1-9,999 national data level). Data from the 2006 CANSIM tables were employed for the national portion.[188]

Table 10. Confidence Interval Results for Personal Income Quintiles

	Study data		National data	
Study levels	**low 95%CI**	**high 95%CI**	**low 95%CI**	**high 95%CI**
$1-10,999	0.1849	0.1919	0.1844	0.1851
$11,000-20,999	0.1844	0.1914	0.2114	0.2121
$21,000-34,999	0.1966	0.2035	0.2198	0.2205
$35,000-49,999	0.1728	0.1798	0.1555	0.1563
$50,000-500,000	0.2440	0.2507	0.2270	0.2277
Total sample size	255,567		24,113,150	

The comparison of personal income quintile data with national individual income data led to an overlapping confidence interval for the lowest quintile only. It was surprising that more levels did not overlap as the range in proportions was narrow at 18-25% for the reduced sample and 16-23% for the national data. Overall, results for the personal income quintile data should be interpreted with some caution.

4.1.1.2.3. Employment Data Compared

The employment variable within the reduced sample had three levels as did the national labour force variable. Results from the 2006 Census Community Profiles for Canada were used for the national data.

Table 11. Confidence Interval Results for Employment

	Study data		National data	
Employment Categories	**low 95%CI**	**high 95%CI**	**low 95%CI**	**high 95%CI**
Employed	0.6993	0.7033	0.6240	0.6245
Not employed	0.2744	0.2806	0.0435	0.0442
Permanently unable to work	0.0176	0.0248	0.3316	0.3322
Total sample size	293,170		25,664,220	

For the Census data the results were derived from a 20% sample which is the citizens who complete the long form survey. Notes that accompany the Statistics Canada table state that the category of "not in the labour force" includes: students, homemakers, retired workers, seasonal workers in an 'off' season who were not looking for work, and persons who could not work because of a long-term illness or disability. The latter part alone was equivalent to the third level of the employment variable used in this study. Findings should be interpreted with some caution as study and national data CIs did not overlap.

4.1.2 Addressing Multicollinearity

Multicollinearity indicates that two or more predictor variables too closely resemble one another or are highly correlated within a multiple regression model. If multicollinearity exists then coefficient estimates may not be accurate as they pertain to the variables being examined. The SES variables were not highly related with one another nor did they correlate highly with Aboriginal status (Tables 12 & 13). Correlations exceeded 0.5 for comparisons of personal income quintiles and income adequacy for both serious traffic and fall injury. This is expected as these variables are both derived from income data within the CCHS with one measuring income in general and the other income sufficiency. In statistical modeling these two variables were never entered into the same model.

Table 12. Correlation Matrix for all SES Variables, Filtered for Traffic Cases

Variables	Education	Employment	Income Adequacy	Income Quintiles	Aboriginal Status
Education	1.0	-0.204 p< .000	0.206 p< .000	0.279 p< .000	-0.056 p< .006
Employmt	-0.204 p< .000	1.0	-0.334 p< .000	-0.393 p< .000	0.043 p< .039
Inc. Adeq.	0.206 p< .000	-0.334 p< .000	1.0	0.525 p<.000	-0.074 p<.000
Inc. Quint.	0.279 p< .000	-0.393 p< .000	0.525 p<.000	1.0	-0.074 p<.001
Aboriginal Status	-0.056 p< .006	0.043 p< .039	-0.074 p<.000	-0.074 p<.001	1.0

Table 13. Correlation Matrix for all SES Variables, Filtered for Falls Cases

Variables	Education	Employment	Income Adequacy	Income Quintiles	Aboriginal Status
Education	1.0	-0.243 p< .000	0.225 p< .000	0.407 p< .000	-0.053 p< .000
Employmt	-0.243 p< .000	1.0	-0.286 p< .000	-0.367 p< .000	0.029 p< .001
Inc. Adeq.	0.225 p< .000	-0.286 p< .000	1.0	0.509 p<.000	-0.095 p<.000
Inc. Quint.	0.407 p< .000	-0.367 p< .000	0.509 p<.000	1.0	-0.068 p<.000
Aboriginal Status	-0.053 p< .000	0.029 p< .001	-0.095 p<.000	-0.068 p<.000	1.0

4.1.3 Weighting in Statistical Models

Statistics Canada data files included the weights applied when conducting modeling. The “Weight Master” is provided per case for all CCHS respondents. For the chi-squared tests, a standardized weight was used for all analyses. The standardized weight was computed per cycle by dividing the weight for each case in that cycle by its mean cycle weight. This method accounts for individual cycle contributions so the sample is more representative of the population. Bootstrapping increases the accuracy of variance estimation when using a complicated survey design. Here, five hundred iterations of each model were run using estimates provided by Statistics Canada.

4.2. Data Analyses: Preliminary Survey Data

Injury and Driving Survey Modules provided useful information on injury circumstances and driving practices, standardized weights were applied to these data.

4.2.1 Injury Module Data

Overall, the reduced sample included 2,342 traffic and 13,548 fall injury cases serious enough to limit normal activities. For serious traffic injury the majority of respondents (88.0%) had only one injury in the past 12 months and for serious fall injury single injuries predominated (79.1%) yet over one-tenth of respondents reported two injuries (12.8%). Half (51.2%) of all serious fall injuries resulted from slipping, tripping or stumbling on any surface or on ice or snow. In line with this, the Canadian Centre for Occupational Health and Safety concluded that a large proportion of falls (60%) occur on the same level and were classified as slips and trips (www.ccohs.ca). The winter months (December, January, February) were common times for serious traffic (26.5%) and fall (30.1%) injury. This was not surprising given that these months are met with harsher weather conditions and injuries commonly occur outside. The summer months (June, July, August) also ranked highly for both serious traffic (25.5%) and fall (27.4%) injury.

This may result from individuals being involved in more activities and having more recreational time.

Sprains and strains were the most common type of serious traffic (45.7%) and fall (42.8%) injury. Next most common types were multiple injuries (14.9%) for traffic and broken or fractured bones (27.9%) for falls. The main body parts injured for serious traffic injury were the neck (25.1%) and upper or lower back/spine (27.8%) whereas serious fall injury tended to impact the upper and lower extremities (59.2%).

Place of injury occurrence differed greatly across the two injury types: for serious traffic injury it was more often the 'street, highway, sidewalk' (81.8%) and for falls, injuries tended to occur in the 'home or surrounding area' (33.9%) or at the 'sports or athletics area' (25.9%). The activity being engaged in at the time of injury was most often work-related (40.7%) for traffic and sports or physical exercise (36.2%) for falls.

The majority (86.0%) of serious traffic cases and two-thirds of serious fall cases (65.4%) sought treatment within 48 hours of injury. For this subset, 55.4% of traffic injury cases and 48.0% of fall injury cases visited the Emergency Department. The second most common treatment site was a doctor's office (26.3% traffic cases, 21.7% falls cases). The proportion of serious traffic injury cases requiring hospital admission was twice that of serious fall injury cases (12.9% vs. 5.5% respectively). This implies that serious traffic injury cases may be more severe relative to serious fall injuries.

4.2.2 Traffic Survey Results

4.2.2.1 Driving Under the Influence Survey (CCHS Cycle 1.1)

There were 91,862 (31.3%) respondents for this module within cycle 1.1 of the CCHS. Valid responses were not provided regarding how many times the respondent drove after consuming two or more drinks within the past hour. Only 4.9% of respondents stated that they had been a passenger with a driver who had too much to drink in the past 12 months.

The above alcohol-related questions were repeated in the Driving and Safety Survey in cycle 2.1. This time there was driver data as in the past 12 months, 8.4% of respondents reported having driven a motor vehicle after consuming two or more drinks in the hour prior to driving. The proportion of 12.2% for being a passenger with a driver who drank alcohol was over double that found in cycle 1.1. Driving and riding with a driver under the influence is a dangerous practice that continues to occur.

Of the individuals who stated that they go out with friends or family to a place where they might be consuming alcohol a fifth of respondents do not (18.1%) arrange to have a designated driver.

4.2.2.2 Driving and Safety Survey (CCHS Cycle 2.1)

There were 53,241 (18.2%) individuals who responded to the Driving and Safety Survey. Most respondents (86%, n=45,700) had driven a motor vehicle in the past 12 months. Seat belt users were classified as those who stated that they fasten their seat belt in a motor vehicle "always" or "most of the time". The majority of occupants in the front and back seats wear a seat belt. This is required by law across Canada as is passenger seat belt use in taxis. The proportion that buckle up in a taxi was much lower (57.8%) than in regular passenger vehicles.

Table 14. Seat Belt Use by Seating Position and Vehicle Type

	# Seat belt users	Total responses	Percent
Driver	44369	45689	97.11%
Front Seat Passenger	50272	51858	96.94%
Back Seat Passenger	41389	48063	86.11%
Riding in Taxi	17567	30375	57.83%

4.2.2.2.1 Distracted/Drowsy Driving

Cellular phone use while driving, including hands-free, was reported as “often” or “sometimes” by 22.0% of respondents. These drivers are cognitively distracted which may involve taking one hand off the wheel. Over a third (35.2%) of respondents reported driving when they felt tired either “often” or “sometimes”. Clearly a fair proportion of respondents engaged in distracted or drowsy driving making them a risk to fellow motorists and other road users.

4.2.2.2.2 Speeding/Aggressive Driving

Just over a quarter (26.6%) of respondents stated that they drive much faster or a little faster relative to other drivers. One-sixth (16.6%) of respondents assert that they drive much or a little more aggressively than other drivers. Aggressive driving and speeding are very dangerous driving practices that put oneself, motorists, pedestrians and cyclists at risk.

Driving survey variables were not included in modeling due to small sample sizes. Bivariate comparisons attained significance when testing driving variables against main outcome variables. Serious fall injuries were more common for aggressive drivers (vs. non-aggressive), speeders (vs. those without a tendency to speed), risky drivers per increasing level of risk, and those willing to ride as passengers with inebriated drivers. Riding with an alcohol-inebriated driver was also significant for serious traffic injury. An overall disregard for one's safety may be operating with less caution in many situations such as walking, running, or sports. The link between types of risking driving/riding and the likelihood of a serious fall injury is not clear.

4.3. Data Analysis: Predicting Serious Traffic Injury

4.3.1 Bivariate Significance of Key Variables

Results of bivariate comparisons using serious traffic injury as the outcome variable and key predictor variables are detailed below. None of the seven interaction terms tested achieved significance within the serious traffic injury model.

Table 15A. Traffic as Outcome and Significance of Predictor Variables

Factor	**Test Outcome**	**Chi-sq Test**	**Statistic WF = Wald F X^2=ChiSq**	**P value**	**Degrees Freedom**
Main Variables					
Education	NS	ACMH	WF=0.6200	p=.4314	1
Personal Inc. Quintiles	Sig	ACMH	WF=6.8480	p=.0091	1
Income Adequacy	NS	ACMH	WF=3.3911	p=.0661	1
Employment	Sig	STD	X^2=4.67	p=.0098	2
Gender	Sig	STD	X^2=6.71	p=.0100	1

Age Group	Sig	ACMH	WF=123.741	p=.0000	1
Region	Sig	STD	X^2=32.63	p=.0000	4
Urban/Rural	Sig	STD	X^2=4.60	p=.0012	4
Aboriginal Status	Sig	STD	X^2=4.94	p=.0267	1
Exploratory Variables					
Heavy Alcohol Use	Sig	STD	X^2=4.21	p=.0408	1
Immigrant Status	NS	STD	X^2=0.99	p=.3205	1
Self-rated Health	Sig	STD	X^2=24.84	p=.0000	1
Smoking Status	Sig	STD	X^2=14.55	p=.0000	2
Survey Variable					
Cycle	Sig	ACMH	WF=25.2099	p=.0000	1

Table 15B. Traffic as Outcome and Significance of Driving-related Variables

	sig	n Tr=1	Chi-sq Test	Statistic WF = Wald F X^2=ChiSq	P value	Degrees Freedom
Use cell phone	NS	402	STD	X^2=1.88	p=.1715	1
Drive when tired	NS	406	STD	X^2=0.78	p=.3770	1
Aggressive driver	NS	405	STD	X^2=0.00	p=.9617	1
Speeding driver	NS	405	STD	X^2=0.04	p=.8402	1
“Risky driver”	NS		ACMH	X^2=1.3890	P=.2391	2
Drive if 2+ drinks	NS	333	STD	X^2=0.90	p=.3440	1
Psgr w/ drunk driver	NS	454	STD	X^2=1.74	p=.1879	1
Use designated driver	NS	547	STD	X^2=0.84	p=.3598	1
Psgr w/ drunk driver	Sig	861	STD	X^2=4.34	p=.0378	1

Note: “Psgr” is an abbreviation for “passenger”

While not included in modeling, the significant outcome for cycle showed a decrease in the proportion of serious traffic injury across cycles/over time. Serious traffic injury proportions were 1.0% for cycle 1.1 (2001), 0.8% in cycle 2.1 (2003) and 0.6% for cycle 3.1 (2005).

