

A Review Of Best Practices

Preventing Motor Vehicle Occupant Injuries In Manitoba

Prepared for Manitoba Health by



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INTRODUCTION

Motor vehicle collisions are the leading cause of unintentional injury death for all Canadians.^{1,2} Collisions are defined differently by reporting agencies. The 9th International Classification of Disease, Clinical Modification (ICD-9CM) system is used by hospitals and Vital Statistics. E-codes are used to indicate external cause of injury such as motor vehicle traffic; these are further distinguished by a decimal point to refer to specific mechanism.³ Codes ending in .0 refer to the driver being injured, whereas those ending in .1 signify an injured passenger. Manitoba's traffic collision data system uses verbal descriptors to distinguish crash types.⁴ These systems are compared in Table 1. Note that the categories used by these coding systems do not consistently match one another.

In Canada, motor vehicle occupants represent approximately 80% of fatally injured road users.¹ Given the high prevalence of occupant injuries in motor vehicle traffic incidents, this report focuses

on interventions for this subgroup. High-risk groups of motor vehicle occupants include young drivers, older drivers, impaired drivers, and unrestrained occupants. The report includes a description of motor vehicle collision data, an examination of risk and protective factors, associated interventions, and best practice recommendations for reducing motor vehicle occupant injuries.

Motor Vehicle Collisions: The Problem in Manitoba

Manitoba Health Data⁵

Motor vehicle traffic injury is the second leading cause of injury death and hospitalization in Manitoba. For deaths, the leading cause is suicide and for hospitalization the leading cause is falls. The following figures illustrate motor vehicle injury death and hospitalization by age and gender.

Table 1. Motor Vehicle (MV) Traffic Collisions by E code and Traffic Collision Data Coding

E-Code	ICD-9CM Type of Incident	Traffic Collision Type
E810	Motor vehicle traffic accident (MVTA) involving collision with a train	Train
E811	MVTA involving re-entrant collision with another MV (not including collision on same roadway e.g., rear-end)	Motor Vehicle
E812	Other MVTA involving collision with MV (parked/stopped/stalled/disabled/abandoned, etc.)	Motor Vehicle/ Fixed Object
E813	MVTA involving collision with other vehicle (non-motor transport e.g., cyclist, animal carrying person, horse-drawn carriage)	Bicycle, Animal
E814	MVTA involving collision with pedestrian	Pedestrian
E815	Other MVTA involving collision on the highway (collide with object/animal)	Fixed Object/Animal
E816	MVTA due to loss of control, without collision on the highway	Motor Vehicle

Figure 1. Motor Vehicle Traffic Injury Deaths by Gender, 1992-1999

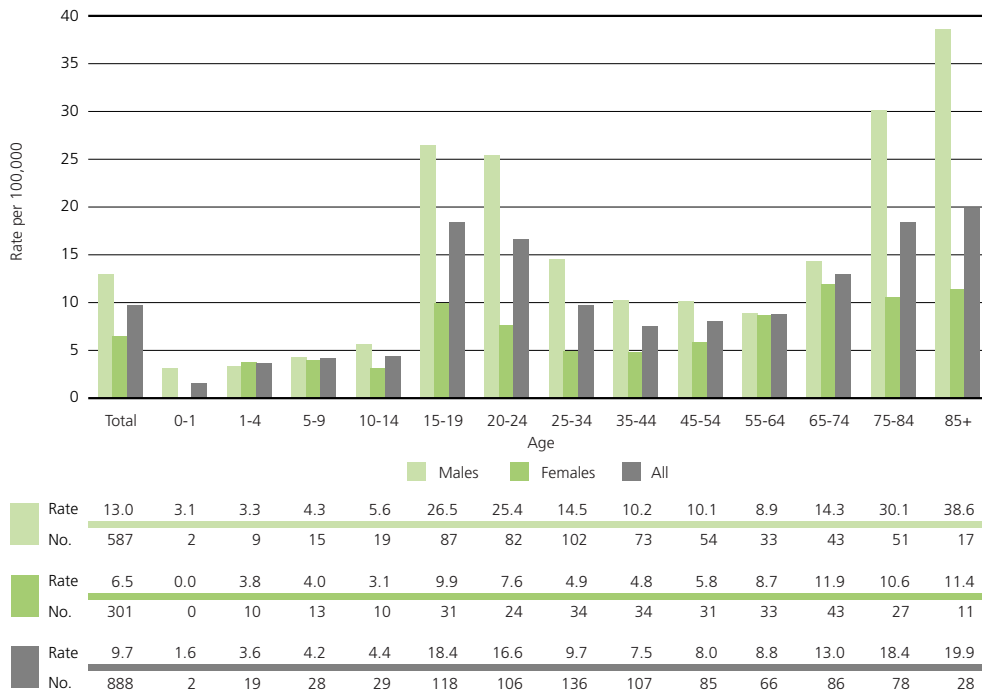
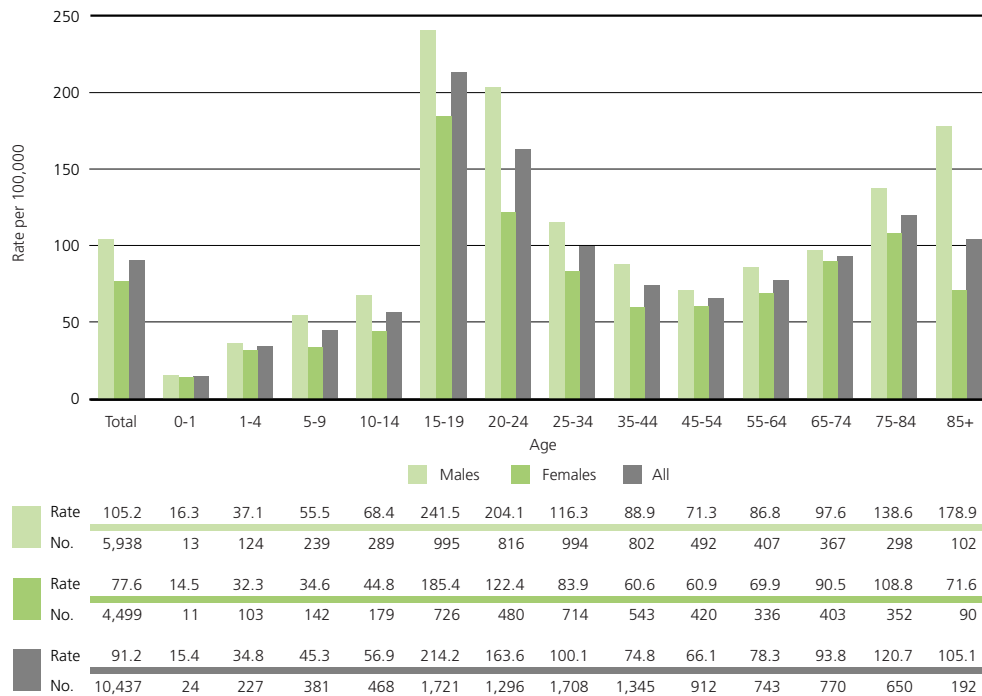


Figure 2. Motor Vehicle Traffic Injury Hospitalizations by Gender, 1992-2001



The data in these figures do not capture motor vehicle occupants specifically, as deaths and hospitalizations are tabulated for all cases involving motor vehicle collisions (i.e., pedestrians, cyclists).

Table 2 includes the proportion of occupants that were involved in motor vehicle collisions. Here occupant proportions were tabulated excluding cases that were 'unspecified'.

Between 1992 and 1999, there were 888 fatalities resulting from motor vehicle traffic incidents in Manitoba. Across all age groups, 57% of motor vehicle-related deaths were to motor vehicle occupants. Males were more likely to be fatally injured in motor vehicle traffic incidents relative to females, especially those between the ages of 15 and 44 years. Rates of injury per 100,000 were greatest among those aged 15-24 years and over 65 years. Considerable potential years of life lost are attributable to motor vehicle collisions. Between 1992 and 1999 there were 31,326 potential years of life lost in Manitoba from motor vehicle traffic injuries with an average of 35.3 years per victim.

Between 1992 and 2001, 10,437 Manitobans were hospitalized due to motor vehicle injuries. Males were hospitalized slightly more often than females (1.3X), and occupants represented 73% of all persons hospitalized for motor vehicle-related injuries. Those hospitalized in 2001 for motor vehicle injuries had an average length of stay of 11.4 days.

Traffic Collision Data⁴

Manitoba Transportation and Government Services publishes Traffic Collision Statistics Reports for all traffic collisions leading to a fatality or injury. A fatal

traffic collision is an event that results in the injured victim dying within 30 days of the incident. Collision data (1997-2001) demonstrate that approximately 60% of incidents occur in Winnipeg. On average there are 112 fatalities and 9,373 injuries per year. The reported injury rate exceeds the hospitalization rate, as this information is collected at the scene and includes an initial estimate of injuries, many of which do not result in hospitalization. Drivers account for 54% of collision fatalities and 62% of collision injuries, and passengers account for 26% of fatalities and 29% of injuries. Similar to the Canadian data reported above, occupants account for 80% of collision fatalities.

