Abstract
Canada has had progressive reductions in road traffic collisions (RTC) since the 1970s as a result of concerted efforts by both government and non-government organizations. However, RTCs remain a leading cause of unintentional injury and death for Canadian children, youth, and young adults. Given the preventable nature of RTCs, a shift in Canada’s present road safety paradigm is required. A review of effective interventions in preventing RTC fatalities and injuries is presented, along with public health’s recommendations for action moving forward.
INTRODUCTION

Preventing injuries and fatalities from road traffic collisions (RTCs) is one of public health’s achievements in the 20th century and continues to be one of its most strategic priorities. \(^1\) Despite declining rates of death and serious injuries from RTCs between 1970 and 2009, road traffic still contributes significantly to Canadian morbidity and mortality. \(^2\) RTCs remain a leading cause of unintentional injury and death for Canadian children, youth and young adults. For example, on Canada’s roads, one person dies every 4 hours, with the loss of one young life every 12 hours. \(^2\) Between 2009 and 2013, fatalities by road user class in Canada was as follows: 50.1% drivers, 18.1% passengers, 15.6% pedestrians, 10.3% motorcyclists, 3.2% bicyclists and others 2.7%. \(^3\) In 2013, the reported fatality rate in Canada was 6 per 100,000 licensed drivers and 3.5 per 100,000 population, with an injury rate of 622.1 per 100,000 licensed drivers. \(^3\)

Financial costs of road crashes and injuries include lost earnings, health care and rehabilitation expenses, and the costs of property damage, administration, police, legal, and insurance. Injuries that range from minor to severe include permanent disability (paraplegia, quadriplegia, brain injury), and chronic physical pain, and in addition, emotional trauma affects not only individuals but also their families and society. \(^4\) Globally, 15-44 year olds accounted for approximately 60% of all disability adjusted life years (DALYs) lost because of road traffic injury in 2002. \(^4\) A study in 1993 found that 90% of families of road traffic fatalities and 85% of disabled road traffic survivors reported a significant decline in their quality of life. \(^5\) Fatal collisions represented less than 1% of collisions reportable under Ontario’s Highway Traffic Act in 2004 but accounted for 64% of Canada’s total social costs. \(^6\) In 2010, RTCs were estimated to be equal to 2% of Canada’s Gross Domestic Product (GDP). \(^7\) The economic burden of transport-related injuries in 2012 was estimated at $3.7 billion, which represents 19% of the total economic burden of injury in Canada. \(^2\)

Developing a safe systems approach to road safety requires a shift in the present paradigm. \(^4,8\) Road safety is a multi-sectoral public health issue. It requires local knowledge and data to guide the implementation of local solutions. Traffic injury is an ethical issue, since many of those who are injured are not at fault, and they are largely preventable and predictable. Road systems should assist users in reducing driving errors and in modifying drivers’, pedestrians’ and cyclists’ behaviour to prevent deaths and injuries. Safety on the road is important, not just to prevent the consequences that occur, but also to give the public confidence that they can use active transportation as a safe way to travel. Given the increasing rates of obesity and physical inactivity in Canada, active transportation including walking and cycling must be supported and cannot be seen as dangerous. Alternative modes of transportation not only improve health but also reduce vehicular traffic use and air pollution. However, it must be safe and be seen as safe.

EPIDEMIOLOGY

In Ontario in 2012, there were 568 deaths related to RTCs. \(^9\) The fatality rate was 6.0 per 100,000 licensed drivers during that year in Ontario. \(^9\) The injury rate from RTCs, although higher at 64.3 per 10,000 licensed drivers, was the lowest ever recorded in Ontario. \(^9\) There has been progress, but until highways are completely safe, action on this issue must continue. This
number of deaths and injuries in the airline industry would not be tolerated, or from a communicable disease. Why is it tolerated on the roads?