4.3.2 Modeling Serious Traffic Injury

Although educational attainment was not significant within the bivariate comparisons for serious traffic injury it was kept in the model as a key socioeconomic status variable. As income adequacy failed to reach significance personal income quintiles was used to represent income. Immigrant status, an exploratory variable, was not significant and therefore not included in the model. Preliminary modeling eliminated the variable heavy alcohol use.

Table 16. Logistic Regression: Serious Traffic Injury as Outcome Variable

Factor/Interaction	**Traffic Wald F**	**Traffic p value**
Education	2.70	0.0450
Personal Income Quintiles	2.20	0.0678 (ns)
Employment	0.46	0.6340 (ns)
Gender	5.53	0.0191
Age group	47.77	0.0000
Urban/Rural	2.94	0.0201
Region	29.26	0.0000
Aboriginal Status	0.00	0.9806 (ns)
Self-rated health	35.57	0.0000
Smoking Status	5.42	0.0047

Cox & Snell R^2 for traffic outcome =0.002773. Overall Model Wald F=744.33, p=0.0000

The final model was re-run to test for a curvilinear effect of age using age squared and the continuous age variable. Neither variable was significant (p=0.5836 for age squared, p=0.3119 for age continuous; results not shown). Therefore, this suggests that a linear relationship was found for the age variable. Results showed that youth/young adults are at greater risk while seniors are at lesser risk of serious traffic injury relative to middle aged counterparts (Table 17).

Table 17. Odds Ratios for Significant Predictor Variables and Serious Traffic Injury

		Traffic Outcome	
Level of Variable		**Odds Ratio**	**95% CI**
Education	1=No High School	1.09	(0.88, 1.34) NS
	2=H.S. Graduation	1.17	(0.97, 1.41) NS
	3=Some Post Sec.	1.34	(1.08, 1.67)
	4=Post Sec. Grad.	1.00 (REF)	
Gender	1=male	1.00 (REF)	
	2=female	1.18	(1.03, 1.35)
Age Group	1=12-34 years	1.75	(1.50, 2.06)
	2=35-64 years	1.00 (REF)	
	3=65+ years	0.50	(0.37, 0.68)
Urban/Rural	1=Urb Core, Sec UC	1.27	(1.05, 1.54)
	2=Urban Fringe	1.09	(0.71, 1.68) NS
	3=Rural Fringe	1.37	(0.98, 1.93) NS
	4=Urb Out CMA/CA	0.94	(0.70, 1.25) NS
	5=Rur Out CMA/CA	1.00 (REF)	
Region	1=Atlantic provs.	1.00 (REF)	
	2=Quebec	0.53	(0.40, 0.69)
	3=Ontario	0.93	(0.75, 1.15) NS
	4=Prairies	1.57	(1.23, 1.99)
	5=British Columbia	1.57	(1.24, 1.99)
Smoking Status	1=Never Smoked	1.00 (REF)	
	2=Former Smoker	0.93	(0.79, 1.09) NS
	3=Current Smoker	1.21	(1.02, 1.43)
Self-rated Health	1=Poor/Fair	1.74	(1.45, 2.08)
	2=Good/VG/Excellent	1.00 (REF)	NA

Note: 95%CI = 95% Confidence Interval corresponding to the odds ratio listed

4.3.2.1 Education

Relative to those who obtain post-secondary graduation there was a higher risk of serious traffic injury for those with some post-secondary education (OR=1.34). The categories of not completing high school and having some post-secondary education did not attain significance.

4.3.2.2 Gender

Females have a higher risk (OR=1.18) of serious traffic injury relative to males. This result does not follow the literature as usually males are at greater risk of traffic injury.

4.3.2.3 Age Group

When compared with the middle age group there was a higher risk of serious traffic injury for youth/young adults (OR=1.75) yet a lower risk for seniors (OR=0.50). The finding for the younger age group follows the literature yet the outcome that seniors are at less risk than middle-aged drivers is an unexpected result.

4.3.2.4 Urban/Rural Residence

Relative to the referent category Rural Outside CMA/CA the only significant difference shown was a higher risk of traffic injury for those in the Urban core and secondary urban core (OR=1.27). This did not follow the hypothesis that those who reside in rural areas would be at greater risk of serious traffic injury, compared to individuals living in urban areas.

4.3.2.5 Region of Residence

Relative to the Atlantic Provinces, living in the Prairies or British Columbia placed one at increased risk of serious traffic injury (OR=1.57 for both). However, less risk was associated with living in Quebec (OR=0.53) compared to the Atlantic Provinces. No predictions were made concerning regional differences and traffic injury risk.

4.3.2.6 Self-Rated Health

Those in poor/fair health had a higher traffic injury risk (OR=1.74) compared with individuals in good/very good/excellent health. This was in line with the hypothesis for self-rated health and serious traffic injury.

4.3.2.7 Smoking Status

Current smokers had a heightened risk (OR=1.21) of serious traffic injury relative to never smokers. There was no significant risk differential for never having smoked versus former smokers.

4.3.3 Supplemental Logistic Regression Models, Filtered for Traffic

4.3.3.1 Road Traffic as Outcome Variable

This model was included in the analyses as it was considered to be a more specific examination of traffic injury that would be more likely a reflection of solely motor vehicle traffic. The road traffic outcome variable refers to only the traffic cases that list "street, highway, sidewalk" as place of occurrence which comprises 82% of all traffic injury cases. In total, there were 1,911 road traffic injury cases. Variables with significant bivariate traffic-predictor chi-square tests were included in the model. Preliminary modeling resulted in the predictors of heavy alcohol use, smoking status and self-rated health being excluded.

Table 18. Logistic Regression: Road Traffic Injury as Outcome Variables

Factor/Interaction	Road traffic Wald F	Road traffic p value
Education	0.59	0.6229 (ns)
Personal Inc. Quintiles	1.51	0.1987 (ns)
Employment	0.47	0.6242 (ns)
Gender	6.46	0.0114
Age group	0.03	0.9669 (ns)
Urban/Rural	2.05	0.0860 (ns)
Region	2.55	0.0387
Aboriginal Status	3.16	0.0763 (ns)

Cox & Snell R^2 for road traffic outcome =0.038809 Overall Model Wald F=13.96, p=0.0000.

Fewer variables attained significance in this model compared with the serious traffic injury model. For road traffic injury, none of the main SES variables were significant and the only other significant predictors were gender and region.

Table 19. Odds Ratios for Significant Predictor Variables and Road Traffic as Outcome

		Road Traffic Outcome	
Level of Variable		**Odds Ratio**	**95% CI**
Gender	1=male	1.00 (REF)	
	2=female	1.55	(1.11, 2.18)
Region	1=Atlantic provinces	1.14	(0.53, 2.42) NS
	2=Quebec	1.00 (REF)	
	3=Ontario	2.22	(1.26, 3.91)
	4=Prairie provinces	1.74	(0.98, 3.08) NS
	5=British Columbia	2.09	(1.16, 3.77)

Note: 95%CI = 95% Confidence Interval corresponding to the odds ratio listed

There was a consistent greater risk of serious road traffic injuries for females (OR=1.55) relative to males. For region, Ontario (OR=2.22) and BC (OR=2.09) had a higher risk of serious road traffic injury relative to Quebec.

4.3.3.2 Neck/Back Injury as Outcome Variable

Neck/back injuries were considered to be indicative of whiplash and therefore more likely to have been incurred by motor vehicle occupants. The binary outcome variable created to examine these injuries compared injuries to the neck, upper back/spine and lower back/spine with those to other body areas. There were 1196 (52.9%) cases that were injuries to the neck or back and 1066 (47.1%) cases that were injuries to other body areas. Variables with significant bivariate traffic-predictor chi-square tests were included in the model. Preliminary modeling led to the removal of heavy alcohol use and smoking status, and self-rated health variables.

Table 20. Logistic Regression: Neck/back as Outcome Variables

Factor/Interaction	**Neck/back Wald F**	**Neck/back p value**
Education	0.80	0.4924 (ns)
Personal Inc. Quintiles	1.24	0.2950 (ns)
Employment	3.29	0.0382
Gender	14.72	0.0001
Age group	1.07	0.3452 (ns)
Urban/Rural	1.87	0.1146 (ns)
Region	3.16	0.0140
Aboriginal Status	1.92	0.1660 (ns)

Cox & Snell R^2 for neck/back outcome =0.061904. Overall Model Wald F=2.75, p=0.0000.

Table 21. Odds Ratios for Significant Predictor Variables and Neck/Back Outcomes

		Neck/back Outcome	
Level of Variable		**Odds Ratio**	**95% CI**
Employment	1=Employed	1.54	(1.08, 2.20)
	2=Not Employed	1.00 (REF)	
	3=Unable to Work	2.05	(0.67, 6.30) NS
Gender	1=male	1.00 (REF)	
	2=female	1.75	(1.31,2.33)
Region	1=Atlantic provinces	1.00	(0.63, 1.58) NS
	2=Quebec	0.88	(0.55, 1.42) NS
	3=Ontario	1.00 (REF)	
	4=Prairie provinces	1.82	(1.22, 2.73)
	5=British Columbia	1.32	(0.90, 1.92) NS

Note: 95%CI = 95% Confidence Interval corresponding to the odds ratio listed

Fewer variables attained significance in this model compared with the serious traffic injury model. For SES, the only significant variable was employment with the risk of neck/back injuries higher for those employed (OR=1.54) compared with individuals not employed. There was a significant result for region with the Prairies (OR=1.82) having a higher risk of neck/back injury relative to Ontario. There was a consistent greater risk of neck/back injuries for females (OR=1.75) relative to males. The relationship between neck/back injuries and gender was explored (Table 22) and the chi-square test was significant. There was a higher proportion of neck/back or whiplash injuries in females.

Table 22. Neck/back Injury by Gender

		Gender		
		1=Male	2=Female	Total
Neck/back Injury	0=”No”	545	521	1066
	1=”Yes”	502	694	1196
% per neck/back		42.0%	58.0%	100%
% Columns		47.9%	57.1%	52.9%
Total		1047	1215	2262

X^2=8.43, p=.0038, df=1

4.4. Data Analysis: Predicting Serious Fall Injury

4.4.1 Bivariate Significance of Key Variables

The results of the bivariate comparisons using serious fall injury as the outcome variable and all key predictor variables are detailed below.

Table 23. Serious Fall Injury as Outcome and Significance of Predictor Variables

Factor	**Test Outcome**	**Chi-sq Test**	**Statistic WF = Wald F X^2=ChiSq**	**P value**	**Degrees Freedom**
Main Variables					
Education	Sig	ACMH	WF=48.2988	p=.0000	1
Personal Inc. Quintiles	Sig	ACMH	WF=72.0577	p=.0000	1
Income Adequacy	Sig	ACMH	WF=4.6603	p=.0313	1
Employment	Sig	STD	X^2=10.13	p=.0000	2
Gender	Sig	STD	X^2=16.73	p=.0001	1
Age Group	Sig	ACMH	WF=161.062	p=.0000	1
Region	Sig	STD	X^2=7.72	p=.0000	4
Urban/Rural	Sig	STD	X^2=4.66	p=.0011	4
Aboriginal Status	Sig	STD	X^2=15.65	p=.0001	1
Exploratory Variables					
Heavy Alcohol Use	Sig	STD	X^2=51.88	p=.0000	1
Immigrant Status	Sig	STD	X^2=118.03	p=.0000	1
Self-rated Health	Sig	STD	X^2=52.25	p=.0000	1
Smoking Status	Sig	STD	X^2=8.02	p=.0004	2
Survey Variable					
Cycle	Sig	ACMH	WF=8.4390	p=.0038	1
Driving Surveys					
Use cell phone	NS	STD	X^2=0.80	p=.3702	1
Drive when tired	NS	STD	X^2=0.01	p=.9214	1

Aggressive driver	Sig	STD	X^2=5.33	p=.0214	1
Speeding driver	Sig	STD	X^2=7.11	p=.0079	1
"Risky driver"	Sig	ACMH	X^2=5.11	p=.0243	2
Drive if 2 drinks	NS	STD	X^2=2.56	p=.1100	1
Psgr with Dr. 2 drinks	Sig	STD	X^2=9.93	p=.0017	1
Use designated driver	NS	STD	X^2=0.61	p=.4346	1
Psgr w/ drunk driver	Sig	STD	X^2=29.49	p=.0000	1

Note: "Psgr" is an abbreviation for "passenger"

While not included in the model, the significant chi-square result for cycle showed an increase in the proportion of serious fall injury across cycles/over time. In cycle 1.1 (2001) 4.4% of respondents had incurred a serious fall injury which rose to 4.6% in cycle 2.1 (2003) and 4.8% in cycle 3.1 (2005).