Analysis of the five most recent annual reports demonstrates that motor vehicle collisions in Manitoba are more likely to occur during November, December, and January, with fatal crashes occurring most often on Friday, Saturday or Sunday, and injury-related collisions occurring most on Fridays. Injury-related collisions occur most frequently between noon and 6 p.m., while fatal collisions are common in that time period as well as between 6 p.m. and midnight. Up to 23% of fatal collisions occur when road conditions are icy, wet or snow-covered while 20-35% occur during cloudy, rainy or snowy weather. On average 72% of collisions involve motor vehicles colliding with other motor vehicles. Fatal collisions most often result when driving off the road, attempting a 90-degree turn, colliding head-on with another vehicle or hitting a pedestrian. Older drivers and those aged 25-34 and 16-19 years are over-represented in fatal motor vehicle crashes.

Table 2. Proportion of Occupants as Motor Vehicle Crash Victims⁵

Age	Proportion of Occupants	
	Deaths (1992-1999)	Hospitalizations (1992-2001)
Under 1 year	1.00	0.95
1-4 years	0.53	0.31
5-9 years	0.39	0.35
10-14 years	0.20	0.45
15-19 years	0.75	0.81
20-24 years	0.77	0.75
25-34 years	0.57	0.77
35-44 years	0.61	0.73
45-54 years	0.51	0.77
55-64 years	0.63	0.72
65-74 years	0.58	0.76
75-84 years	0.44	0.81
85+ years	0.39	0.73
Total	0.57	0.73

Economic Impact

Motor vehicle collisions have a substantial economic impact on the province. The lifetime cost associated with motor vehicle collisions was estimated in 1989 as \$9,062(US) per person, with the average cost of a fatal injury \$352,042 and the average cost of hospitalization estimated at \$43,409.⁶ These represent direct costs, such as those associated with medical care as well as additional indirect costs related to the inability to participate in regular activities such as sports and school, lost work time and wages for parents, other costs paid by the family such as transportation and medication, and intangible costs associated with pain, trauma, and quality of life.

In Manitoba, the average annual cost due to motor vehicle injuries is \$120 million; this represents 15% of the total injury costs for the province.⁷ This figure includes \$45 million attributed to direct health care costs. The burden of child motor vehicle occupant injury has been assessed at \$9,300 US per victim.⁸

A National Initiative

Road Safety Vision 2010 (RSV 2010) is a national initiative of Transport Canada that aims to reduce

the burden of motor vehicle collision injuries in Canada.⁹ Transport Canada seeks a 30% decrease in the average number of road user fatalities and serious injuries from 2008 to 2010, as compared with 1996-2001 figures. Manitoba will benefit from this enhanced national focus on road safety.

RSV 2010 initiatives include the National Occupant Restraint Program (NORP) and the Strategy To Reduce Impaired Driving (STRID). Strategies include enforcement and awareness campaigns, legislation, and education.

Road Safety Vision 2010 includes a focus on high-risk drivers (e.g., impaired drivers, red light runners, habitual speeders, and restraint non-users). These sub-categories represent a significant proportion of fatally and seriously injured drivers.

Similar to Canada, the United States has developed road safety targets. Healthy People 2010 sub-goals include targeting unrestrained occupants, increasing child restraint use, and decreasing alcohol-impaired driving deaths and injuries.

Sub-targets for Transport Canada's Road Safety Vision 2010: Motor Vehicle Occupants⁹

- A 95% restraint use rate for seat belts and the proper use of child restraints
- A 40% decrease in unbelted fatalities and seriously injured occupants
- A 20% decrease in recidivism for multiple offenders
- A 40% decrease in road users fatally or seriously injured by drunk drivers
- A 20% decrease in road users killed or seriously injured in speed/intersection crashes
- A 20% reduction in young driver fatalities and serious injuries
- A 40% decrease in fatalities and serious injuries occurring on rural roadways.

METHODOLOGY

Literature Search

Databases

Seven electronic databases were searched for research articles on the topic of motor vehicle occupant injuries and injury prevention. The databases included CINAHL (1982-2004/07), EMBASE (1980-2004/08), MEDLINE (1966-2004/08 wk 3), PsycInfo (1972-2004/08 wk 3), PubMed (1951-2004), SportDiscus (1830-2004/08) and Social Sciences Full Text (1983/02 to 2004/06). Search terms used included 'motor vehicle occupant', 'traffic', 'injury prevention', and 'review'. On-line archives of the Injury Prevention journal were searched (ip.bmjournals.com) using the headings 'motor vehicle' and 'traffic' to identify any additional articles or relevant editorial content. Cochrane databases were also searched for systematic reviews and studies of motor vehicle occupant interventions.

Internet Searches

The Google search engine (www.google.ca) was used to search for best practices and systematic reviews using the search terms above. In addition, many injury-specific websites were targeted and searched manually, including:

- The Centre for Disease Control's National Centre for Injury Prevention and Control (www.cdc.gov/ncipc/),
- Safe Kids Canada (www.safekidscanada.ca),
- Health Canada's Injury Section (www.hc-sc.gc.ca/pphb-dgspsp/injury-bles),

- The Harborview Injury Prevention & Research Centre (www.depts.washington.edu/hiprc),
- Transport Canada (www.tc.gc.ca),
- The Canadian Association of Road Safety Professionals (www.carsp.ca),
- The Traffic Injury Research Foundation (www.trafficinjuryresearch.com),
- The National Highway Traffic Safety Administration (www.nhtsa.dot.gov),
- The Insurance Institute for Highway Safety (www.highwaysafety.org),
- The World Health Organization's Department of Injuries and Violence Prevention (www.who.int/violence_injury_prevention),
- And international injury prevention centres.

Other Sources

Additional sources included the IMPACT library, reference texts, statistical reports, and published systematic reviews of injury prevention best practices. Many of these are available on-line or by contacting IMPACT (www.hsc.mb.ca/impact).

RISK FACTORS

Motor vehicle crashes implicate three groups of factors that increase the risk of collision and occupant injury: human factors, factors associated with the roadway environment and motor vehicle factors.¹⁰ Human factors take into account the actions or conditions of the driver (e.g., age, seat belt non-use, speeding, using alcohol or drugs, inattention, or errors) and occupant (e.g., seating position, seat belt use). Factors pertaining to the roadway environment include design factors (e.g., medians, lane width, shoulders, curves, signage), roadside hazards (e.g., poles, trees, embankments), and driving conditions (e.g., ice, rain, snow, fog). Vehicle factors are design issues that contribute to a crash (e.g., SUVs and the risk of rollover) and the risk of injury in a crash (e.g., vehicle size, crumple zones, airbags). Human factors are considered to be the most important factor contributing to collisions, followed by issues regarding the road environment, and lastly vehicle-related factors.¹⁰

Knowledge of the risk factors associated with motor vehicle collisions and occupant injury can aid in the development of effective prevention strategies. Significant risk factors have been clearly identified and described.

Human Factors

Age

The association between age and motor vehicle injury is a U-shaped curve, where young drivers and older adults are at greater risk of fatal injury. Motor vehicle occupants 16-20 years and over 75 years of age have a greater chance (per vehicle-miles travelled) of being in a fatal crash than other age groups.¹⁰ These subgroups are most often involved in crashes, especially ones that are fatal.

Children

Motor vehicle collision is an important cause of childhood injury, death, and disability. The CDC states that 'motor vehicle injuries are the greatest public health problem facing children today'.¹¹ For Canadian children, motor vehicle-related injuries are the leading cause of injury death.^{2,12} Motor vehi-

cle occupant injuries represent 69% of motor vehicle fatalities and 46% of hospitalizations among Canadian children and youth less than 20 years of age.¹ Children 15-19 years of age are most at risk, accounting for 71% of occupant deaths and 67% of occupant hospitalizations. In Manitoba, approximately 10 child fatalities result from motor vehicle collisions annually.¹³ National data demonstrate that for every fatally injured child approximately 13 children and youth are hospitalized.¹ Between 11% and 13% of all pediatric motor vehicle occupants presenting to the emergency department require hospitalization.¹ Head injuries are the most common cause of morbidity and mortality in serious motor vehicle collisions, and can lead to long-term disability.^{14,15} National Highway Traffic Safety Administration data (US) show that nearly 40% of fatally injured child occupants and approximately 54% of injured child occupants are unrestrained.¹⁶ Other contributing factors may include improper restraint and car seat non-use and misuse.