The number of people killed involving an inattentive driver increased from 2011 to 2012 in Ontario and represented 14.8% of all motor vehicle fatalities in 2012 in the province.\(^9\) Although the number of licensed senior drivers over 80 years old has increased four-fold over the 20 years up to 2012, and although the common wisdom is that the elderly pose a danger on the roads, the number of fatalities among senior drivers in this age group decreased from 2011 to 2012.\(^9\) Despite a graduated driver licensing system in Ontario for novice drivers that has resulted in a decrease in the average fatality rate for young drivers 16 to 19 years of age,\(^9\) the largest percentage of passenger fatalities and serious injuries was in 15 to 19 year olds, followed by 20 to 24 year olds in Canada.\(^3\) Although Ontario has a rate of usage of seatbelts of 96%, approximately one quarter of vehicle occupants killed in Ontario’s roads were unbelted.\(^9\) The number of motorcycle rider, pedestrian and bicycling fatalities increased in 2012 from 2011 by 44.7%, 15.3% and 23.8% respectively.\(^9\)

Across all levels of severity in collisions (fatality, minimal-minor-major injury), the average full average social cost of a collision in Ontario in 2004 was $77,000.\(^6\) Ontario Trauma Registry 2009 reported that RTCs accounted for 35% of in-hospital deaths for 2008 to 2009, and of these injuries and deaths, almost 30% were pedestrians.\(^10\)

BACKGROUND

In Canada, responsibility for road safety is shared between different levels of federal, provincial and territorial, and municipal governments, and other road safety and private sector partners.\(^7\) Federally, the government is responsible for regulations and standards related to the manufacture and importation of motor vehicles, tyres and child restraints. Provincial and territorial governments are responsible for licensing drivers, registering vehicles and administering justice and jurisdictional road safety programmes, including road policies and regulations. Municipal governments are responsible for operations of the road.

Canada’s 2010 Road Safety Strategy set a national target of a 30% decrease in the average number of road users killed and seriously injured during the 2008-2010 period over comparable 1996-2001 baseline numbers, addressing the specific areas of occupant restraints, impaired driving, commercial vehicle safety, vulnerable road users, speed, intersection safety, rural roads, young drivers and high-risk drivers.\(^11\) This goal was largely achieved. The largest reductions in fatalities occurred on rural roads, followed by crashes involving unrestrained occupants and those involved in intersection crashes.\(^7\) Notable progress was achieved for seriously injured unrestrained motor vehicle occupants, those involved in rural road crashes and young drivers. However, the number of fatally and seriously injured vulnerable road users and drinking drivers experienced the least progress among this national target.\(^7\)

Most provinces and territories presently use key elements of Canada’s 2015 Road Safety Strategy as a guideline in developing their own road safety plans, while still supporting a national strategy. The vision of this national strategy is that “Canada will have the safest roads in the world”, with no set numerical targets.\(^11\) Primary focus is to address the factors of users’ of the roads that contribute to preventable deaths and injuries in the areas of impaired driving
(alcohol, drugs, fatigue, distraction), speed and aggressive driving, occupants’ protection (restraint use, safer roads, vehicle technology enhancements) and environmental factors (roadway construction and configuration, road surface condition, road and roadside design [lighting, signage], urban and rural infrastructure). Some identified key target groups include young drivers under 25 years old, and vulnerable road users (pedestrians, motorcyclists, disabled, elderly).

Four identified strategic objectives include: raising public awareness and commitment to road safety, improving communication about safety on the roads, co-operation and collaboration among all stakeholders, and enhancing enforcement and improving road safety information through the support of research and evaluation.11

PREVENTION OF TRAFFIC-RELATED FATALITIES AND INJURIES

Although the rates of road traffic injury and death have declined in Canada2 and Ontario12 over the past four decades, they are still considerably higher especially compared to other preventable causes of mortality and morbidity. Continued efforts to prevent collisions are essential. A safe systems framework to road safety addresses risk factors and integrates interventions related to road users, vehicles and the environment.4,8 Strategies can be categorized for each of the inter-related vertices of road safety into the following: education and training, enforcement (policy, legislation, and regulation), engineering technologies, empowerment of road users (awareness, information), physical environment (road infrastructure) and social environment (partnerships within, and between government and non-governmental organizations).