4.4.2 Modeling Serious Fall Injury

All main and explanatory variables were significant for the bivariate analyses and were included in the model. A higher order education by gender interaction term was significant so the education and gender main effects were not reviewed separately. Regarding SES, personal income quintiles also yielded significant results.

Table 24. Logistic Regression: Serious Fall Injury as Outcome Variable

Factor/Interaction	**Traffic Wald F**	**Traffic p value**
Education x Gender	5.35	0.0012
Education	---	---
Personal Income Quintiles	15.80	0.0000
Employment	0.62	0.5398 (ns)
Gender	---	---
Age group	40.77	0.0000
Urban/Rural	1.38	0.2394 (ns)
Region	8.34	0.0000

Aboriginal Status	0.51	0.4744 (ns)
Heavy Alcohol Use	37.94	0.0000
Immigrant Status	29.75	0.0000
Self-rated health	40.20	0.0000
Smoking Status	3.67	0.0261

Cox & Snell R^2 for falls outcome = 0.004951. Overall Model Wald F=1438.77, p=0.0000.

4.4.2.1 Interaction: Education by Gender

It was previously hypothesized that the effect of education would be larger for males rather than females and that concurs with the result obtained below. To further investigate the significant interaction the model was re-run stratified by gender and examining the education variable output. Education was significant as determined by a significant Wald F Statistic for males (Wald F=2.72, p=0.0441) and females (Wald F=4.34, p=0.0050).

Table 25. Illustration of Education by Gender Interaction Effects for Falls

		MALES		**FEMALES**	
Level of Variable		**Odds Ratio**	**95% CI**	**Odds Ratio**	**95% CI**
Education	1=No High School	1.14	(1.03, 1.27)	1.14*	(0.99, 1.31)
	2=H.S. Graduation	1.03*	(0.92, 1.16)	0.86	(0.75, 0.98)
	3=Some Post Sec.	1.16*	(1.00, 1.34)	1.06*	(0.93, 1.22)
	4=Post Sec. Grad.	1.00 (REF)		1.00 (REF)	

*non-significant

This interaction shows that for males there is a higher risk of serious fall injury for those with less education yet this was only significant for the lowest group of not completing high school (OR=1.14) relative to post-secondary graduates. For females, when compared with post-secondary graduation, less educational completion was associated with fewer falls yet only for those who completed high school (OR=0.86).

Table 26. Odds Ratios for Predictor Variables for the Serious Fall Injury

		Falls Outcome	
Level of Variable		**Odds Ratio**	**95% CI**
Personal Income Quintiles	1=$1-10,999	1.37	(1.23, 1.51)
	2=$11,000-20,999	1.06	(0.96, 1.18) NS
	3=$21,000-34,999	0.97	(0.88, 1.07) NS
	4=$35,000-49,999	1.00	(0.89, 1.11) NS
	5=$50,000-500,000	1.00 (REF)	
Age Group	1=12-34 years	1.41	(1.25, 1.60)
	2=35-64 years	1.05	(0.94, 1.17) NS
	3=65+ years	1.00 (REF)	
Region	1=Atlantic provs.	1.00 (REF)	
	2=Quebec	0.98	(0.87, 1.10) NS
	3=Ontario	1.13	(1.01, 1.26)
	4=Prairies	1.13	(1.01, 1.27)
	5=British Columbia	1.33	(1.16, 1.51)
Heavy Alcohol Use	0=Not a Heavy Alcohol User	1.00 (REF)	
	1=Heavy Alcohol User	1.35	(1.23, 1.49)
Immigrant Status	1=Immigrant	1.00 (REF)	
	2=Non-Immigrant	1.33	(1.20, 1.48)
Self-rated Health	1=Poor/Fair	1.39	(1.25, 1.53)
	2=Good/VG/Excellent	1.00	
Smoking Status	1=Never Smoked	1.11	(1.03, 1.19)
	2=Former Smoker	1.00 (REF)	
	3=Current Smoker	1.03	(0.95, 1.12) NS

Note: 95%CI = 95% Confidence Interval corresponding to the odds ratio listed

4.4.2.2 Personal Income Quintiles

There was a significant difference among personal income quintiles for risk of serious fall injury. Relative to the highest quintile, those in the lowest quintile had a higher risk of serious fall injury (OR=1.37). This supports the hypothesis for socioeconomic status variables and disparity.

4.4.2.3 Age Group

Relative to the older age group there was a higher risk of serious fall injury for youth/young adults (OR=1.41). This is contrary to the literature where seniors are at greatest risk of fall injury. For the continuous age variable the mean was 38.86 years with a standard deviation of 16.810 years. Neither the continuous age variable, nor the assessment of a curvilinear age effect via age squared, yielded a significant result.

4.4.2.4 Region

For region the risk of serious fall injury was greater for Ontario and the Prairies (both OR=1.31), and British Columbia (OR=1.33) compared to the Atlantic provinces.

4.4.2.5 Heavy Alcohol Use

Relative to those who did not drink heavily, there was a higher risk of serious fall injury for heavy alcohol users (OR=1.35).

4.4.2.6 Immigrant Status

Non-immigrants had a higher risk of serious fall injury (OR=1.33) relative to immigrants. This is an interesting result given the exploratory nature of including this variable in the project.

4.4.2.7 Self-Rated Health

Compared with those in good/very good/excellent health being in poor/fair health was associated with a higher risk (OR=1.39) of serious fall injury.

4.4.2.8 Smoking Status

Relative to former smokers, never- smokers have a heightened risk (OR=1.11) of serious fall injury. There was not a significant risk differential for current smokers relative to the other two categories. The rationale behind this result is unclear.

4.5. Data Analysis: Predicting Serious Traffic and Fall Injury Severity

4.5.1 Severity as a Three-Level Outcome Variable

Not all injured persons sought treatment within 48 hours and some received care at more than one type of site. A formula was developed to select the most serious treatment method per case. Severity was reduced to a three-level outcome as there were very few cases for self-care. Frequencies for the three-level severity outcome are summarized in Table 27.

Table 27. Severity Levels by Injury Outcome

	Serious Traffic Injury	**Serious Fall Injury**
1 Admitted to hospital	290	739
2 Visited the Emergency Department (ED)	940	4624
3 Seen by Other Health Professional	580	3080
Total	1810	8443

4.5.1.1 Bivariate Tests of Severity, Filtered for Traffic Injury

Chi-squared statistics were conducted for all predictors and the traffic injury severity outcome variable. Only one significant difference was evidenced for driving survey variables with severity filtered by traffic so the single significant finding is reported. Output for the variable cycle was excluded for non-significance as well.

Table 28. Severity Outcomes Filtered by Traffic and Significance of Predictor Variables

Factor	Test Outcome	Chi-sq Test	Statistic WF = Wald F	P value	Degrees Freedom
Main Variables					
Education	Sig	TCMH	WF=13.3161	p=.0003	1
Personal Inc. Quintiles	Sig	TCMH	WF=6.5960	p=.0105	1
Income Adequacy	Sig	TCMH	WF=7.6933	p=.0057	1
Employment	Sig	ACMH	WF=6.8412	p=.0012	2
Gender	Sig	ACMH	WF=4.1665	p=.0418	1
Age Group	Sig	TCMH	WF=5.0885	p=.0245	1
Region	Sig	ACMH	WF=11.9559	p=.0000	4
Urban/Rural	Sig	ACMH	WF=10.2456	p=.0000	4
Aboriginal Status	NS	ACMH	WF=0.0402	p=.8411	1
Exploratory Variables					
Heavy Alcohol Use	NS	ACMH	WF=1.0536	p=.3052	1
Immigrant Status	Sig	ACMH	WF=8.6144	p=.0035	1
Self-rated Health	NS	ACMH	WF=2.6097	p=.1068	1
Smoking Status	Sig	ACMH	WF=3.5883	p=.0284	2
Driving Surveys					
Psgr w/ drunk driver	Sig	ACMH	WF=6.3239	p=.0122	1

Riding with a driver who had 2+ drinks in the hour before driving was significant for traffic injury severity [WF=6.3239, p=.0122]. Descriptive data illustrating which treatment outcome was selected had half attending the Emergency Department, a third being admitted to hospital and 17% seeing a health professional.

4.5.1.2 Injury Severity Filtered by Serious Traffic Injury

Bivariate comparisons were not significant for Aboriginal status, heavy alcohol use and self-rated health so these variables were excluded from the models. Preliminary modeling led to the removal of immigrant status and smoking status. Income adequacy was selected over personal income quintiles as the latter was not significant in early modeling.

Table 29. Multinomial Regression: Severity as Outcome Variable Filtered for Traffic

Factor/Interaction	**Wald F**	**p value**
Education	12.88	0.0449
Income Adequacy	33.37	0.0151
Employment	13.50	0.0091
Gender	6.56	0.0376
Age group	13.74	0.0082
Urban/Rural	53.41	0.0000
Region	48.88	0.0000

Overall Model Wald F=255.21, p=0.0000.

Relevant to the SES variables, education, income adequacy, and employment were significant in the severity model filtered by serious traffic injury. Age group, gender, urban/rural residence and region of residence were also significant. Results are summarized for the key SES variables across the two-level severity groupings.

4.5.1.3 Injury Severity Filtered for Serious Fall Injury

Chi-squared tests were conducted for all predictors and the severity outcome. Bivariate comparisons were not significant for heavy alcohol use, Aboriginal status, driving survey or cycle variables so they were excluded from the model.

Table 30. Severity Outcomes Filtered by Falls and Significance of Predictor Variables

Factor	Test Outcome	Chi-sq Test	Statistic WF = Wald F	P value	Degrees Freedom
Main Variables					
Education	NS	TCMH	WF=2.2323	p=.1358	1
Personal Inc. Quintiles	Sig	TCMH	WF=9.6789	p=.0020	1
Income Adequacy	NS	TCMH	WF=1.9549	p=.1627	1
Employment	Sig	ACMH	WF=8.7653	p=.0002	2
Gender	Sig	ACMH	WF=9.6196	p=.0020	1
Age Group	Sig	TCMH	WF=5.3135	p=.0216	1
Region	Sig	ACMH	WF=7.6448	p=.0000	4
Urban/Rural	Sig	ACMH	WF=12.6401	p=.0000	4
Aboriginal Status	NS	ACMH	WF=0.8718	p=.3509	1
Exploratory Variables					
Heavy Alcohol Use	NS	ACMH	WF=0.0409	p=.8398	1
Immigrant Status	Sig	ACMH	WF=4.5148	p=.0341	1
Self-rated Health	Sig	ACMH	WF=11.5963	p=.0007	1
Smoking Status	Sig	ACMH	WF=4.7385	p=.0091	2

Following preliminary modeling smoking status and immigrant status were removed.

Table 31. Multinomial Regression: Severity as Outcome Variable Filtered for Falls

Factor/Interaction	Wald F	p value
Education	5.91	0.4333 (ns)
Personal Income Quintiles	10.28	0.2456 (ns)
Employment	8.64	0.0707 (ns)
Gender	30.41	0.0000
Age group	42.58	0.0000
Urban/Rural	40.26	0.0000
Region	37.66	0.0000
Self-rated Health	11.14	0.0038

Overall Model Wald F=1070.98, p=0.0000

For the severity model filtered by falls there were no significant relationships found for any of the key socioeconomic status variables. Gender, age, urban/rural, region and self-rated health were all significant variables in the model. Results varied for the severity outcome and gender comparisons and serious fall injury depending on the outcome dyad compared. For other variables the direction of the effects shifted as well.

4.5.2 Severity as a Two-Level Outcome Variable

Severity was tested as a binary variable via logistic regression, and filtered for serious traffic injury cases. The levels of “admitted to hospital” and “visiting the Emergency Department” were combined to represent more severe injury and visiting a health professional signified less severe injury. There were 1181 (60.5%) more severe cases and 770 (39.5%) less severe cases. Due to a lack of significance immigrant status was not included in the model. Preliminary modeling resulted in the exclusion of the heavy alcohol use, self-rated health and smoking status.