Teen Drivers

Motor vehicle collisions are the leading cause of death for young adults 15-24 years of age, with approximately 15 fatalities to Manitoba teens (15-19 years of age) each year.⁵ Teen drivers have the highest fatality rate of all drivers. There is also a higher risk for passenger deaths in vehicles driven by teens relative to older drivers.^{17,18} A study comparing passenger deaths in vehicles driven by teens (versus those 30-59 years of age) showed a six-fold increased risk with teen drivers [RR 5.79, 95% CI 5.5 to 6.09].¹⁸ This increased risk to passengers is unique to teen drivers.¹⁹ The risk is increased with two or more passengers and when the passengers are also teens.²⁰⁻²²

While young drivers in Manitoba (16-19 years of age) represent 6% of licensed drivers, they account for 12% of motor vehicle crashes. Drivers in this age group also account for 76% of fatalities and 65% of motor vehicle occupant injuries.^{4,17} At night, teen drivers have been implicated in 11% of crashes and 19% of fatal crashes occurring between 10:00 p.m.

and 6:00 a.m.²³ Lack of driving experience, alcohol, immaturity, passenger distraction, and risk-taking behaviour are the main factors implicated in teens' heightened crash risk.^{4,10,24-28} Teens tend to drive more aggressively and are less likely to recognize and effectively respond to hazardous situations.^{25,29} Risk factors for teen driver injury-related crash rates include driving at night, driving without supervision, transporting passengers, using alcohol, being 16 years of age (vs.17), and being male.³⁰ Risk factors for deaths among teens include driver inexperience, male gender, speeding, seatbelt non-use, night driving, and alcohol or drug use.^{24,25,31-33}

Newly licensed drivers have higher crash rates during their first months of licensure.²⁶ In Manitoba, new drivers are three times as likely to be involved in a collision relative to experienced drivers, per 100,000 kilometres travelled.⁵ Attributing the teen driver problem to driver inexperience alone is not sufficient as the risks of crash, injury, and death are not as high for other new drivers.^{26,34}

Older Drivers

Older drivers are also at higher risk for motor vehicle collision fatality; in 1997 those over 65 years of age represented 15% of the population and 23% of fatalities.⁴ This may be due to compromised vision, loss of psycho-motor skills and declines in cognition leading to impaired driving skills.³⁵ United States data demonstrate that fatal collisions involving older drivers occur most often during the daytime (81%), on weekdays (72%), and involve another vehicle (72%).³⁶ After age 70, the involvement rates of drivers in fatal and nonfatal motor vehicle crashes increase when adjusted for miles driven.^{37,38} In terms of driving exposure, older drivers tend to have lower average annual mileage than other drivers. When compared with 30-59 year old drivers, older drivers (75+ years of age) have higher driver deaths [RR 3.02, 95% CI 2.86 to 3.19] and higher death rates among their passengers [RR 2.52, 95% CI 2.39 to 2.66].¹⁸ This is a particular concern as the population of older drivers increases.³⁹ Older adults also have a greater likelihood of death or serious injury after traffic collision, perhaps due to their increased physical frailty and associated medical conditions.^{38,39}

Gender

In Manitoba, traffic-related mortality rates for males are twice the rate for females (13.0 vs. 6.5 per

100,000), while males are hospitalized 1.4X as often as females (105.2 vs. 77.6 per 100,000).⁵ Young male drivers are a particularly high risk group.²⁵ Manitoba traffic collision data demonstrate that males are more likely to be fatally injured in motor vehicle crashes than females, however slightly more women are non-fatally injured (54%).⁴ There are a number of hypotheses for the increased risk among males, including driving behaviour, restraint use, and alcohol use. Men engage in aggressive driving behaviours more often than women, and manifest road rage symptoms more readily.⁴⁰ Two-thirds of unrestrained occupants are male, and males are more likely to have higher blood alcohol levels.^{41,42}

First Nations Populations

First Nations individuals are at greater risk of motor vehicle injury and death than the general population. The risk of motor vehicle death is nearly double that of other Manitobans (9.4 per 100,000 in Non-First Nations Manitobans and 18.2 for First Nations populations).⁵ Similarly, the rate of hospitalization among First Nations is more than three times the non-First Nations rate (270.7 per 100,000 for First Nations populations and 80.2 in Non-First Nations populations). Road conditions, vehicle age and condition, occupant non-restraint, impaired driving, and increased exposure to driving are possible contributing factors.

Alcohol & Drug Use

Alcohol continues to be one of the most significant factors contributing to serious motor vehicle collisions.⁴³ Economically, alcohol is the most significant contributing factor, followed by the non-use of seat belts.⁴⁴ In Manitoba, alcohol was a factor in 37% of fatal crashes where the presence or absence of alcohol could be determined.⁴⁵ In this study, most (76%) alcohol-related crash victims were male drivers with a blood alcohol concentration exceeding the legal limit. Alcohol involvement in crashes was most common among 20-25 year old victims. Positive blood alcohol concentrations are associated with an increased risk of death, greater injury severity, increased crash likelihood, poor clinical outcomes, and crash culpability.⁴⁶⁻⁴⁹ Significant impairment occurs at very low blood alcohol concentration (BAC) levels.⁴⁸

Serious injury is more likely among motor vehicle crash patients with a positive blood alcohol concen-

tration compared to those patients who have not consumed alcohol [OR=1.59 95% CI 1.03 to 2.45].⁴² In this study, alcohol consumption led to a 30% increase in injury severity scores. This effect was present even for patients who had low blood alcohol concentrations. Those with a positive BAC were more likely at fault, less likely to be restrained, and their vehicles had higher scores for amount of 'vehicle crush'. Relative to their non-drinking counterparts, those with a positive BAC are significantly more likely to be male, involved in a single-vehicle collision, unrestrained, ejected, and traveling at higher speeds.⁵⁰

Drug use is also a factor contributing to crash risk. The most commonly used drugs among drivers involved in crashes include benzodiazepines, cocaine, amphetamines and opioids with multiple substance use being common.⁵¹ Cannabis and benzodiazepine use by drivers leads to increases in crash risk, with a greater risk attributed to combining alcohol and drugs, or multiple drugs. A systematic review of the relationship between benzodiazepine use and motor vehicle collisions demonstrated that this drug is associated with approximately twice the risk of a collision.⁵² This risk is enhanced for those over 65 years of age who take longer-acting or larger doses of benzodiazepines.

Driver Error

Driver error has been found to be an important contributing factor for motor vehicle collisions, and is cited in 42% of Manitoba traffic fatalities. Manitoba traffic fatality data show that the most common types of driver error are speed, loss of control, failing to yield, and disobeying traffic controls.⁴ Drivers make a variety of poor judgments, including poorly evaluating stopping distances, improperly judging distances of cars traveling behind them, and turning the wrong way down a one-way street.¹⁰

Driver Inattention

Drivers are subjected to a constantly altering road environment that makes it necessary for them to continually respond and react. Driving is a complex activity that requires constant attention to information from different sources as well as a state of alertness for adequate vehicle control.⁵³ Being unable to process information and respond promptly can lead to collisions. In Manitoba, distraction or inattention is the prevailing cause for up to 59% of cases of non-

fatal collisions where drivers are at fault.⁴ Driver inattention includes distraction and drowsiness. Distraction can be visual, auditory (e.g., noise, cellular phone use), cognitive, or involve biomechanical tasks (e.g., adjusting the radio).¹⁰ One study measuring drowsiness in highway drivers found that crash risk was increased for those who felt they were falling asleep [RR=14.2, 95% CI 1.4 to 147] and those who drove long distances [RR 2.2, 95% CI 1.4 to 3.3, per additional 100 miles].⁵⁴ Sleep deprivation also played a role in increased crash risk, while strategies to increase alertness were protective (e.g., use of rest stops, drinking coffee, listening to the radio).

Cellular telephone use by drivers can adversely impact driving behavior.²⁸ Drivers using cell phones have been found to have a greater risk of at-fault crashes relative to non-users.⁵⁵ They also have a higher proportion of rear-end collisions. In one study, cellular phone were used to evaluate cognitive distraction. A hands-free device was used and tasks were conveyed over the phone which varied in cognitive complexity.⁵³ When drivers were distracted with cognitive tasks they engaged in less visual scanning, more hard braking, and provided lower driving safety ratings. Technological distraction while driving is also present for in-vehicle DVD players and monitors. In general, attempting to complete other tasks while driving has been found to compete with a driver's ability to remain alert and attentive.⁴⁰

Occupant Restraint

Proper occupant restraint reduces the incidence and severity of injury in a collision, and includes seat belt and child restraint devices.^{56,57} Interventions that increase occupant restraint use could significantly reduce motor vehicle occupant injuries and their associated economic burden. In one California study, hospital costs for an unrestrained occupant were 25% more than for a restrained motor vehicle occupant.⁵⁸

Seat Belts

Seat belt non-use is a major risk factor for vehicle occupant injury.²⁸ Driver restraint use is also one of the most important predictors of child restraint use; restrained drivers are more than twice as likely to restrain a child than unrestrained drivers.⁵⁹ Overall in Manitoba (July 2001), the seat belt wearing rate for light duty vehicles (passenger cars, vans, light

trucks) was 82.3%.⁶⁰ Rates were found to be higher for passenger cars and vans, but a much lower use rate was found for light truck occupants (driver 69%, all occupants 67%) compared with passenger car and van occupants (83-85%). Manitoba's Traffic Collision Statistics Reports demonstrate that on average (1997-2001) 43% of fatally injured vehicle occupants were not wearing a seat belt.⁴

The effectiveness of seat belts in injury reduction has been well documented. Relative to unrestrained occupants, those using seat belts have a reduced overall risk of injury [RR=0.42, 95% CI 0.36-0.48].⁴¹ Seat belt use is also associated with significant risk reduction for injuries to the head, thorax and abdomen.

Child Restraints

Deaths and injuries resulting from motor vehicle collisions are largely preventable through the proper use of child restraint devices, including car seats, booster seats, and seat belts.⁶¹ Properly used car seats reduce the risk of death and serious injury by 70%.^{61,62} Unrestrained children are at a greater risk of injury and death in the event of a motor vehicle collision when compared to restrained children. One study examining the relative risk of injury for unrestrained children found that they were at a higher risk of all types of injuries (RR = 1.7, 95% CI 1.17-2.45), and head injuries in particular (RR = 3.13, 95% CI 1.78-5.51).⁶³

Manitoba law requires that children less than five years of age and weighing less than 50 pounds must be in an approved child restraint.⁶⁴ In Manitoba in 1997 child restraint use rates were 89% for infants, 87% for toddlers (one to four years of age), 83% for children five to nine years of age, and 88% for 10-15 year-olds.⁶⁵ It should be noted that these data do

not indicate whether age-appropriate restraints were used or whether restraints were correctly used.

Common Child Car Seat Errors

The top three⁷⁴:

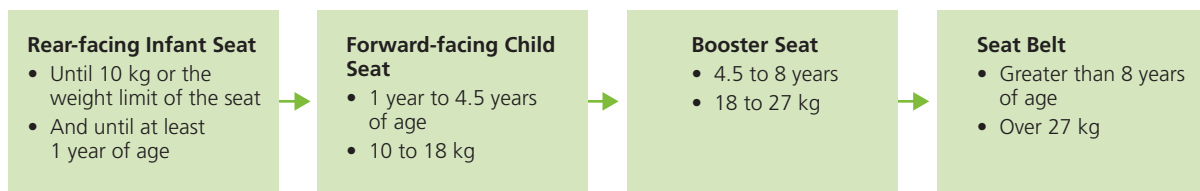
- seat not tightly secured to the vehicle
- harness straps not snug
- chest clip not at armpit

Other common errors^{75,76}

- failing to restrain the child
- not anchoring the tether strap
- placing a rear-facing infant seat in front of a passenger air bag
- not using a locking clip when necessary
- routing the seat belt through the incorrect path
- routing the harness straps through incorrect slots
- using recalled or otherwise unsafe seats

Transport Canada uses a four-stage system for determining the type of occupant restraint for children (see Figure 3).⁶⁶ When using a child restraint system, one must secure the child restraint to the motor vehicle, and secure the child within the child restraint system.⁶⁶ The vast number and type of available car seats and booster seats creates great confusion for consumers, leading to errors in selection, installation, and use.

Figure 3. Transport Canada's Four-stage System for Child Occupant Restraint



Non-use and improper use of these devices are significant problems in Canada, with one in eight children traveling unrestrained and an estimated 60-80% of restrained children traveling with substandard restraint (wrong device, installation errors, use errors).^{62,67,68} It is estimated that misused restraints are only 44% effective.⁶¹ Manitoba data (www.mpi.mb.ca) demonstrate that 56% of child car seats are not properly installed, particularly forward-facing child seats (59% misuse) and rear-facing infant seats (49% misuse). Misuse can lead to the child being ejected from the seat, and in some cases, from the vehicle. These injuries are typically fatal.^{61,69,70}

Restraining a child in a motor vehicle using any child restraint system is a complex task where errors and omissions can have serious consequences. Child restraint errors are a prevalent and potentially life-threatening problem.⁷¹ Observational studies have shown that 80-90% of child restraint systems are used incorrectly.^{61,62,66,67,72,73} Some errors compromise the protection offered by the device and may render it equivalent to non-use.⁶¹ Improper restraint includes non-use, selecting and using the wrong seat type for the child's age and weight; using an outdated, recalled or damaged seat; installing the seat incorrectly; improperly securing the child in the seat; and positioning errors, such as allowing children 12 and under to ride in the front seat.

One study concluded that parents are more likely to misuse infant car seats than toddler car seats. This may be due to seat type or design.⁷⁷

One of the most problematic errors is "premature graduation" from one stage to the next. Premature graduation is most common in children moving to stage 2 (forward-facing) and in children moving to stage 4 (seat belt). Premature graduation to a forward facing child seat places children at risk for spinal cord injuries, as their weak necks are unable to withstand the thrust of a frontal crash.⁷⁵ To reduce this risk, infants should be kept rear-facing as long as possible.⁶¹

When children aged two to five years old are prematurely graduated to a seat belt, they have a 3.5X-increased risk of significant injury compared with children of the same age using appropriate child restraint systems. Children in seat belts are also at greater (RR=4.2, 95% CI 2.6 to 6.7) risk for significant head injuries.⁷⁸ When a child uses an adult seat belt, the shoulder belt lies across the neck and

the lap belt rests on the mid-abdomen; in a frontal collision, the lap belt itself may injure the child. "Lap belt syndrome" may result in injury to the lumbar spine, spinal cord and internal abdominal organs.^{61,79-81} One study found that the odds of children sustaining a spinal injury was 24 times greater for those wearing a lap belt versus a lap-shoulder belt.⁸²

Booster seats properly position the child so that the shoulder belt lies over the shoulder and across the chest, while the lap belt rests across the thighs. In Canada, the largest issue with booster seats is non-use. One study found that only 6% of children who would benefit from booster seats were restrained in one.⁸³ Other research shows that restraint use declines with the increasing age of the child.⁸⁴ Booster seat use peaks prematurely at age three and then drops off significantly at age four.⁸⁵ A British Columbia study found that 82% of children four to nine years of age were not using booster seats.⁸⁶

Booster seat non-use places children who are between four to nine years of age at increased risk of death and injury. The protective effect of booster seats has been demonstrated; the risk of injury for children four to seven years of age in a booster seat is 59% lower than for children in seat belts.⁸¹

Speed

Speed is an important factor contributing to motor vehicle occupant injury.²⁸ Speed influences the risk of a crash as well as crash outcomes; speed is associated with an increased number and severity of injuries, and a greater likelihood of fatality. Speeding includes both driving at a speed beyond the posted limit and driving too fast for conditions.⁴ Drivers prone to speeding often fail to adjust their speed when weather or road conditions are poor. Crash risk increases as speed increases, particularly at intersections and when overtaking other vehicles.²⁸

Speed is a factor in 15% of all crashes and 30% of all fatal crashes (www.nhtsa.dot.gov). Males are more likely than females to be involved in fatal crashes where speed is a contributing factor. Young drivers are also at increased risk of fatal injury, in part due to their tendency to speed.¹⁰ Research assessing the increase of speed limits on rural free-ways in Washington State, from 55 to 65 mph, found higher fatal crash rates following this change.⁸⁷ One study found a 17% increase in fatality rates following the removal of the United States

National Maximum Speed Limit.⁸⁸ The Insurance Institute for Highway Safety concluded that increases in vehicle speeds led to increases in fatality rates. States with speed limits of 75 mph had 38% more deaths per million vehicle miles driven relative to states with lower speed limits.⁸⁹

Roadway Environment Factors

Roadway Conditions

The road environment can be compromised by poor surface conditions (e.g., water, snow, ice, oil, holes, ruts, edge drop-offs, wear) and conditions causing reduced visibility (e.g., reduced light, poor weather). Slippery roads and the presence of wild animals are the two most common environmental conditions implicated in Manitoba traffic collisions.⁴

The Rural Roadway Environment

Rural areas are defined as those with populations of 1,000-9,999, which are outside metropolitan areas. Manitoba traffic data demonstrate that a disproportionate number of traffic collisions occur in rural areas (24%) and rural roads account for 76% of total fatalities.⁴ Increased speeds have been cited as a contributing factor for this discrepancy. Other potential factors include the tendency for rural drivers to drive longer distances, often on inferior road surfaces, relative to urban drivers.⁹⁰ Manitoba's rural seat belt use rate was 80.8% for front seat occupants of light duty vehicles in September 2002.⁹¹ This rate was 1.5% lower than the average seat belt use rate for light duty vehicles in Manitoba, measured in 2001.⁶⁰

Vehicle Factors

Vehicle Type

Crashworthiness tests are conducted by the Institute of Highway Safety in the United States. Rollovers are more common in sport utility vehicles (3X rate of passenger cars) this can be attributed to design features such as a higher centre of gravity, narrow width, and a shorter wheel base.¹⁰

Child occupant injury is highest in compact extended cab pick-up trucks; these are not recom-

mended as family vehicles. There is a three-fold increased risk of injury in compact extended cab pick-up trucks compared to all other types of passenger vehicles. Children placed in the rear seats of compact extended cab pickup trucks are at increased risk of injury relative to rear-seated children in other vehicles [OR=4.75, 95% CI 2.39-9.43].⁹²

A new issue with multiple-vehicle collisions is that of 'vehicular mismatch', which can involve incompatibilities in weight, ride height, and stiffness.⁹³ With weight mismatch, occupants in the lighter vehicle are at increased risk of death and injury.⁹⁴ For instance, SUVs and pick-up trucks pose greater risks to occupants of their 'crash partner' cars.⁹⁵ Bumper mismatch occurs when large vehicles strike smaller ones. Since the bumpers are not the same height, the smaller vehicle is hit higher up than the bumper, which is designed to absorb the impact of a crash. Mismatch is a particular problem for lateral collisions where children are struck at a higher level (mid-door) by a larger vehicle. This results in deeper intrusion at the level of the thorax or head versus the pelvis region. A Canadian study demonstrated that lateral impact crashes, relative to non-lateral crashes, led to a higher mean Injury Severity Score, more chest injuries and more intra-abdominal injuries.⁹⁶

Occupant Protection Devices

Passenger airbags, while protective for adults, are associated with an increase in child fatality risk of 31% for restrained children and 84% for unrestrained children.⁹⁷ Airbag deployment is associated with deaths and injuries among child occupants for both front and side airbags.⁹⁸ "Smart" airbags are currently being designed which will be appropriate for the different ages and sizes of occupants.⁹⁹

Seating children in the rear seat, or second row, is protective for most vehicle types, with the exception of compact extended cab pick-up trucks, where the reverse is true.¹⁰⁰ For children traveling in these types of vehicles, the risk of significant injury is higher in the second row than in the front row (13% in rear and 2.8% in front) For other passenger vehicles, the second row may provide greater protection due to greater distance from the point of impact as well as the absence of a passenger airbag.