Table 32. Severity as Three and Two-Level Outcome Variable with Traffic Injury Filter

	Severity as a 3-level Outcome			**Severity as a 2-level Outcome**		
Factor	**Wald Chi-square/df**		**p value**	**Wald Chi-square/df**		**p value**
Education	12.88	3	0.0449	1.29	3	0.2763 (ns)
Income Adequacy	33.37	9	0.0151	1.07	9	0.3850 (ns)
Employment	13.50	2	0.0091	3.87	2	0.0215
Age group	13.74	2	0.0082	5.05	2	0.0068
Gender	6.56	1	0.0376	6.50	1	0.0111
Urban Rural	53.41	4	0.0000	11.88	4	0.0000
Region	48.88	4	0.0000	10.65	4	0.0000
Aboriginal Status				0.77	1	0.3794 (ns)

Cox & Snell R^2 for severity outcome =0.141485 Overall Model Wald F=5.08, p=0.0000.

The three-level and two-level severity models included similar variables yet in the two-level model fewer variables reached significance. In the two-level model the only significant SES factor was employment and here, the more advantaged group (employed; OR=1.69) was at greatest risk of severe traffic injuries rather than the unemployed respondents.

Table 33. Odds Ratios for Significant Predictor Variables in the Two-Level Severity Model Filtered by Serious Traffic Injury

		Severity2 by Traffic Outcome	
Level of Variable		**Odds Ratio**	**95% CI**
Employment	1=Employed	1.69	(1.12, 2.55)
	2=Not Employed	1.00 (REF)	
	3=Unable to Work	0.85	(0.34, 2.10) NS
Gender	1=male	1.00 (REF)	
	2=female	1.55	(1.11, 2.17)
Age Group	1=12-34 years	0.63	(0.47, 0.84)
	2=35-64 years	1.00 (REF)	
	3=65+ years	0.91	(0.40, 2.06) NS
Urban/Rural	1=Urb Core, Sec UC	4.94	(2.97, 8.22)
	2=Urban Fringe	3.25	(1.02, 10.37)
	3=Rural Fringe	2.79	(1.33, 5.84)
	4=Urb Out CMA/CA	1.49	(0.74, 3.00) NS
	5=Rur Out CMA/CA	1.00 (REF)	
Region	1=Atlantic provs.	0.85	(0.48, 1.53) NS
	2=Quebec	0.27	(0.16, 0.47)
	3=Ontario	1.00 (REF)	
	4=Prairies	1.55	(1.05, 2.29)
	5=British Columbia	1.68	(1.16, 2.43)

Note: 95%CI = 95% Confidence Interval corresponding to the odds ratio listed

For the general predictors the results did not always align with prior predictions. With gender, females had a greater risk (OR=1.55) of severe traffic injury compared to males. For age group and traffic injury severity there was less risk for youth/young adults (OR=0.63) compared to middle-aged respondents. For urban/rural residence the reference group was the last category of Rural outside CMA/CA compared to this, there was a higher risk for urban core/secondary urban core (OR=4.94), then urban fringe (OR=3.25) and lastly rural fringe (OR=2.79). With region, there was a higher risk of severe traffic injury for BC (OR=1.68) and the Prairies (OR=1.55), and a protective factor for Quebec (OR=0.27), with Ontario as the referent group.

4.6. Overview of Results Obtained

Clearly a relationship exists, for those in the study sample, among traffic and fall injury "serious enough to limit one's normal activities" and socioeconomic status. All three types of SES variables were significant within various models, yet results should be interpreted with caution due to sampling bias. Findings did not uncover any socioeconomic gradients nor were conclusions strong and consistent in direction across all comparisons. Interesting results were found for the outcomes of road traffic and neck/back filtered by injury, here fewer variables were significant compared to the full serious traffic injury model. For both these outcomes females had a higher likelihood of injury.

For serious traffic injury, education was the only significant SES variable in the model. Serious fall injury was associated with a significant education by gender interaction and a significant association for personal income quintiles. With the interaction males with less education were at greater likelihood of a serious fall yet for females lower education put one at less risk, post-secondary graduates were the referent group. Relationships were also found among serious traffic and fall injury outcomes and other key predictors examined within this research project. Not all findings follow the hypothesized relationships yet they provide interesting results worthy of further examination. Severity filtered by serious fall injury did not result in any of the SES variables reaching significance in the model yet in contrast all three types of SES variable were significant in the traffic injury severity model. Use of a two-level injury severity model, filtered for traffic, resulted in less predictors reaching significance, relative to the three-level severity model. Here, the only significant SES variable was employment.

5. DISCUSSION

5.1 Project Summary

This research project examined the impact of the social determinants of health and other key predictors on the incidence and severity of serious traffic and fall injury. The two injury mechanisms studied are the injury types with the highest amount of fatalities, serious injury, overall injury burden, and economic costs. The goal was to identify at-risk sub-groups, particularly for SES variables, relevant to those outcomes. Once risk groups are known the results can be disseminated to policy developers, program planners and decision makers for their consideration regarding targeted prevention strategies. How recipients apply the information is relevant to the third dimension of Haddon's matrix regarding policy analysis and issues to consider for strategy development.[189]

It is necessary to note that while significant results were found there is a caveat that they must be interpreted with caution. This is due to bias within the reduced sample of only complete cases. It was not possible to attempt other missing data solutions as once the issue was uncovered access to the Statistics Canada Research Data Centre had expired. This matter is further discussed under the category of limitations.

5.1.1 Results for Stated Goals

The objective of conducting an initial assessment of the association between individual-level socioeconomic variables and serious traffic and fall injury for Canadians from youth to adulthood was met. As was the objective of comparing serious traffic and fall injury with the social determinants of health and relevant predictors, in terms of frequency and severity.

Educational attainment was associated with serious traffic injury incidence in Canadians 12 years of age and over. The social determinants of health were differentially associated with serious traffic and fall injury. Regarding falls, an education by gender interaction resulted as well as a personal income quintile difference. Sociodemographic, individual and behavioural variables played a role in serious traffic and fall injury occurrence and injury severity.

Hypotheses were partially confirmed as socioeconomic differences were present for serious traffic injury within the reduced sample. SES did not interact with age groups examined, yet youth/young adults were often at increased risk. Traffic injury severity differed by all three types of SES, age group, and gender yet no significant interactions were found.

5.2 Main Findings: Predicting Serious Traffic and Fall Injury

The purpose of this research project was to establish the association of the social determinants of health with traffic and fall injury occurrence and severity.

5.2.1 Socioeconomic Variables and their Association with Traffic and Fall Injury

Research on SES is exploratory as prior findings do not exist regarding how SES variables are associated with serious traffic and fall injury for the age range examined.

For serious traffic injury, individuals who completed some post-secondary school were at greater risk than post-secondary graduates. This outcome provides some support for the hypothesis that those with less education are at increased risk of serious traffic injury. The lack of significant findings for other education level subcategories might be due to missing data breakdowns (e.g. "some high school" had 49% of cases in the removed sample). SES gradients were not evidenced for serious traffic injury risk. For the road traffic injury outcome none of the SES variables were significant in the model. This model used a subset of the traffic injury outcome data to examine only traffic injuries occurring on the street, highway or sidewalk.

Employment was the only SES variable associated with whiplash (neck/back) injury which is relevant to motor vehicle occupants. Whiplash-associated disorders are a key cause of poor health and utilize much resources.[190] The risk of whiplash injury was higher for individuals who were employed versus the unemployed. Here, having access to data on vehicle miles travelled to control for that variable would have been advantageous. Then it could be isolated whether travel to, from and during work places one at greater likelihood of whiplash injury.

For serious fall injury, the education by gender interaction showed that males had a greater likelihood of serious fall injury if they did not finish high school versus graduated from a post-secondary program. For females there was the opposite effect where high school completion was associated with a reduction in serious fall injury compared to females with post-secondary graduation. These findings may point to less educated males being more careless in their day-to-day activities Also, male-oriented jobs for less educated males may involve more physical activity which exposes workers to more dangerous situations (e.g. construction, house painting). With the counter-intuitive result for females it is difficult to explain why less education reduced the likelihood of serious fall injury. For income quintiles, the group with the lowest incomes is at greatest risk of a serious fall, relative to the most affluent. This result supports the hypothesis.

For the most part, lower SES was associated with a greater risk of serious traffic and fall injury, but these findings were less widespread than predicted.

5.2.2 Relevant Predictors and their Association with Serious Traffic and Fall Injury

5.2.2.1 Gender

Finding that females have a significantly higher risk of serious traffic injury relative to males does not align with the majority of the literature which places males at greatest risk. One Canadian study concluded that a larger proportion of females reported being in a motor vehicle collision.[108] It is possible that more males are fatally injured or sustain minor to moderate injuries while females are likely to be seriously injured in traffic. These issues could be the result of distinctions among passengers and drivers which could not be assessed in this project. For road traffic and whiplash injury a higher risk was evidenced for females relative to males. In line with this, a study of rear-end collisions demonstrated that with the same crash severity, women had a higher risk of initial whiplash-type symptoms than men.[191] Survey response patterns may also play a role as women tend to answer telephone surveys more readily. However, in this study 50.3% of respondents in the reduced sample were male.

5.2.2.2 Age Groups

Youth/young adults were the only at-risk age group identified for serious traffic injury (referent middle aged) and serious fall injury (referent seniors). Younger individuals have been confirmed to have a heightened risk of serious traffic and fall injury. The traffic result did not align with prior research identifying the elderly as an at-risk group. Statistics from the US Department of Transportation show that an average of 500 older adults are injured in traffic crashes each day.[192] Data from the CDC show that one in three adults 65 years of age and older falls each year (www.cdc.org). Regarding serious traffic injury and the elderly, a focus on drivers and perhaps pedestrians would be beneficial to further investigate associations.

Not finding the elderly to be an at-risk group for serious traffic or fall injury seems to be an aberration. This is given the expansive literature on falls in older women which often result in hospitalization, hence a serious injury. It should be noted that there was a high proportion of missing data for the elderly (50%). Age group divisions were also more evenly spread for the removed versus reduced sample, so there were more seniors within the incomplete cases. This may point to their capacity to complete the survey in its entirety. The 2012 Populations by Age and Sex Statistics from Statistics Canada website show that seniors represent 10.7% of the population. In the current study they comprised 9.4% of cases. The CCHS may not be capturing the very old groups beyond 75 years.

5.2.2.3 Urban and Rural Residence

The risk of serious traffic injury was hypothesized to be higher for rural versus urban residents. A reduced likelihood of serious traffic injury resulted for the Urban living outside CMA/CA and Rural living outside CMA/CA subcategories relative to those in the urban/secondary urban core. Evidently, results do not align with the hypothesis or published Canadian research. A BC study evidenced an average of 50% increase in relative risk of MVC hospitalization for rural populations over six years.[138] In Alberta, a higher motor vehicle crash fatality rate was found for rural versus urban areas.[193] In urban areas, perhaps greater vehicle density, hence more traffic congestion, places motorists at risk of serious injury. The risk of serious fall injury was heightened for the urban fringe and somewhat higher for residents in urban areas outside a CMA/CA in comparison to the urban/secondary urban core. Rates of serious fall injury were not expected to vary by urban or rural residence.

5.2.2.4 Region of Residence

For serious traffic injury it is presumed that laws and regulations across regions are fairly similar in Canada (e.g. seat belt legislation, Graduated Licensing programs). Serious traffic injury was more likely to occur in the Prairies and BC and less in Quebec. This result is somewhat in line with the Collision Statistics for Canada which show that in 2010 there were 625.9 (SK), 570.5 (MB), 490.5 (AB), 461.5 (BC) and 548.6 (QC) injuries per 100,000 population.[194] With road traffic injury, BC and Ontario residents had a higher risk relative to individuals residing in Quebec. Those who live in the Prairies are at increased risk of whiplash injury relative to Ontarians. A higher likelihood of incurring a serious fall injury was present among those who reside in Ontario compared with the Atlantic Provinces. Across model types the referent category differed so it is harder to compare findings.