INTERVENTIONS

Overall Findings

Seat Belt Enforcement

The effectiveness of seat belts and child restraints in reducing the risk of motor vehicle occupant injury have been demonstrated.⁴⁶ Seat belt legislation increases seat belt use and decreases fatal and non-fatal occupant injuries among adults and adolescents.¹⁰¹ Enforcement of legislation has been shown to be effective in increasing seat belt use.¹⁰² Primary enforcement of seat belt laws enables law enforcement personnel to stop a vehicle solely to determine if a seat belt is being worn, while secondary enforcement only permits seat belt citations if non-use is determined while the vehicle is stopped for another violation. Primary enforcement has been found to be more effective in increasing rates of seat belt use and in decreasing mortality.^{101,103} Seat belt use is lower in states with secondary enforcement laws.¹⁰⁴ Enhanced enforcement programs (e.g., blitzes) provide increased enforcement of seat belt laws at certain locations and times and are generally complemented by public awareness campaigns advertising the enhanced enforcement.¹⁰⁵ Overall, these programs have led to a 16% increase in observed seat belt use.¹⁰¹ An assessment of Click-It or Ticket Programs highlights the importance of media partnership; marginal seat belt use increases were seen in states with seat belt enforcement and little or no advertising, while highly publicized campaigns demonstrated an 9% increase in seat belt use.¹⁰⁶

Reducing Alcohol-Impaired Driving

Systematic reviews have assessed methods to reduce alcohol-impaired driving.¹⁰⁷ Laws mandating a maximum blood alcohol concentration (BAC) of .08 g/100ml for drivers 21 years or over are effective in reducing alcohol-related crash fatalities.^{105,107} Mandating lower BAC limits for young and inexperienced drivers is effective in reducing alcohol-related crashes among 18-20 year old drivers.¹⁰⁷ This initiative has been termed the 'zero tolerance law'; although it includes BAC levels between 0.001 and 0.02 g/100ml.

Other reviews show that zero tolerance laws are effective in reducing injuries and crashes for young drivers.¹⁰⁸ However, a review assessing the benefit of changing the Canadian BAC law from .08 to .05 g/100ml did not deem the reduction worthwhile.¹⁰⁹ More recent initiatives that are effective in reducing impaired driving include policy changes to control access to alcohol and controlling pricing and promotion.¹¹⁰

The impact of increasing the minimum legal drinking age (MLDA) to 21 years of age has been assessed. A higher MLDA has led to a 15% reduction in fatal crashes, while lowering the MLDA has led to an 8% increase in fatal crashes in the 18-20 year old age group.^{107,111} An assessment of the current literature (1960-2000) on MLDA laws demonstrated an inverse relationship between MLDA laws and alcohol consumption and traffic crashes.¹¹²

Sobriety checkpoints deter alcohol-impaired driving by giving drivers an increased perceived risk of detection and arrest.¹⁰⁵ Two types of checkpoints exist: random breath testing (RBT), where all drivers can be stopped, and selective breath testing (SBT), where police can only stop drivers suspected of consuming alcohol. Both have been found to be effective in reducing alcohol-related fatalities, injuries, and crash rates.^{43,107} With SBT, fatal and non-fatal injury crashes decreased 20%, whereas for RBT programs fatal and non-fatal crashes decreased 16%. Overall crash rates decreased 20 and 18%, respectively.¹⁰⁷

Interventions for alcoholic beverage servers have been found to be effective in reducing alcohol-related intoxication under certain conditions. Programs that were intensive, provided high quality face-to-face training and were backed by strong managerial support led to a reduction in alcohol intoxication in patrons.¹⁰⁷ Initiatives include offering food, providing delayed service to quick drinkers and refusing service. While it is implied that reductions in patron intoxication will reduce alcohol-impaired driving, this has not been documented.

Decreasing Recidivism

Other systematic reviews have addressed methods to target drunk driving recidivism. Administrative Per Se Laws apply to drivers who exceed the blood alcohol level of .08, beyond which it is illegal to drive a vehicle.⁹⁴ The right to drive can be immediately revoked as a penalty for driving impaired. Assessments of this initiative show inconsistent findings.¹¹³ Ignition Interlock Systems require an offender to provide a breath sample in order to start the vehicle; if the sample is found to be positive for alcohol, the vehicle ignition system is disabled. This method was found to be effective in reducing drunk driving recidivism.¹¹⁴ Ignition interlock participants were 15-69% less likely to be re-arrested for driving while intoxicated.¹¹⁴ At present, ignition interlock programs are not available in Manitoba.

Many effective interventions exist for reducing alcohol-impaired driving (e.g., sobriety checkpoints, increasing alcohol taxes, and prohibiting beer advertising on television). What remains to be seen is which interventions work best and in what combinations, and whether results are sustainable in the long-term. Methodological problems were found by some of the reviews. More sophisticated research studies are needed to answer these questions.

Graduated Driver Licensing

Graduated Driver Licensing (GDL) programs are effective in reducing crash rates and injuries for young drivers, and can be beneficial for novice (non-teen) drivers as well.^{28,115,116} The goal of GDL is to enable drivers to gain experience under lower risk conditions.¹¹⁷ Once competence is demonstrated in one stage participants can 'graduate' to the next stage, which has fewer restrictions. Situations that contribute to increased crash risk are night driving, driving with (teen) passengers, and alcohol use; therefore GDL programs often place restrictions on these activities.¹¹⁸ Many GDL programs include zero tolerance for alcohol.

GDL programs have been shown to be effective. In one study, crash rates decreased 31% in the first year while injury crash rates decreased 28%, among 16-year-old drivers.¹¹⁵ In Michigan, the long-term impact of GDL was assessed following the first four years of the program. Here, sixteen year old drivers demonstrated significant reductions in crash risk (44% for fatal crashes, 38% for non-fatal injury crashes).¹¹⁹ In addition, there was a 59% risk reduc-

tion for crashes at night, yet this program requires the presence of a licensed adult over 21 years of age or older from midnight to 5 a.m.

GDL programs are fairly new, and more rigorous assessment of their effectiveness is needed. Most programs have focused on using the program as a whole as the unit of analysis.¹¹⁶ The impact of individual components should be investigated to identify key elements.^{115,120} Preliminary findings demonstrate that early intervention with violators has had a deterrent effect, and that night driving and teen passenger restrictions are beneficial.^{34,121} GDL program components in need of further research include exit tests (prior to full licensure), hazard perception tests, and speed and roadway access restrictions.¹²²

Driver Education

High school driver education programs encourage young people to drive earlier and lead to increased crash involvement rates.^{4,123} In fact, ceasing to provide funding for driver education programs led to a decline in licensure and in crash rates of 16-17 year-old drivers in Connecticut.¹²⁴ Post-license driver education programs involving both remedial training and advanced driver-training have been assessed. There is no evidence that these programs reduce traffic-related injuries or crashes.¹²⁵

Child Restraints

A systematic review of health promotion programs and child restraint use found positive effects for loan programs, education programs, and legislative enforcement of child seat laws.¹²⁶ One review documented that child safety seat laws led to a 13% increase in child safety seat use, a 35% decrease in fatalities, and a 17% decrease in fatal and non-fatal injuries.¹²⁷ Community-wide information and enhanced enforcement campaigns promote child safety seats through increased public awareness and enforcement (e.g., car seat check stops, law enforcement).¹⁰⁵ These programs have increased child safety seat use in a variety of populations and settings.¹²⁷ Incentive and education programs are also effective in increasing child safety seat use in variety of populations and settings.¹⁰⁵ These initiatives led to a 10% increase in child restraint use, however, changes were not assessed beyond four and a half months.

An assessment of community and clinical programs aimed at increasing child safety seat use among chil-

dren under five years of age found that pre-school programs led to an increase in seat belt use rates from 12 to 52%.¹²⁸ Media campaigns led to an increase of up to 14%, and peripartum counselling gains were 6-27%. While moderately effective in the short-term, restraint use decreased one month following the intervention. Community-based injury prevention interventions involving multiple strategies are recommended.¹²⁹ Community-wide education and awareness programs can contribute to increasing child safety seat use and may complement laws and their enforcement.¹³⁰

Interventions are required to address the non-use of booster seats in children between four and eight years of age. One United States jurisdiction saw a coordinated advocacy campaign result in a 20% increase in booster seat use (from 14 to 34%) among four year-old children.⁸⁵ A number of jurisdictions have implemented or are considering booster seat legislation. Community campaigns have led to marginal increases in booster seat use, yet increases from these initiatives are limited and may not be sustained (e.g., 26%).¹³⁰

Finally, adult seat belt use is an important predictive factor in child restraint use. In one study, when the adult was belted the child was belted 68% of the time, and when the adult was not belted, the child was only restrained 17% of the time.¹³²