5.2.2.5 Self-Rated Health

Self-rated health results were in the predicted direction for both serious traffic and fall injury. Those who rated their health more poorly were at increased likelihood of injury. Self-rated health has not been extensively researched with outcomes of serious traffic and fall injury and so these represent initial findings in the area. General injury results also found that injury risk increased as self-rated health status decreased.[134]

5.2.2.6 Smoking Status

Uncovering a link between health behaviours and serious traffic and fall injury provides a challenge in terms of stimulating positive behavior change. It was found that relative to never smokers there is a greater likelihood of serious traffic injury for current smokers, which aligns with the proposed hypothesis. Results were more puzzling with never smokers being at higher risk of serious fall injury compared to former smokers. Smoking cessation may instigate other positive changes such as living a more risk-averse lifestyle. Hence, former smokers may decide to be physically healthier and more cautious in fall risk scenarios and general living. A public health approach targeting the risk behavior to reduce or eliminate it, with the knowledge that the outcome was associated with many health issues, is likely best.

5.2.2.7 Heavy Alcohol Use

Heavy alcohol use was not a significant predictor of serious traffic injury. In line with the hypothesis, a significantly increased risk for serious fall injury was evidenced for heavy drinkers as opposed to non-heavy drinkers. Here, general efforts aimed at reducing high levels of alcohol consumption may also help to prevent serious fall injury. A public health approach that targets the risk behavior intending to greatly reduce or eliminate it could have side benefits of impacting other outcomes. The heightened fall risk may pertain to consuming alcohol or being inebriated prior to walking which would impede one's balance and motor control.

5.2.2.8 Aboriginal Status

Aboriginal status was found to be related to socioeconomic status for preliminary data analyses. Aboriginal status attained significance for bivariate tests with serious traffic and fall injury outcomes. This variable was not significant within any models. Chi-squared results showed greater proportions of serious traffic and fall injury in Aboriginal versus non-Aboriginal subpopulations. While preliminary, the traffic injury finding aligns with prior outcomes that Aboriginal Canadians (16+) had a much higher risk of sustaining a motor vehicle crash injury compared with non-Aboriginal Canadians.[69] The CCHS cases categorized as Aboriginal are off-reserve and more likely residing in urban versus remote areas. Therefore, differences found cannot be readily attributed to geographic dispersion or long travel to medical care. Confounding factors such as education and affluence may play a role in differences.

5.2.2.9 Immigrant Status

Results were significant for serious fall injury where immigrants had a reduced risk of injury relative to non-immigrants. Individuals from foreign countries may practice greater safety and perhaps over time become more lax once they adapt to Canadian customs.

5.3 Main Findings: Predicting Injury Severity

The three-level severity outcome measured injury severity by the location where an injury was treated with levels of very severe (Admitted to hospital), moderate severity (Visited the Emergency Department)) and low severity (Saw a health professional). None of the three interaction terms tested attained significance within the models filtered by serious traffic or fall injury. Regarding SES, all three variables were significant for traffic severity yet none achieved significance for fall injury severity. The direction of the SES-traffic injury severity relationships differed depending on which two levels of the severity outcome were being contrasted. Within both injury severity models the variables of gender, age group, urban/rural and region were significant. For fall severity, self-rated health was also significant. Some findings confirmed the hypothesis of lower SES being associated with greater severity. Overlap may exist between the categories of visiting an ED and seeing a health professional in terms of severity, as health professionals are generally only available during business hours and outside this the ED may be the only option. However, some walk-in clinics have later hours and can be visited in evenings or on weekends, however, walk-in clinics are generally only available in urban centres.

5.3.1 Severity as a Two-level Outcome

The top two severity levels were combined (hospital admission, ED) and contrasted with the third (health professionals). The new binary outcome was tested using logistic regression. The three-level and two-level severity models had similar significant variables yet more were significant in the three-level model. For the two-level traffic severity model the only significant SES variable was employment. Here, employed respondents had a higher risk of more severe traffic injuries relative to the unemployed. This may be the result of employed individuals spending more time in dense rush-hour traffic to commute to and from their workplaces. Here, adjusting for vehicle miles travelled would have been beneficial.

For the general predictors, results did not always align with prior findings. With gender, females had a greater risk (OR=1.55) of severe traffic injury compared to males. For age group and traffic injury severity there was less risk for youth/young adults (OR=0.63) compared to middle-aged respondents. For urban/rural residence the reference group was the last category of Rural outside CMA/CA compared to this, there was a higher risk for rural fringe (OR=2.79), urban fringe (OR=3.25) and urban core/secondary urban core (OR=4.94). With region, there was a higher risk of severe traffic injury for the Prairies (OR=1.55) and BC (OR=1.68), and a protective factor for Quebec (OR=0.27), with Ontario as the referent group.

The severity area is not well-studied so it is difficult to find previously published research that aligns with or contradicts the above findings.

5.4 Project Significance

5.4.1 Informing Strategies and Their Impact

The goal was to reveal issues to consider by decision makers regarding the personal and societal burden of serious traffic injury.

This project resulted in identifying subpopulations at greater risk of serious traffic injury and injury severity. Risk factors have been identified in line with the second step of the public health approach.[23] The study aim of informing relevant decision makers of the results to enable them to select targeted interventions with the goal of reducing these key injury types and injury severity is complicated by the sample bias. This new knowledge can be shared with the proviso that results should be interpreted with caution yet that may not lead to much change. It may be preferable to attempt to replicate the findings and perhaps build on them (e.g. study victim types) and approach decision makers when unbiased research is available.

5.4.2 Project Limitations

5.4.2.1 Evaluating the Sample Used

Using only complete cases yielded a reduced (73%) sample with over a quarter of the original cases removed. This level of non-response is high and leads to questions of why respondents were not filling in all items in the survey. Chi-square tests comparing removed and retained samples for key predictor and outcome variables yielded mostly significant results, suggesting the remaining sample may be biased.

5.4.2.1.1 Examining the Spread of the Missing Data

How missing data is spread is important. Ideally it would be missing at random yet sometimes certain subgroups may be less invested in completing the survey or unable to provide valid responses to each question. Levels of each predictor variable were compared to identify those with higher proportions of missing data. For the SES variables, the subgroups with more missing data were those with less resources.

5.4.2.1.2 Quantifying the Extent of Bias for SES Predictors

The reduced sample data was compared with similar national population data for key SES variables to validate that the sample is representative of the population. For the income adequacy variable there were no available national data to compare to. This was confirmed following extensive searches of the Statistics Canada website, a telephone discussion with a Statistics Canada Analyst, and a review of available literature.

Confidence intervals did not overlap when the survey and national datasets were compared per level of educational attainment. This is not the desired result as it demonstrates that the reduced sample does not align with population-based data. However, it is apparent that the categories in both datasets do not map onto one another exactly, and data are from different years yet close in time overall. The reduced sample data may not represent an aberrant sample, as one study that used data from the next CCHS cycle (4.1) for a smaller sample (n=103,990) displayed similar proportions to the study from lowest to highest education level attained as 20%, 17%, 8% and 55%.[195] These coincide very closely with study data, particularly the large proportion for post-secondary graduation. Confidence intervals (CIs) used in the above study and those for the current reduced sample study overlapped for the level of “less than secondary school”. In addition, when the population and sample data were compared the two datasets were not an exact match in terms of years and variable category. Recoding was necessary and imprecise at times. It would have been preferable if the population data was from 2001-5 not 2006.

For income quintiles only the lowest quintile overlapped when comparing the study and national data CIs. Per data source, the distribution of income across the five categories did not match exactly nor were both datasets from the exact same time period. Income quintile results should be interpreted with some caution. For employment, CIs did not overlap when study and national data were compared. Also the third category for the study data, being ‘permanently unable to work” did not directly map onto the broader third national category. A research article that used the 2007/8 CCHS data and focused on individuals 25-64, included proportions that more closely align with the reduced sample data. Here, 84% were “in the labour force”, 13% were “not currently employed”, and 3% were “permanently unable to work”.[196] The confidence intervals for “permanently unable to work” overlapped among the other study (195) and the reduced sample data in the current study.

5.4.2.1.3 Conclusions Regarding Data Distortion

For all but one predictor variable there were significant differences among the reduced and removed samples when chi-square tests were performed. Also, the reduced sample data did not coincide well with population data when confidence intervals were compared for overlap per level of each SES variable. For all of the SES and other predictor results obtained the findings must be interpreted with caution. It is possible that findings contrary to hypotheses may result from the bias introduced. These outcomes are relevant to data quality including reliability and validity, capacity for replication, and the generalizability of research results.[164] The study findings can only be concluded to be generalizable to the biased sample used.

5.4.2.2 Pitfalls from the Use of Large Surveys

Use of large national surveys posed some problems including the need for complex weighting schemes, and extensive coding required. This likely impacted the power to detect effects. It was not possible to exhaustively assess the validity of the survey data as only formal scales are fully tested. Finally, in cross-sectional survey research association can be concluded yet it is not possible to arrive at causation.

5.4.2.3 Broad Traffic Injury Outcome and Its Occurrence

The main drawback of secondary data use is the inability to tailor questions to optimally meet one's research needs. In this project a key problem was the lack of specific data on traffic injury. Having a more focused outcome variable would have been preferable to "transportation accidents". It would have been beneficial to draw conclusions specific to drivers, passengers, pedestrians, and cyclists. Relevant to severity, motor vehicle incidents accounted for 57% of Emergency Department visits, 54% of hospitalizations, 53% of permanent partial disability and 56% of permanent total disability when all transport incidents are considered (2004).[8]

Also, the CCHS may not be the ideal tool for studying serious traffic injury given the rare occurrence of these injuries (0.7%) among respondents. Injury Module data showed that there are 5.8 times as many serious fall injury cases as serious traffic injury cases.

5.4.2.4 Data not Captured and Limited Generalizability of Results

Another factor that would have been beneficial to include is one's overall "vehicle miles travelled". It could be that not controlling for that variable reduces the potency of findings. That is based on the assumption that driving more may increase serious traffic injury risk. Making that assumption is problematic as it could be that safe drivers are safe regardless of how much they travel and risky drivers in turn are dangerous in general. However, when one considers doing an extensive amount of driving, factors such as tiredness and inattentiveness will factor in. Also information on culpability would have added to defining what types of motor vehicle collisions were occurring. It should be noted that some models yielded small R-square statistics which implies that not much variance is accounted for and findings have limited applicability.

5.4.3 Overall Research Gains from This Project

This project included the first assessment of the association between the social determinants of health and serious traffic and fall injury for Canadians from youth to end of life. The project has many strengths including: a national focus, comparing and contrasting two key injury mechanisms with a high health and financial toll, use of multiple individual-level SES measures, large sample size, studying SES and injury across an under-examined age span from adolescence through adulthood, and the novel examination of serious traffic and fall injury severity.

Comparing serious traffic injury with serious fall injury led to the illumination of many significant differences as well as similarities. SES seemed to have a greater association with serious traffic injury versus serious fall injury for both overall injury and injury severity. Many significant relationships were found among included predictors and serious traffic and fall injury and injury severity. An interesting finding for gender is that more females incur serious traffic and fall injury yet traffic and fall injury severity was higher among males.

5.4.4 Lessons Learned in Carrying Out This Project

The exercise of completing a Master's degree involves designing and developing a research project, carrying out original research and reporting results with interpretations for findings. All of those tasks have been achieved within this project. Extensive experience was acquired in the use of complex databases and advanced statistical techniques. Complicated coding procedures were learned and used in SPSS while writing statistical operations syntax for SUDAAN was a new skill developed. A great deal of new knowledge was acquired regarding missing data identification, testing, determining its impact, judging corrective action and their effectiveness.

It cannot be concluded from this research project that there exists a definitive relationship, in an absolute direction, among the three socioeconomic status variables examined and serious traffic and fall injury and severity. Therefore, the task of informing decision makers of at risk groups for traffic and fall injury and severity is not simple. Despite the use of appropriate weights and statistical methods, the approach for dealing with missing data was flawed. Given the bias that resulted from reducing the sample to complete cases, perhaps using imputation to address missing data would have been preferable.

In hindsight, the CCHS may not have been the best resource to study traffic injury and SES. However, in 2006-7 when it was being reviewed for this project there were no other databases identified and accessible. The very low proportion of serious traffic injury and high proportion of missing data proved problematic. Also, categorical breakdowns within the CCHS were not always ideal so much re-coding and researching of appropriate alternatives was carried out. The appeal of the CCHS were its national focus, large sample sizes per cycle, availability of several cycles to join, inclusion of driving surveys, thorough injury module, and overall breadth enabling a variety of predictors to be examined (e.g. smoking, alcohol use, immigrant status, Aboriginal status). It was desirable to have a large sample size for greater power and confidence in results.