Rear Seating

Research has shown that the rear seat is much safer for child passengers compared with the front seat [OR=5.5, 95% CI 3.7-8.1].¹³² Interventions to improve rear seating have failed to yield significant results.¹³³ Restraint use and rear seating are associated with significant decreases in the odds of child fatality following a crash.⁹⁷ The rear seat has been found to be protective for children less than 15 years of age [aOR 1.7, 95%CI 1.6-2.0] especially when restraints were used [aOR 2.7, 95%CI 2.4-3.1].^{134,135} In particular, the rear centre position is most protective for children. The exception is the rear seat of compact extended cab pick up trucks, which have an increased risk to children, compared to the front seat. Children six to 12 years of age who travel alone with the driver are at greatest risk of being seated in the front seat.¹³⁶

Enforcement of Speed

Use of Cameras

Speed control strategies have led to a reduction in collisions, injuries and fatalities.¹³⁷ Recent technological advances in speed detection include red light cameras, which are able to detect speeders and red light runners. Red-light cameras are effective in reducing red-light-running crashes and red-light violations.¹³⁸ Reductions in crash frequency have been associated with increasing levels of camera-driven ticketing.¹³⁹ In Manitoba, the site of speed cameras are well publicized; however research has demonstrated that concealing this information may lead to greater speed reductions.¹⁴⁰

Modifying Speed Limits

In 1995, the National Maximum Speed Limit of 55 mph was removed in the United States. This enabled states to set their own maximum levels in excess of 55 mph. Increasing the speed limit to 65 mph led to an increase in fatality rates, especially on rural interstates.^{94,141} Speed was found to be directly related to crash risk, injury likelihood and severity, and fatality risk.^{94,142}

Traffic Calming

Traffic calming is the use of physical modifications to the road environment in order to modify driver behaviour (e.g., reduce speeds), to improve conditions for other road users (e.g., cyclists and pedestrians), and reduce environmental problems.¹⁴³ Traffic calming strategies include lane narrowing, narrowing of road entrances, speed bumps, roundabouts, special speed zones, improving signage and lighting, and redistributing traffic (e.g., one-way streets).^{143,144} Medians help separate opposing traffic lanes and reduce head-on collisions, wider lanes offer greater space among adjacent vehicles, and shoulders provide a recovery area.¹⁴⁵

One study assessing the effectiveness of area-wide traffic calming schemes in reducing motor vehicle injury outcomes showed a decrease in road user deaths (0.63) and injuries (0.89).¹⁴⁴ One meta-analysis concluded that guardrails reduce crash severity.¹⁴⁶ Two initiatives, installing roundabouts and installing centre-line rumble strips on rural two-lane roads have led to reductions in crashes.^{94,147,148} Some interventions, proposed to make intersections safer for older drivers and pedestrians, incorporate

traffic calming strategies; these include 4-way stop signs, roundabouts, signal timing, longer walk signals, and protected left turn signals.³⁸

Summary of Evidence

For this report, the methods of the Canadian Task Force on Preventive Health Care and the Community Guide were adopted (see Appendix A). The

Community Guide is a published set of systematic reviews that summarize motor vehicle occupant injury prevention strategies. The Community Guide methods involve a highly structured review system. The strength of the evidence of this subset of reviews rates evidence as ‘strong’, ‘sufficient’ or ‘insufficient’ (see Appendix B).¹⁰⁵ Table 3 summarizes the evidence for interventions that have been systematically reviewed.

Table 3. Summary of Evidence and Ratings for Motor Vehicle Occupant Interventions

Intervention	Qualifying studies	Strength of evidence	Recommendation
Restraint Use			
Enhanced enforcement programs ¹⁰¹	15	Strong evidence	Strongly recommended
Primary (vs. secondary) enforcement laws ¹⁰¹	13	Strong evidence	Strongly recommended
Primary and secondary enforced seat belt laws ¹⁰³	48	Fair (Level II-3)	Recommended (primary enforcement)
Safety belt use laws ¹⁰¹	33	Strong evidence	Strongly recommended
Alcohol-Impaired Driving			
0.08% blood alcohol concentration laws ¹⁰⁷	9	Strong evidence	Strongly recommended
Lowering the BAC Limit to .05 in Canada ¹⁰⁹	10	Fair (Level II-3)	Insufficient evidence to determine effectiveness
Minimum legal drinking age laws ¹⁰⁷	33	Strong evidence	Strongly recommended
Random alcohol screening ⁴³	14	Fair (Level II-3)	Recommended
Server intervention training programs ¹⁰⁷	5	Sufficient evidence	Recommended
Sobriety checkpoints ¹⁰⁷	23	Strong evidence	Strongly recommended
Reducing Recidivism			
Administrative Per Se Laws and drunk driving recidivism ¹¹³	3	Fair (Level II-2)	Insufficient evidence to determine effectiveness
Alcohol Ignition Interlock Programs for reducing drink driving recidivism ¹⁴⁹	14	Good (Level I)	Recommended
Ignition interlock devices in reducing drunk driving recidivism ¹¹⁴	6	Good	Strongly Recommended
Young and Novice Drivers			
Graduated driver licensing ³⁴	7	Fair (Level II-3)	Insufficient evidence to determine effectiveness
Graduated driver licensing for reducing crashes in young drivers ¹¹⁵	13	Fair (Level II-3)	Recommended
High school driver education ¹⁵⁰	9	Good (Level I)	Discouraged
School-based driver education ¹²³	3	Good (Level I)	Discouraged
Lower BAC laws for young or inexperienced drivers ¹⁰⁷	6	Sufficient evidence	Recommended
Lower BAC laws for younger drivers ¹⁰⁸	6	Fair (II-3)	Recommended
Child Occupants			
Child safety seat use laws ¹²⁷	9	Strong evidence	Strongly recommended
Child restraint loan schemes ¹²⁶	9	Good (Level 1)	Recommended
Child restraint and seat belt legislation ¹²⁶	9	Fair (Level II-1)	Recommended
Enforcement of child restraint legislation ¹²⁶	5	Fair (Level II-1)	Recommended
Community-wide information and enhanced enforcement campaigns ¹²⁷	4	Sufficient evidence	Recommended
Distribution and education programs ¹²⁷	10	Strong evidence	Strongly recommended

Intervention	Qualifying studies	Strength of evidence	Recommendation
Education-only programs ¹²⁷	3	Insufficient evidence	Insufficient evidence to determine effectiveness
Educational campaigns to increase child restraint and seat belt use ¹²⁶	16	Good (Level I)	Recommended (moderate short-term effectiveness)
Health promotion programs to increase child restraint use ¹²⁸	18	Good (Level I)	Recommended (moderate short-term effectiveness)
Incentive and education programs ¹²⁷	4	Sufficient evidence	Recommended
Interventions that promote rear seat use by children ¹³³	6	Fair (Level II-3)	Insufficient evidence to determine effectiveness
Traffic Calming			
Area-wide traffic calming ¹⁴⁴	16	Fair (Level II-1)	Insufficient evidence to determine effectiveness
Area-wide urban traffic calming ¹⁴³	33	Fair (Level II-1)	Recommended
Guardrails and crash cushions ¹⁴⁶	32	Fair (Level II-2)	Recommended
Traffic calming and engineering measures ¹²⁶	6	Fair (Level II-1)	Recommended
Other Interventions			
Daytime running lights (meta-analysis) ¹⁵¹	17	Good (Level I)	Strongly recommended
Post-license driver education programs ¹²⁵	24	Good (Level I)	Discouraged
Problem driver improvement programs (meta-analysis) ¹⁵²	35	Fair (Level II-3)	Recommended

Other Interventions

The following interventions have not been as extensively evaluated.

Daytime running lights

Use of daytime running lights has decreased multi-vehicle daytime crashes by up to 15%.¹⁵¹

Driver remediation

Results from a meta-analysis on driver remediation methods support interventions to improve driver performance.¹⁵²

Airbags

Since 1998, all new cars are required to have airbags for front seat occupants; some models also have side (and other) airbags and curtains. Airbags are supplemental restraint systems that inflate automatically when in-vehicle sensors detect crash forces. Airbags can seriously harm children riding in the front seat, particularly rear-facing infants and young children.

Transport Canada data demonstrate that airbags saved 313 lives and resulted in an economic savings of \$469 million between 1990 and 2000.¹⁵³ Airbags for front occupants of light duty vehicles

saved 55 lives annually.¹⁵⁴ Using airbags together with seat belts is effective in reducing injuries and deaths to adult passengers. Studies have demonstrated the protective effect of their combined use for the risk of cervical spine injuries [OR= 0.19, 95% CI 0.12-0.30] and facial injury risk, when compared with the use of seat belts alone or airbags alone (1: 449, 1:40 risk, and 1:148 risk, respectively).^{155,156} In the first study, a less potent injury reduction for seat belts alone was found yet merely using the airbag was not protective of cervical spine injuries. Other researchers have concluded that airbags do not offer added protection in addition to seat belt use in frontal crashes nor reduce risk in the absence of restraint.⁴¹

For children under ten years of age the risk of death is 34% higher for those seated in front of a passenger side airbag.¹⁵⁷ The risk of injury was 5.3 times higher for children exposed to passenger airbags, relative to an unexposed comparison group [OR=5.3, 95% CI 2.1-13.4].¹⁵⁸ Transport Canada recommends that all children 12 years of age and under be seated in the rear seat, preferably in the centre.⁶⁶ A recent study found that airbags offered protection for those 15-18 years of age. Those under 15 may be at increased risk of injury.¹⁵⁹

The Insurance Institute for Highway Safety conducted side impact tests on two vehicle types and followed this with tests of the same vehicle models that had side impact airbags. Vehicles with side airbags offered greater head-protection and resulted in lower injury measures during these crash tests.¹⁶⁰

However, side impact airbags can pose a risk to children in outboard seating positions, especially those who tend to lean against the side of the vehicle. Children are best protected in the back seat in the centre position, and if they must sit in an outboard position, they should be discouraged from leaning on the door to minimize injury risk.¹⁶¹

Anticipatory Guidance

It has been suggested that pediatricians and health care providers should counsel parents regarding child safety seat use and proper installation.^{46,75,85,94,99,162}

Research shows that interventions delivered in a clinical setting only result in modest improvements in long-term car seat use.¹⁶³

Media Campaigns

While media campaigns increase awareness, knowledge, and change attitudes, they have not been proven to change behaviour.²⁵ There may be benefits to combining media campaigns with other strategies (i.e., to publicize enforcement campaigns, to increase compliance, and to increase perceived risks).