5.4.5 Future Directions Stemming From Results Obtained

These findings can serve as a catalyst for future research in the area with the proviso that they are tentative due to bias. In future, it would be advantageous to expand the spectrum of injury examined to include fatal injury, highly serious injuries, and less serious injuries, with the focus remaining on traffic injury and the three levels of SES. It is unfortunate that there is not a national collision database to examine traffic injuries and assess different crash types or conditions that result in traffic injury and death. Locally, one could link the Manitoba Centre for Health Policy data repository to the Manitoba Public Insurance data for a province-wide study of how crash factors and health and SES outcomes are related. Here it is beneficial that Manitoba Public Insurance is the sole insurer for driving. In Ontario many private insurance agencies and carriers exist and assembling all of their data would be impossible. This type of project would focus on a specialized sample yet may yield a wealth of information which could be generalizable to other jurisdictions. Also, these data are more complete for the social determinants of health so the missing data issue is minimized.

Given the Canada-wide focus of this research project, results can aid in meeting national road safety targets. Canada's Road Safety Strategy 2015 (www.ccmta.ca/crss-2015) seeks to inspire road safety stakeholders from all levels of government and public and private sector stakeholders to work together towards the common objective of making road travel safer. Disseminating current results that suggest socioeconomic associations with serious traffic injury and severity, can aid in highlighting social determinants of health worthy of addressing for targeted road safety efforts. This project highlights that regardless of the proviso for these data the areas of SES and traffic and fall injury and SES and traffic and fall severity are worthy of further study. Many of the non-SES variables also demonstrated relationships with serious traffic and fall injury and severity as well. Conducting further research on these injury outcomes will clarify the relationships more solidly in the absence of bias. This may further bolster current findings or present novel findings. Government and injury prevention groups can later consider the merit of restructuring programs to consider disparity.

References

1. Public Health Agency of Canada. Leading Causes of Death in Canada, 2004. Accessed August 15th, 2008 at www.phac-aspc.gc.ca/publicat/lcd-pcd97/index-eng.php, 2004.
2. Public Health Agency of Canada. Leading Causes of Hospitalizations in Canada, 2004. Accessed August 15th, 2008 at www.phac-aspc.gc.ca/publicat/lcd-pcd97/table2-eng.php, 2004.
3. Statistics Canada. Leading Causes of Death at Different Ages 1999. Ottawa, ON: Minister of Industry (Catalogue #84-503), 2001.
4. Health Canada. Canadian Injury Data: Leading Causes of Death and Hospitalization in Canada. (accessed September 15th, 2004 at www.hc-sc.gc.ca/pphb-dgspsp/injury-bles.
5. Health Canada. For the Safety of Canadian Children and Youth: From Injury Data to Preventive Measures. Ottawa, ON: Health Canada, 1997.
6. Public Health Agency of Canada. Canadian Injury Data: Mortality 1997 and Hospitalizations 1996-1997. Accessed February 15th, 2006 at http://www.phac-aspc.gc.ca/injury-bles/cid98-dbc98/index.html, 1998.
7. Transport Canada. Canadian Motor Vehicle Traffic Collision Statistics: 2011. Ottawa: Minister of Transport. , 2014.
8. SMARTRISK. The Economic Burden of Injury in Canada. Toronto, ON: Smartrisk, 2009.
9. Transport Canada. Canadian Motor Vehicle Traffic Collision Statistics. Ottawa: Minister of Transport. Report 2009.
10. Marmot MG, Smith GD, Stansfield S, Patel C, North F, Head J. Health Inequalities among British civil servants: The Whitehall II study. *Lancet* 1991; 337(1387-93).
11. Potter BK, Speechly KN, Gutmanis IA, Campbell MK, Koval JJ, Manuel D. A comparison of measures of socioeconomic status for adolescents in a Canadian national health survey. *Chronic Diseases in Canada* 2005; 26(2/3): 80-9.
12. Winkleby MA, Jatulis DE, Frank E, Fortmann SP. Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. *Am J Public Health* 1992; 82(6): 816-20.
13. Chen HY, Ivers RQ, Martiniuk ALC, Boufous F, Senserrick T, Woodward M. Socioeconomic status and risk of car crash injury, independent of place of residence and driving exposure: results from the DRIVE Study. *J Epidemiol Community Health* 2010; 64: 998-1003.
14. Rutland-Brown W, Langlois JA, Thomas KE, Xi YL. Incidence of traumatic brain injury in the United States, 2003. *J Head Trauma Rehabil* 2006; 21(6): 544-8.
15. Canadian Institute for Health Information. Analysis in Brief: Injury Hospitalizations and Socio-economic Status. Ottawa, ON: CIHI, 2010.
16. Registered Nurses' Association of Ontario. Prevention of Falls and Fall Injuries in the Older Adult: Nursing Best Practice Guideline. Toronto, ON: RNAO, 2002.
17. Public Health Agency of Canada. Child and Youth Injury in Review, 2009 Edition – Spotlight on Consumer Product Safety. Ottawa, ON: PHAC, 2009.

18. Gill T, Taylor AW, Pengelly A. A population-based survey of factors relating to the prevalence of falls in older people. *Gerontology* 2005; 51(5): 340-5.
19. Ministry of Health Planning. Prevention of falls and injuries among the elderly: A special report from the Office of the Provincial Health Officer B.C. Vancouver, BC: Ministry of Health Planning, 2004.
20. Engstrom K, Diderichsen F, Laflamme L. Socioeconomic differences in injury risks in childhood and adolescence: a nation-wide study of intentional and unintentional injuries in Sweden. *Injury Prevention* 2002; 8: 137-42.
21. Brownell MD, Derksen SA, Jutte DP, Roos NP, Ekuma O, Yallop L. Socio-economic inequities in children's injury rates: Has the gradient changed over time? *Can J Public Health* 2010; 101(Suppl 3): S28-31.
22. Faelker T, Pickett W, Brison RJ. Socioeconomic differences in childhood injury: a population based epidemiologic study in Ontario, Canada. *Inj Prev* 2000; 6(3): 203-8.
23. Christoffel T, S Scavo Gallagher. Injury Prevention and Public Health: Practical Knowledge, Skills, and Strategies. Gaithersburg, Maryland: Aspen Publishers, Inc., 1999.
24. Robertson J. Injury Epidemiology. Oxford: Oxford University Press, 1992.
25. World Health Organization, Department of Injuries and Violence Prevention. World Report on Road Traffic Injury Prevention, 2004.
26. Health Canada (Pless B, Millar, W.). Unintentional Injuries in Childhood: Results from Canadian Health Surveys. Ottawa, ON: Minister of Public Works and Government Services Canada, 2000.
27. Mackay M, Reid DC, Moher D, Klassen T. Systematic Review of the Relationship Between Childhood Injury and Socio-economic Status. Ottawa, ON: Minister of Public Works and Government Services Canada, 1999.
28. Health Canada - Population and Public Health Branch. Injury Surveillance in Canada: Current Realities and Challenges. Otttawa, ON: Health Canada; 2003.
29. Hasselberg M, Laflamme L. Socioeconomic background and road traffic injuries: A study of young car drivers in Sweden. *Traffic injury prevention* 2003; 4: 249-54.
30. Forget EL. The Town with No Poverty—Using Health Administration Data to Revisit Outcomes of a Canadian Guaranteed Annual Income Field Experiment. Winnipeg, Manitoba: University of Manitoba.
31. Pless IB. Childhood injury prevention: Time for tougher measures. *CMAJ* 1996; 155(10): 1429-31.
32. Rice DP. Cost of illness studies: What is good about them? *Inj Prev* 2000; 6(3): 177-9.
33. Gregg MB. Field Epidemiology (2nd. ed.). Oxford, England: Oxford University Press, 2002.
34. SMARTRISK. Ending Canada's Invisible Epidemic: A Strategy for Injury Prevention. Toronto: SMARTRISK, 2005.
35. Wilkins K, Park E. Injuries. *Health reports / Statistics Canada, Canadian Centre for Health Information = Rapports sur la sante / Statistique Canada, Centre canadien d'information sur la sante* 2004; 15(3): 43-8.
36. Haddon WJ. The changing approach to epidemiology, prevention and amelioration of trauma: The transition to approaches etiologically rather than descriptively based. *Am J Public Health* 1968; 58(1431-1438).

37. Haddon WJ. Advances in the epidemiology of injuries as a basis for public policy. *Public Health Reports* 1980; 95(5): 411-21.
38. Haddon WJ. On the escape of tigers: An ecological note. *Am J Public Health* 1970; 60(12): 2229-34.
39. Haddon WJ. Options for the prevention of motor vehicle crash injury. *Israel J Med Sci* 1980; 16(45-68).
40. Runyan C. Introduction: Back to the future - Revisiting Haddon's conceptualization of injury epidemiology and prevention. *Epidemiol Rev* 2003; 25: 60-4.
41. Rivara FP, Grossman DC, Cummings P. Injury Prevention: Parts 1 & 2. *New Engl J Med* 1997; 337(8): 543-8; 338(9), 613-8.
42. American Association of State Highway and Transportation Officials. Highway Safety Design and Operations Guide 1997. Washington, DC: AASHTO, 1997.
43. Young TK. Population Health: Concepts and Methods (2nd ed.). New York: Oxford University Press; 2005.
44. Evans RG, GL Stoddart. Producing Health, Consuming Health Care. In Evans RG et al. Why are Some People Healthy and Others Not? New York: Aldine De Gruyter, p. 217-230, 1994.
45. Evans RG, Barer ML, Marmor TR. Why Are Some People Healthy and Others Not? The Determinants of Health of Populations. New York: Walter de Grutyer, Inc., 1994.
46. Federal Provincial and Territorial Advisory Committee on Population Health for the Meeting of the Ministers of Health. Toward a Healthy Future: Second Report on the Health of Canadians. Ottawa: : Minister of Public Works and Government Services, Catalogue #: H39-468/1999E, 1999.
47. Raphael D. Addressing the social determinants of health in Canada: Bridging the gap between research findings and public policy. *Policy Options* 2003; March.
48. Marmot M, Wilkinson RG. Social Determinants of Heath (2nd. ed.). New York: Oxford University Press, 2006.
49. Elvik R, Vaa T. The Handbook of Road Safety Measures. Oxford: Elsevier Ltd.; 2004.
50. Brownell M, De Coster C, Penfold R, Derksen S, Schultz J, Dahl M. Manitoba Child Health Atlas Update. Winnipeg, Manitoba: Manitoba Centre for Health Policy, 2008.
51. Braver ER. Race, Hispanic origin, and socioeconomic status in relation to motor vehicle occupant death rates and risk factors among adults. *Accid Anal Prev* 2003; 35: 295-309.
52. Whitlock G, Norton R, Clark T, Pledger M, Jackson R, MacMahon S. Motor vehicle driver injury and socioeconomic status: a cohort study with prospective and retrospective driver injuries. *J Epidemiol Community Health* 2003; 57(7): 512-6.
53. Parkin PC, Khambalia A, Kmet L, Macarthur C. Influence of socioeconomic status on the effectiveness of bicycle helmet legislation for children: a prospective observational study. *Pediatrics* 2003 112((3 Pt 1)): e192-6.
54. Scholer SJ, Hickson GB, Ray WA. Sociodemographic factors identify US infants at high risk of injury mortality. *Pediatrics* 1999; 103(6 Pt 1): 1183-8.