License Renewal Policies

Driver's license renewal policies that mandated vision tests older drivers were found to lower fatal crash risk for this age group.

RECOMMENDATIONS

Methodology

A hierarchical method was used to evaluate the quality of the evidence, adapted from the Canadian Task Force on Clinical Preventive Health Care and the Community Guide.^{105,164} Many motor vehicle-related interventions have been rigorously assessed and can be strongly recommended; some interventions have weaker or conflicting findings.

Systematic reviews were the primary source used, as they provide a systematic evaluation of a large number of rigorous studies for each motor vehicle occupant injury intervention.

Recommendations

An alphabetical grading system indicates whether the level of research evidence for each intervention was determined to be good (A), fair (B) or poor (C). Similar systems have been used in other assessments of intervention effectiveness.¹⁵² This grade translates into a recommendation of *strongly recommended* (or discouraged), *recommended*, *recommended based on expert opinion*, or *insufficient evidence to recommend* (see Appendices A & B). Where interventions fell into more than one category the highest level of recommendation was used.

Strongly Recommended

Interventions that are *strongly recommended* are supported by the best type of evidence, and are effective methods to prevent motor vehicle occupant injuries.

Recommended

Interventions that are *recommended* are supported by evidence and may include less sophisticated research designs or less potent findings.

Recommended Based on Expert Opinion

These interventions are recommended by respected authorities or expert committees.

Insufficient Evidence to Determine Effectiveness

Interventions that had *insufficient evidence to determine effectiveness* warrant further research and cannot be recommended at present. These interventions included: lowering Canada's blood alcohol concentration law to .05 g/100ml, administrative per se laws for drunk driving recidivism, child restraint education programs, and programs promoting rear seat use by children.

Discouraged

Interventions that are *discouraged* lead to negative outcomes. The only interventions that were discouraged included: driver education, particularly for young drivers; and post-license driver education programs.

MOTOR VEHICLE OCCUPANT INJURY PREVENTION BEST PRACTICES

Strongly Recommended

Occupant restraint enforcement programs, primary enforcement laws, seat belt laws

.08g/100ml blood alcohol laws, minimum legal drinking age of 21 years,
use of sobriety checkpoints, ignition interlock systems

Child safety seat laws

Daytime running lights

Recommended

Random alcohol screening, server intervention training programs

Graduated licensing, lower BAC laws (zero tolerance)

Child restraint loan programs

Community-wide information and health promotion programs to increase
seat belt and child restraint use

Enforcement of child restraint legislation

Incentive programs

Traffic calming programs, guardrails and crash cushions

Problem driver improvement programs

IMPLICATIONS FOR MANITOBA

Opportunities for Improvement

Several initiatives that are strongly recommended or recommended already exist in Manitoba. These include .08 laws for impaired driving, use of sobriety checkpoints, child restraint laws, and graduated licensing. For the latter two, enhancement of current legislation could further reduce injuries. Legislative changes to improve motor vehicle occupant safety in Manitoba include amending the Highway Traffic Act to improve child passenger safety. (e.g., include mandatory booster seats). In addition, the Graduated Driver Licensing Program could be enhanced with stronger restrictions. In general, Manitoba should strive to comply with the National Occupant Restraint Program (NORP) guidelines.

Booster Seat Legislation

Manitoba child passenger safety laws should be enhanced to include booster seat legislation. Currently, Ontario and Quebec are the only Canadian provinces with booster seat legislation. Manitoba's College of Physicians and Surgeons' Child Health Standards Committee recommends that current Manitoba car seat and seat belt legislation should be strengthened to meet Transport Canada guidelines.

Enhancing the Graduated Driver Licensing Program

Graduated licensing programs have led to a reduction in the crash risk of young drivers.^{28,115} Since many GDL programs, including that in Manitoba, do not consist of all the recommended elements, they often have room for improvement. Manitoba's GDL program does not include a curfew, and teen passenger restrictions are limited.¹⁶⁵ Researchers have identified a need for improvement in the structure and enforcement of current GDL requirements.¹²¹ Several United States programs have been enhanced to more adequately effect injury reduction in young drivers (e.g., Florida, Georgia, Louisiana).¹¹⁵ Current research is investigating which components of GDL are most effective in preventing occupant injuries to young and new drivers.²³ So far, placing restrictions on night driving and carrying teen passengers have proven effective.¹⁶⁶ Table 4 shows areas in which Manitoba's GDL program meets, does not meet, or exceeds recommendations for graduated licensing programs.¹⁶⁷ GDL program evaluations conducted by the Insurance Institute for Highway Safety & Traffic Injury Research Foundation gave Manitoba's program a grade of 'Fair'. No Canadian GDL programs received a higher rating (scale: 'good', 'fair', 'marginal', 'poor'). Note: Table 4 does not include zero tolerance laws, which are a component of Manitoba's GDL program.

Table 4. Comparison of Graduated Licensing Program Recommendations

GDL Recommendations	Manitoba's Rating*	Manitoba Program Components
G1: Learner's Stage		
Consider the age distribution of the beginning driver population to decide whether to apply the program to all beginners or only young beginners	√	All beginners complete GDL requirements
Implement three-stage licensing systems	√	Required
Starting age of 16 years	X	15 years, 6 months if enrolled in driver's education
Require adult supervision and restrict driving at their discretion	X	No requirement
Require 30-50 hours of certified driving, some of which should be allocated to night time driving	X	No requirement
Establish a minimum 6 month learner phase	√	9 months

GDL Recommendations	Manitoba's Rating*	Manitoba Program Components
G2: Intermediate Stage		
Do not permit any unsupervised driving before 16 years, six months	X	Minimum age 16 years, 3 months
Restrict unsupervised night driving to newly licensed drivers	X	No ban on driving at certain times
No more than one (teen) passenger when unsupervised	–	Contingent on Time 1 passenger from 00:00-05:00 unless supervised then as many passengers as there are seat belts
Minimum completion age 18 years	X	17 years, 6 months
Exit test to ensure competence prior to full licensure	X	No requirement
General Issues		
Driver's Education not required; if used, integrate with GDL. No justification for time discounts.	X	Time discount for earlier entry into G1/GDL program
Penalty program delaying graduation for those with poor driving records	✓	Violators attend a hearing which could result in stage duration extensions, license suspension, greater restrictions or an added driving course

Removing Occupant Restraint Exemptions

The National Occupant Restraint Program has published recommendations for optimal passenger protection. Table 5 compares these to Manitoba's current legislation.¹⁶⁹ Manitobans could benefit from the removal of exemptions for seat belt and

child seat use.^{1,169} Currently in Manitoba, taxicabs, vehicles rented for less than 21 days, casual or occasional transportation of children, and children with medical certificates are not required to comply with child restraint legislation.⁶⁴ Use of seat belts is also subject to numerous exemptions in Manitoba, most of which are unfounded.⁶⁴

Table 5. NORP Recommendation and Manitoba Legislation

NORP Provisions	Manitoba's Highway Traffic Act
No person shall operate or permit the operation of a motor vehicle unless the driver and all passengers are properly restrained, in restraining devices of a kind prescribed in the regulations, and the devices are properly secure to the motor vehicle	<ul style="list-style-type: none"> Exemptions in effect
The driver is responsible for ensuring that all passengers under the age of 16 are restrained according to their size or development, either in a vehicle seat belt or child passenger restraint systems that meets the Canadian Motor Vehicle Safety Standards (CMVSS) and shall be called a child seat or booster seat.	<ul style="list-style-type: none"> Up to 18 years of age Booster seats not incorporated in the Act
No person shall operate or permit the operation of a motor vehicle unless all passengers classified as infants or under one year of age are carried in rear-facing child seats	<ul style="list-style-type: none"> More specific than MB law
No person shall operate or permit the operation of a motor vehicle while a rear-facing child restraint system is installed in the front seat and when the vehicle is equipped with an active airbag on the front passenger side	<ul style="list-style-type: none"> Not specified in MB law
No person shall operate or permit the operation of a motor vehicle unless passengers who are 37 kg (80 lb) and/or aged 8 and under are properly restrained in a device, as defined by regulations, appropriate for their size and according to manufacturer's instructions	<ul style="list-style-type: none"> Use of booster seats is not incorporated in the Act
No person shall operate or permit the operation of a motor vehicle unless passengers aged 12 and under are lap/shoulder properly restrained in the rear seat, unless all such available positions in the rear seat are in use by other passengers 12 and under	<ul style="list-style-type: none"> Not specified in MB law
The use of aftermarket add-on devices for seat belts or children's restraint systems for which standards have not been established by Transport Canada is prohibited	<ul style="list-style-type: none"> Not specified in MB law
Any person who violates any of the above provisions shall be assessed a monetary fine and driver's license demerit points	<ul style="list-style-type: none"> These penalties apply to current MB laws
The jurisdiction shall engage in: (i) public education and awareness activities to inform the public about proper occupant passenger protection, and (ii) enforcement campaigns to demonstrate strong commitment to vehicle occupant safety	<ul style="list-style-type: none"> Not specified in MB law
Exemptions should only be allowed where market availability of restraint systems does not match the anthropomorphic data at the 95 percentile or vehicle seat belt/seat height configuration is not compatible with commonly available products	<ul style="list-style-type: none"> Medical exemptions in MB

Enforcement

Enforcement of motor vehicle legislation is needed to increase restraint use, decrease impaired driving, reduce speeding, and deal effectively with traffic violators. This is consistent with efforts of Manitoba Public Insurance's Road Safety Division, which targets three areas for making Manitoba roads safer:

- Reduce impaired driving
- Increase occupant restraint use
- Reduce speeding

Traffic Calming

Traffic calming is an effective method of reducing motor vehicle occupant injuries. This strategy can be considered by municipal planning divisions and the provincial traffic services department.

APPLICATION OF FINDINGS

Recommendations for the prevention of motor vehicle occupant injuries are applicable to parents, parents, schools and daycares, public health, enforcement agencies and all levels of government and. Outlined below are suggested strategies for reducing deaths and injuries due to motor vehicles.

Parents

- Parents should ensure that their children always use an age-appropriate child restraint system or seat belt as recommended by Transport Canada.
- Parents should ensure that child passengers are seated in the rear seat whenever possible.
- Parents should ensure that all occupants are properly restrained (e.g., transporting friends of their children) and that their children are properly restrained when riding in others' vehicles.
- Parents should ensure that child restraints are installed properly to minimize injury risk.
- Parents should actively supervise their teens when they are learning to drive, encourage safe driving habits, and ensure compliance with GDL restrictions.

Physicians

- Physicians should provide parents with age-appropriate anticipatory guidance regarding child occupant restraints. They should also stress eliminating dangerous habits involving seat belt use (e.g., graduating too soon to the next stage of restraint, placing the shoulder belt under the arm or behind the back).
- Continuing Medical Education activities should review age-appropriate child restraint use and new developments in car seat safety (e.g., LATCH).
- Physicians should be encouraged to educate the public regarding occupant safety, through the media or other venues.

- Physicians should advocate for improved child protection in motor vehicles such as provincial legislation that is consistent with NORP guidelines.

Schools/Daycare Centres

- Schools and childcare providers should develop safe transport policies.
- Schools and childcare providers should promote correct age-appropriate child restraint use.
- Schools and childcare providers could educate parents on child motor vehicle safety through invited speakers and other educational initiatives.

Public Health Nurses/Home Visitors

- During home visits and other encounters with families public health nurses should provide anticipatory guidance on child passenger safety.
- Selected home visitors and health care providers should consider becoming certified child restraint technicians to provide support and continuing education for their region.
- Public health nurses should be encouraged to educate the public regarding occupant safety, through the media or other venues.

Regional Health Authorities (RHAs)

- RHAs should ensure that motor vehicle occupant injury prevention strategies are implemented and evaluated.
- RHAs should ensure that motor vehicle collision data are collected and monitored. This could include sentinel or periodic surveillance of emergency department visits.
- RHAs should work with community partners such as municipalities, RCMP, police, schools, childcare providers, and other organizations to build regional capacity for implementing motor vehicle occupant safety programs and strategies.

Law Enforcement Agencies

These include municipal police, RCMP, Manitoba Transportation and Government Services.

- Law enforcement agencies should ensure that current road safety legislation is adequately enforced. This will require ongoing funding of enhanced enforcement activities such as visible random roadside checks for occupant and child restraint use and alcohol use.
- Law enforcement agencies should collect data regarding violations of traffic safety laws such as occupant restraint, red light and speeding infractions and make this information available to the public.
- Law enforcement agencies should promote traffic safety in the community and advise the public on ways to improve road safety and the consequences of unsafe practices.

Manitoba Health

- Manitoba Health should consider the use of the National Ambulatory Care Reporting System (NACRS) in regional emergency departments to improve the data collection, analysis, and monitoring of motor vehicle injuries.
- Manitoba Health should encourage the development of standardized assessment tools and educational materials for motor vehicle occupant injury prevention strategies for use by the RHAs.
- Age-specific standardized checklists and parent information materials should be developed.

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APPENDIX A: EVALUATION CRITERIA

In developing grades of recommendation for each intervention, first the body of evidence was graded according to the level of evidence, which reflects study design (Table A). For levels of evidence, the Canadian Task Force on Preventive Health Care methods were used. These correspond to grades of recommendation (good, fair, conflicting, and insufficient). Then a summary grade of recommendation

was assigned, using the Community Guide methods (Table C), in order to provide a common framework for this series of Manitoba injury prevention best practices reports. This system provides a clear hierarchy of recommendations, and clearly indicates where expert opinion is considered to increase the strength of the recommendation.

Table A. Levels of Evidence and Grade of Recommendation

Grade	Level of Evidence	Criteria
Good	I	Evidence obtained from at least one properly randomized control trial
Fair	II-1	Evidence obtained from well-designed controlled trials without randomization
	II-2	Evidence obtained from one or more cohort or case-control analytic studies
	II-3	Evidence obtained from comparisons between times or places with or without an intervention. Dramatic results in uncontrolled experiments could be included
Poor	III	Opinions of respected authorities based on clinical experience, descriptive studies or reports of expert committees

Table B. Recommendations Grades for Specific Clinical Preventive Actions

A	There is good evidence to recommend the clinical preventive action.
B	There is fair evidence to recommend the clinical preventive action.
C	The existing evidence is conflicting and does not allow making a recommendation for or against use of the clinical preventive action, however other factors may influence decision-making.
D	There is fair evidence to recommend against the clinical preventive action.
E	There is good evidence to recommend against the clinical preventive action.
I	There is insufficient evidence (in quantity and/or quality) to make a recommendation, however other factors may influence decision-making.

Table C. Grades of Recommendation

Code	Evidence Level of Evidence	Canadian Task Force Recommendation	Strength of Evidence	Community Guide Recommendation
I	Good	Strongly recommended or Discouraged	Strong	Strongly recommended
II-1 II-2 II-3	Fair	Recommended or Recommended based on expert opinion	Sufficient	Recommended
III	Insufficient	Recommended based on expert opinion	Insufficient empirical information supplemented by expert opinion	Recommended based on expert opinion
			Available studies do not provide sufficient evidence to assess	Insufficient evidence to determine effectiveness
Any level		Insufficient evidence to determine effectiveness	Sufficient or strong evidence of ineffectiveness or harm	Discouraged

Adapted from 'Canadian Guide to Clinical Preventive Health Care' www.hc-sc.gc.ca/hppb/healthcare/pdf/clinical_preventive/methe.pdf and the Community Guide www.thecommunityguide.org/.

APPENDIX B: COMMUNITY GUIDE EVALUATION METHODS

Table 1. Assessing the strength of a body of evidence on effectiveness of population-based interventions in the Guide to Community Preventive Services (Excerpted from: Briss PA, Zaza S, Pappaioanou M. et al. Developing an Evidence-Based Guide to Community Preventive Services-Methods. *Am J Prev Med* 2000;18(15).

Evidence of Effectiveness ^a	Execution - Good or Fair ^b	Design Suitability - Greatest, Moderate or Least	Number of Studies	Consistent ^c	Effect Size ^a	Expert Opinion ^e
Strong	Good	Greatest	At least 2	Yes	Sufficient	Not used
	Good	Greatest or Moderate	At least 5	Yes	Sufficient	Not used
	Good or Fair	Greatest	At least 5	Yes	Sufficient	Not used
	Meet design, execution, number and consistency criteria for sufficient but not strong evidence				Large	Not used
Sufficient	Good	Greatest	1	Not applicable	Sufficient	Not used
	Good or Fair	Greatest or Moderate	At least 3	Yes	Sufficient	Not used
	Good or Fair	Greatest, Moderate or Least	At least 5	Yes	Sufficient	Not used
Expert opinion	Varies	Varies	Various	Varies	Sufficient	Supports a recommendation
Insufficient	A. Insufficient designs or execution		B. Too few studies	C. Inconsistent	D. Small	E. Not used

^a The categories are not mutually exclusive; a body of evidence meeting criteria for more than one of these should be categorized in the highest possible category.

^b Studies with limited execution are not used to assess effectiveness.

^c Generally consistent in direction and size.

^d Sufficient and large effect sizes are defined on a case-by-case basis and are based on Task Force opinion.

^e Expert opinion will not be routinely used in the Guide but can affect the classification of a body of evidence as shown.

^f Reasons for determination that evidence is insufficient will be described as follows. A. Insufficient designs or executions; B. Too few studies; C. Inconsistent; D. Effect size too small; E. Expert opinion not used. These categories are not mutually exclusive and one or more of these will occur when a body of evidence fails to meet a criteria for strong or sufficient evidence.