55. Macpherson AK, Macarthur C, To TM, Chipman ML, Wright JG, Parkin PC. Economic disparity in bicycle helmet use by children six years after the introduction of legislation. *Inj Prev* 2006; 12(4): 231-5.
56. Gilbride SJ, Wild C, Wilson DR, Svenson LW, Spady DW. Socio-economic status and types of childhood injury in Alberta: A population based study. *BMC Pediatrics* 2006; 6(30).
57. Macpherson AK, Cernat G, Schull MJ. Injuries in Ontario. *Healthcare quarterly (Toronto, Ont* 2006; 9(1): 29-30.
58. Brownell M, Friesen D, Mayer T. Childhood injury rates in Manitoba: Socioeconomic influences. *Can J Public Health* 2002; 93 Suppl:S50-6.
59. Edwards P, Green J, Roberts I, Lutchmun S. Deaths from injury in children and employment status in family: analysis of trends in class specific death rates. *BMJ* 2006; doi:10.1136/bmj.38875.757488.4F: 1-4.
60. Wilkins K, Mackenzie S. Work injuries. *Health reports / Statistics Canada, Canadian Centre for Health Information = Rapports sur la sante / Statistique Canada, Centre canadien d'information sur la sante* 2007; 18(3): 25-42.
61. Mo F, Turner MC, Krewski D, Merrick J. Adolescent injuries in Canada: findings from the Canadian community health survey, 2000-2001. *Int J Inj Contr Saf Promot* 2006; 13(4): 235-44.
62. Tan JKH, Sheps SB. Health decision support systems. Gaithersburg, MD: Aspen Publishers Inc.; 1998.
63. Keating D, Hertzman C. Developmental Health and Wealth of Nations: Social, Biological and Educational Dynamics. New York: The Guilford Press, 1999.
64. Syme SL. The Social Environment and Health. *Daedalus - Journal of the American Academy of Arts and Sciences* 1994; 123(4): 79-86.
65. Chen E, Martin AD, Matthews KA. Socioeconomic status and health: Do gradients differ within childhood and adolescence? *Social science & medicine (1982)* 2006; 62(9): 2161-70.
66. Laflamme L, Engström K. Socioeconomic difference in Swedish children and adolescents injured in road traffic incidents: Cross-sectional study. *BMJ* 2002; 324: 396-7.
67. Manitoba Health. Injuries in Manitoba: A 10-Year Review. Winnipeg, Manitoba, 2004.
68. Health Canada. Unintentional and intentional injury profile for Aboriginal people in Canada. 1990-1999. Ottawa, ON: Health Canada, 2001.
69. Karmali S, Laupland K, Harrop AR, et al. Epidemiology of severe trauma among status Aboriginal Canadians: a population-based study. *CMAJ* 2005; 172(8): 1007-11.
70. Tjepkema M, Wilkins R, Senecal S, Guimond E, Penney C. Mortality of urban Aboriginal adults in Canada, 1991-2001. *Chronic Diseases in Canada*, 2010; 31(1): 4-21.
71. Evans L. Traffic Safety. Bloomfield Hill, MI: Science Serving Society; 2004.
72. United States General Accounting Office. Highway Safety: Research Continues on a Variety of Factors that Contribute to Motor Vehicle Crashes. Report to Congressional Requestors, March 2003.
73. Federal Provincial and Territorial Advisory Committee on Population Health. Statistical Report on the Health of Canadians. Ottawa, ON Minister of Public Works and Government Services, 1999.

74. Transport Canada. Road Safety Vision 2010: 2005 Annual Report. Ottawa, ON: Transport Canada and Canadian Council of Motor Transport Administrators; 2005.
75. Cvijanovich NZ, Cook LJ, Mann NC, Dean JM. A population-based study of crashes involving 16- and 17-year-old drivers: the potential benefit of graduated driver licensing restrictions. *Pediatrics* 2001; 107(4): 632-7.
76. Foss RD, Evenson KR. Effectiveness of graduated driver licensing in reducing motor vehicle crashes. *Am J Prev Med* 1999; 16(1 Suppl): 47-56.
77. Molloy J, Develin E. Young Drivers Literature Review. Research Report 2001. Accessed June 21, 2007 at www.youthsafe.org/pubs_resources.shtml. 2000.
78. Simons-Morton BG. Reducing young driver crash risk. *Inj Prev* 2002; 8 Suppl 2: ii1-2.
79. Laberge-Nadeau C, Maag U, Bourbeau R. The effects of age and experience on accidents with injuries: should the licensing age be raised? *Accid Anal Prev* 1992; 24(2): 107-16.
80. Williams AF, Preusser DF, Ulmer RG, Weinstein HB. Characteristics of fatal crashes of 16-year-old drivers: implications for licensure policies. *J Public Health Policy* 1995; 16(3): 347-60.
81. Braver ER, Trempel RE. Are older drivers actually at higher risk of involvement in collisions resulting in deaths or non-fatal injuries among their passengers and other road users? *Inj Prev* 2004; 10(1): 27-32.
82. National Highway Traffic Safety Administration, editor. Facts About Young Adults Aged 16-20: Motor Vehicle Occupant Protection Facts. Accessed October 4th, 2004 at www.nhtsa.dot.gov/people/injury/airbags/occupantprotectionfacts.
83. Chen L-H, Baker SP, Braver ER, Li G. Carrying Passengers as a Risk Factor for Crashes Fatal to 16- and 17-Year-Old Drivers. *JAMA* 2000; 283(12): 1578-82.
84. Preusser DF, Ferguson SA, Williams AF. The effect of teenage passengers on the fatal crash risk of teenage drivers. *Accid Anal Prev* 1998; 30(2): 217-22.
85. Williams AF, Ferguson SA. Rationale for graduated licensing and the risks it should address. *Inj Prev* 2002; 8 Suppl 2: ii9-14; discussion ii-6.
86. McCartt AT. Teen Crash Risks Addressed by Laws and Regulations. Workshop Powerpoint Presentation. Accessed November 21st, 2007 at www.bocyf.org/mccartt presentation: Insurance Institute for Highway Safety; 2006.
87. Hartling L, Wiebe N, Russell K, Petruk J, Spinola C, Klassen TP. Graduated driver licensing for reducing motor vehicle crashes among young drivers. *Cochrane database of systematic reviews (Online)* 2004; (2): CD003300.
88. Shope JT, Molnar LJ. Graduated driver licensing in the United States: evaluation results from the early programs. *Journal of safety research* 2003; 34(1): 63-9.
89. Insurance Institute for Highway Safety & Traffic Injury Research Foundation. Graduated Licensing: A Blueprint for North America, August 2004.
90. Canadian Paediatric Society. Are We Doing Enough? A Status Report on Canadian Public Policy and Child and Youth Health - 2007 Edition. Ottawa, ON: Canadian Paediatric Society, 2007.
91. McKnight AJ, Peck RC. Graduated driver licensing: what works? *Inj Prev* 2002; 8 Suppl 2: ii32-6; discussion ii6-8.
92. McKnight AJ, Peck RC. Graduated driver licensing and safer driving. *Journal of safety research* 2003; 34(1): 85-9.

93. Zwerling C, Jones MP. Evaluation of the effectiveness of low blood alcohol concentration laws for younger drivers. *Am J Prev Med* 1999; 16(1 Suppl): 76-80.
94. Beck KH, Shattuck T, Raleigh R, Hartos J. Does graduate licensing empower parents to place greater restrictions on their newly licensed teens' driving? *Health Education and Behavior* 2003; 30: 695−708.
95. Evans L. Age and fatality risk from similar severity impacts. *J Traffic Med* 2001; 29: 10-9.
96. Department of Transport. Older Drivers: A Literature Review. United Kingdom, 2001.
97. Insurance Institute for Highway Safety. Older drivers up close. They aren't dangerous, except maybe to themselves. Special Issue: Older drivers. *Status Report* 2001; 36(8): 1-7.
98. Mayhew DR, Simpson HM, Ferguson SA. Collisions involving senior drivers: high-risk conditions and locations. *Traffic injury prevention* 2006; 7(2): 117-24.
99. Grabowski DC, Morrisey MA. The effect of state regulations on motor vehicle fatalities for younger and older drivers: a review and analysis. *Milbank Q* 2001; 79(4): 517-45, iii-iv.
100. Coopersmith HG, Korner-Bitensky NA, Mayo NE. Determining medical fitness to drive: physicians' responsibilities in Canada. *CMAJ* 1989; 140(4): 375-8.
101. American Academy of Pediatrics. Committee on Injury and Poison Prevention. The teenage driver. *Pediatrics* 2006; 118(6): 2570-81.
102. Underwood M. The older driver. Clinical assessment and injury prevention. *Arch Intern Med* 1992; 152(4): 735-40.
103. Tavris DR, Kuhn EM, Layde PM. Age and gender patterns in motor vehicle crash injuries: importance of type of crash and occupant role. *Accid Anal Prev* 2001; 33(2): 167-72.
104. James L. Dealing with stress, aggression and pressure in the vehicle: Taxonomy of driving behaviour as affective, cognitive and sensorimotor. In: Rothe JP, ed. Driving Lessons: Exploring Systems that Make Traffic Safer. Edmonton, AB: The University of Alberta Press. pp 21-49; 2002.
105. McGwin G, Jr., Metzger J, Alonso JE, Rue LW, 3rd. The association between occupant restraint systems and risk of injury in frontal motor vehicle collisions. *J Trauma* 2003; 54(6): 1182-7.
106. Waller PF, Hill EM, Maio RF, Blow FC. Alcohol effects on motor vehicle crash injury. *Alcohol Clin Exp Res* 2003; 27(4): 695-703.
107. OECD/ECMT. Young Drivers: The Road to Safety. Paris, France: Transport Research Centre; 2006.
108. Vingilis E, Wilk P. Predictors of motor vehicle collision injuries among a nationally representative sample of Canadians. *Traffic injury prevention* 2007; 8(4): 411-8.
109. Briggs NC, Schlundt DG, Levine RS, Goldzweig IA, Jr. SN, Warren RC. Seat belt use among Hispanic ethnic subgroups of national origin. *Injury Prevention* 2006; 12: 421-6.
110. Mathews J, Zollinger T, Przybylski M, Bull M. The association between risk-taking behavior and the use of safety devices in adolescents. *45th Annual Proceedings of the Association for the Advancement of Automotive Medicine* 2001; 45: 23-6.

111. Whitlock EP, Orleans CT, Pender N, Allan J. Evaluating primary care behavioral counseling interventions: An evidence-based approach. *Am J Prev Med* 2002; 22: 267-84.
112. Gielen AC, Sleet D. Application of behavior-change theories and methods to injury prevention. *Epidemiol Rev* 2003; 25: 65-76.
113. Manitoba Transportation and Government Services. Traffic Collision Statistics Reports 1997-2001. Winnipeg, MB: Annual Review, Manitoba Justice.
114. Transportation Research Board. Managing Speed: Review of Current Practice for Setting Speed Limits. Special Report SR254. Accessed October 15th, 2004 at www.gulliver.trb.org/publications/sr/_sr254.pdf, 1988.
115. Aarts L, van Schagen INLG. Driving speed and the risk of road crashes: A review. *Accident Analysis and Prevention* 2006; 38(2): 215-4.
116. Farmer CM, Retting RA, Lund AK. Changes in motor vehicle occupant fatalities after repeal of the national maximum speed limit. *Accid Anal Prev* 1999; 31(5): 537-43.
117. Pilkington P, Kinra S. Effectiveness of speed cameras in preventing road traffic collisions and related casualties: systematic review. *BMJ* 2005; 330(7487): 331-4.
118. Transport Canada - Seat Belt Sense. The case for restraints: What you need to know about seat belts, air bags and child restraints. Ottawa, ON: Road Safety and Motor Vehicle Regulation, Transport Canada., 2007.
119. James EC, Lenz JO, Swenson WM, Cooley AM, Gomez YL, Antonenko DR. Snowmobile trauma: an eleven-year experience. *Am Surg* 1991; 57(6): 349-53.
120. Ranney TA, Mazzae E, Garrott R, Goodman MJ. NHTSA Driver Distraction Research: Past, Present and Future. Washington: NHTSA; 2000.
121. Wang J-S, Knipling RR, Goodman MJ. The role of driver inattention in crashes: New statistics from the 1995 crashworthiness data system. *40th Annual Proceedings of the Association for the Advancement of Automotive Medicine* 1996: 377-92.
122. Wilson J, Fang M, Wiggins S, Cooper P. Collision and violation involvement of drivers who use cellular telephones. *Traffic injury prevention* 2003; 4(1): 45-52.
123. Miley S. UN SG calls for global ban on cell phone use while driving. Accessed July 8, 2010 at: http://jurist.org/paperchase/2010/05/un-sg-calls-for-global-ban-on-using-cell-phones-while-driving.php, 2010.
124. Cummings P, Koepsell TD, Moffat JM, Rivara FP. Drowsiness, counter-measures to drowsiness, and the risk of a motor vehicle crash. *Inj Prev* 2001; 7(3): 194-9.
125. Elford RW. Prevention of motor vehicle accident injuries (<15 years of age). In: Canadian Task Force on the Periodic Health Examination Canadian Guide to Clinical Preventive Health Care. Ottawa, ON: Health Canada, 1994.
126. Maio RF, Waller PF, Blow FC, Hill EM, Singer KM. Alcohol abuse/dependence in motor vehicle crash victims presenting to the emergency department. *Acad Emerg Med* 1997; 4(4): 256-62.
127. Miller TR. The effectiveness review trials of Hercules and some economic estimates for the stables. *Am J Prev Med* 2001; 21(4 Suppl): 9-12.
128. Ogden EJ, Moskowitz H. Effects of alcohol and other drugs on driver performance. *Traffic injury prevention* 2004; 5(3): 185-98.
129. Singleton M, Qin H, Luan J. Factors associated with higher levels of injury severity in occupants of motor vehicles that were severely damaged in traffic crashes in Kentucky, 2000-2001. *Traffic injury prevention* 2004; 5(2): 144-50.

130. Stoduto G, Vingilis E, Kapur BM, Sheu WJ, McLellan BA, Liban CB. Alcohol and drug use among motor vehicle collision victims admitted to a regional trauma unit: demographic, injury, and crash characteristics. *Accid Anal Prev* 1993; 25(4): 411-20.
131. Elder RW, Shults RA, Sleet DA, Nichols JL, Zaza S, Thompson RS. Effectiveness of sobriety checkpoints for reducing alcohol-involved crashes. *Traffic injury prevention* 2002; 3: 266-74.
132. Grube JW, Stewart K. Preventing impaired driving using alcohol policy. *Traffic injury prevention* 2004; 5(3): 199-207.
133. Kelly E, Darke S, Ross J. A review of drug use and driving: epidemiology, impairment, risk factors and risk perceptions. *Drug Alcohol Rev* 2004; 23(3): 319-44.
134. Cunningham R, Carter K, Connor J, Fawcett J. Does health status matter for the risk of injury? *The New Zealand Medical Journal* 2010; 123(1327): 1-12.
135. Tremblay S, Ross NA, Berthelot J-M. Regional socio-economic context and health. *Supplement to Health Reports* 2002; 13: 1-12.
136. Zwerling C, Peek-Asa C, Whitten PS, Choi SW, Sprince NL, Jones MP. Fatal motor vehicle crashes in rural and urban areas: decomposing rates into contributing factors. *Inj Prev* 2005; 11(1): 24-8.
137. Tignor SC. Traffic Control Devices: Overview. In Institute for Transportation Engineers. The Traffic Safety Toolbox: A primer for traffic safety.Washington, DC (pp. 39-46): ITE, 1999.
138. Bell N, Simons RK, Lakha N, Hameed SM. Are we failing our rural communities? Motor vehicle injury in British Columbia, Canada, 2001-2007. *Injury* 2012; 43(11): 1888-91.
139. Federal Office of Road Safety. National Road Safety Strategy Implementation Task Force: Australia's Rural Road Safety Action Plan, Monograph 9, 1996.
140. Transport Canada. 1996 Canadian Motor Vehicle Traffic Collision Statistics: Special Tabulations. Ottawa, ON: Transport Canada, 1997.
141. Statistics Canada. Canadian Community Health Survey (CCHS) Cycle 3.1 (2005): Public Use Microdata File (PUMF) User Guide. 2006. www.statcan.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=3226&lang=en&db=IMDB&dbg=f&adm=8&dis=2.
142. Statistics Canada. Canadian Community Health Survey (CCHS). 2006. www.statcan.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=3226&lang=en&db=IMDB&dbg=f&adm=8&dis=2 (accessed August 15th 2007).
143. Bouchard DR, Pickett W, Janssen I. Association between obesity and unintentional injury in older adults. *Obes Facts* 2010; 3(6): 363-9.
144. Doan Q, Koehoorn M, Kissoon N. Body mass index and the risk of acute injury in adolescence. *Paediatr Child Health* 2010; 15(6): 351-6.
145. Perez CE. Passengers of intoxicated drivers. *Health reports / Statistics Canada, Canadian Centre for Health Information = Rapports sur la sante / Statistique Canada, Centre canadien d'information sur la sante* 2005; 16(2): 35-7.
146. Tjepkema M. Non-fatal injuries among Aboriginal Canadians. *Health Reports* 2005; 16(2): 9-22. Statistics Canada, Catalogue 82-003.

147. Tjepkema M. Repetitive strain injury. *Health reports / Statistics Canada, Canadian Centre for Health Information = Rapports sur la sante / Statistique Canada, Centre canadien d'information sur la sante* 2003; 14(4): 11-30.
148. Thomas S. Combining Cycles of the Canadian Community Health Survey. Ottawa, ON: Proceedings of the Statistics Canada Symposium 2006: Methodological Issues in Measuring Population Health, 2006.
149. Thomas S. Combining Cycles of the Canadian Community Health Survey. Ottawa, ON: Statistics Canada. Health Data Users Conference Presentation; 2007.
150. Beland Y. Canadian community health survey--methodological overview. *Health reports / Statistics Canada, Canadian Centre for Health Information = Rapports sur la sante / Statistique Canada, Centre canadien d'information sur la sante* 2002; 13(3): 9-14.
151. Dalenius T. A First Course in Survey Sampling. In Krishnaiah, P.R., Rao, C.R. (eds.). Handbook of Statistics 6: Sampling. Amsterdam, Netherlands: Elsevier Science Publishers B.V. (pp. 15-46); 1988.
152. Roberts SE, Vingilis E, Wilk P, Seeley J. A comparison of self-reported motor vehicle collision injuries compared with official collision data: An analysis of age and sex trends using the Canadian National Population Health Survey and Transport Canada data. *Accid Anal Prev* 2008; 40: 559-66.
153. Pampalon R, Hamel D, Gamache P, Raymond G. A deprivation index for health planning in Canada. *Chronic Diseases in Canada* 2009; 29(4): 178-91.
154. Fransoo R, Martens P, Burland E, The Need to Know Team, Prior H, Burchill C. Manitoba RHA Indicators Atlas 2009. Winnipeg, Manitoba: Manitoba Centre for Health Policy, 2009.
155. Gilmour H. Depression and risk of heart disease. *Health reports / Statistics Canada, Canadian Centre for Health Information = Rapports sur la sante / Statistique Canada, Centre canadien d'information sur la sante* 2008; 19(3): 1-12 Statistics Canada Catalogue no. 82-003-X.
156. Badawi G, Gariepy G, Page V, Schmitz N. Indicators of self-rated health in the Canadian population with diabetes. *Diabet Med* 2012; Jan 16, epub ahead of print.
157. Community Health Programs Directorate - First Nations and Inuit Health Branch. Unintentional and Intentional Injury Profile for Aboriginal People in Canada 1990-1999. Ottawa, ON: Health Canada, 2001.
158. Ryb GE, Dischinger P, Kufera J, Soderstrom C. Smoking is a marker of risky behaviors independent of substance abuse in injured drivers. *Traffic injury prevention* 2007; 8(3): 248-52.
159. Shinar D, Schechtman E, Compton R. Self-reports of safe driving behaviours in relationship to sex, age, education and income in the US adult driving population. *Accid Anal Prev* 2001; 33: 111-6.
160. Cummings P. Missing Data and Multiple Imputation. *JAMA Pediatr* 2013: 1-7.
161. Twisk JWR. Applied Longitudinal Data Analysis for Epidemiology. Cambridge: Cambridge University Press; 2003.
162. Langkamp DL, Lehman A, Lemeshow S. Techniques for handling missing data in secondary analyses of large surveys. *Acad Pediatr* 2010; 10(3): 205-10.
163. Azar B. Finding a solution for missing data. . *Monitor on Psychology* 2002; 33(7): 70-1.

164. McKnight PE, McKnight KM, Sidani S, Figueredo A. Missing Data: A Gentle Introduction. New York: The Guildford Press, 2007.
165. Brick JM, Kalton G. Handling missing data in survey research. *Stat Methods Med Res* 1996; 5(3): 215-38.
166. Armitage P, Berry G, Matthews JNS. Statistical Methods in Medical Research. Oxford: Blackwell Science Ltd, 2002.
167. Mainous AG, 3rd, Hueston WJ. Using other people's data: the ins and outs of secondary data analysis. *Family medicine* 1997; 29(8): 568-71.
168. Eekhout I, de Boer RM, Twisk JW, de Vet HC, Heymans MW. Missing data: a systematic review of how they are reported and handled. *Epidemiology* 2012; 23(5): 729-32.
169. Talbert S, Sole ML. Too much information: research issues associated with large databases. *Clin Nurse Spec* 2013; 27(2): 73-80.
170. Graham JW. Missing data analysis: making it work in the real world. *Annu Rev Psychol* 2009; 60: 549-76.
171. Roda C, Nicolis I, Momas I, Guihenneuc-Jouyaux C. Comparing methods for handling missing data. *Epidemiology* 2013; 24(3): 469-71.
172. Allison P. Missing Data. In Series: Quantitive Applications in the Social Sciences. *Sage Monographs* 2001; 136: 1-104.
173. Hassard TH. Understanding Biostatistics. St. Louis, MI: Mosby-Year Book, Inc.; 1991.
174. Nathan G. Inference Based on Data from Complex Survey Designs. In Krishnaiah, P.R., Rao, C.R. (eds.). Handbook of Statistics 6: Sampling. Amsterdam, Netherlands: Elsevier Science Publishers B.V. (pp. 247-266); 1988.
175. Lee ES, Forthofer R, Lorimer RJ. Analyzing Complex Survey Data. Newbury Park, CA: Sage Publications, Inc.; 1989.
176. Kneipp SM, Yarandi HN. Complex sampling designs and statistical issues in secondary analysis. *West J Nurs Res* 2002; 24(5): 552-66.
177. Kaplan B, Schold J, Meier-Kriesche HU. Overview of large database analysis in renal transplantation. *Am J Transplant* 2003; 3(9): 1052-6.
178. Korn EL, Graubard BI. Analysis of Health Surveys. New York: John Wiley & Sons Inc.; 1999.
179. Efron B, Tibshirani RJ. An Introduction to the Bootstrap. New York: Chapman & Hall, Inc.; 1993.
180. Statistics Canada. National Population Health Survey: Household Component - Longitudinal. 2004. http://www.statcan.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=3225&lang=en&db=IMDB&dbg=f&adm=8&dis=2 (accessed August 28th 2007).
181. Manitoba Centre for Health Policy. Primary Prevention: An Examination of Data Capabilities in Manitoba. Winnipeg, Manitoba: Manitoba Health, 2005.
182. Stats Tutor. Spearman's correlation. (accessed Nov. 08 2013).
183. Chan YH. Biostatistics 305: Multinomial logistic regression. *Singapore Med J* 2005; 46(6): 259-69.
184. Gravetter FJ, Wallnau LB. Statistics for the Behavioural Sciences: A First Course for Students of Psychology and Education. St. Paul, MN: West Publishing Company; 1992.

185. Zeni MB, Kogan MD. Existing population-based health databases: useful resources for nursing research. *Nursing outlook* 2007; 55(1): 20-30.
186. Fitzmaurice GM, Laird NM, Ware JH. Applied Longitudinal Analysis. Hoboken, NJ: John Wiley & Sons, Inc.; 2004.
187. Rivara FP, Cummings P, Koepsell TD, Grossman DC, Maier RV. Injury Control: A Guide to Research and Program Evaluation. Cambridge, UK: Cambridge University Press; 2001.
188. Statistics Canada. Individual by total income level, by province and territory (Canada). Ottawa, ON: Statistics Canada, CANSIM Table 111-0008, 2006.
189. Runyan CW. Using the Haddon matrix: Introducing the third dimension. *Inj Prev* 1998; 4: 302-7.
190. Galasko CSB, Murray P, Stephenson W. Incidence of whiplash-associated disorder. *BC Medical Journal* 2002; 44(5): 237-40.
191. Krafft M, Kullgren A, Malm S, Ydenius A. Influence of crash severity on various whiplash injury symptoms: A study based on real-life rear-end crashes with recorded crash pulses. Stockholm, Sweden: Folksam Research and Karolinska Institutet. Paper Number: 05-0363., 2005.
192. Federal Highway Administration - Department of Transportation (US). Highway Statistics 2009. Available from URL: http://www.fhwa.dot.gov/policyinformation/statistics/2009/dl22.cfm. Washington, DC: FWHA, 2011.
193. Kmet L, Brasher P, Macarthur C. A small area study of motor vehicle crash fatalities in Alberta, Canada. *Accid Anal Prev* 2003; 35(2): 177-82.
194. Transport Canada. Canadian Motor Vehicle Traffic Collision Statistics: 2010. Ottawa: Minister of Transport. Report #TP3322, 2010.
195. Tu AW, Masse LC. The relationship between income and weight control strategies among canadian adults. *Can J Public Health* 2012; 103(6): e438-42.
196. Churcher L, Chan CH, Badley EM. Chronic back problems and labor force participation in a national population survey: impact of comorbid arthritis. *BMC Public Health* 2013; 13: 326.