Effectiveness of Interventions and Strategies

The literature was searched to identify effective public health interventions and policies that reduce injuries and deaths associated with the use of streets, roads and highways by pedestrians, cyclists, public transit users, and users of private motor vehicles. Owing to the volume of literature and diversity of interventions and programs, systematic or literature reviews were used to synthesize evidence for the primary outcomes of interest which were broadly classified into five categories:

1. legislation and enforcement,
2. safety education programs
3. road and transportation infrastructure
4. vehicle design
5. distracted or inattentive driving.

Legislation

Seat belt and child safety laws

The evidence for safety seat belt and child safety (child restraint and booster seats appropriate for child’s age and weight) laws is unequivocal. A mandatory seat belt law was introduced in Ontario in 1976 and by 1991, seat belt legislation was enacted in all Canadian jurisdictions.2 In
2011, 96% of surveyed Canadians reported wearing seat belts. However, approximately 25% of killed car occupants in Canada were unrestrained at the time of their MVC. Clearly, better enforcement of this life-saving measure is required.

Safety seat belt laws showed a median decrease of 9% (range 2.0% - 18%) in fatal crash injuries and a median decrease of 8.0% (range 3.0% - 20%) in overall crash injuries, both fatal and not fatal). One systematic review that evaluated the effectiveness of child safety seat laws showed a median decrease of 35% (range 25.0% - 57.3%) in fatal crash injuries and a median decrease of 17.3% (range 10.5% - 35.9%) in overall crash injuries (fatal and non-fatal). Laws requiring the use of seat belts clearly continue to be needed and enforced.

Speed Limits and Enforcement

The probability that a crash will result in injury is proportional to the square of the speed. For fatalities, this probability is proportional to the fourth power of the speed and for serious injuries, this is proportional to the cube of the speed. The probability of a pedestrian’s dying as a result of a car crash increases exponentially as the speed of the car increases. For example, pedestrians have a 90% chance of surviving when cars strike them at speeds lower than 30 km per hour (km/h), but less than a 50% chance of surviving impacts at 45 km/h. One review showed a reduction of 53% and 42% in the frequency of a fatal or serious injury, and in the frequency of injury accidents, respectively with reduced speed limit zones (30 km/h). Key measures for managing speed include setting speed limits to 30 to 40 km/h in residential and high pedestrian traffic areas, enforcing speed limits and implementing traffic-calming measures. Additional measures are needed to reduce speed, and the culture of speed, if deaths and injuries are to be reduced further.

Safety Cameras

As of May 2015, Bill 99 was introduced in the Ontario legislature requiring safety cameras to be installed in highway construction zones. Two systematic reviews looked at the effectiveness of speed enforcement detection devices, such safety cameras, for injuries related to MVCs. One paper showed a reduction of 17% to 58% in fatal or serious injuries and a reduction of 17% to 23% in crashes causing injury, associated with the use of these devices. The other systematic review showed a reduction of 12% to 65% for injuries (fatal and not fatal) and 17% to 71% reduction for crash related mortality in the immediate vicinity of speed camera. It appears that there continues to be a role for monitoring speed and poor driving with technology, and that the removal of photo radar in Ontario in the late 1900s was a huge error. Many lives would have been saved over the last 20 years, had this policy not been rescinded by the government of that time.

Red light cameras have similarly shown a benefit in prevention of road traffic accidents resulting in a reduction of 29% (adjusted relative risk (RR) = 0.71, 95% CI 0.55-0.93) in total casualty crashes.

Speed not only increases the risk and consequences of RTCs but also was a contributing factor for cars in 30% of cyclist deaths in Ontario between 2006 and 2010. A review of Ontario’s pedestrian traffic fatalities between 2004 and 2008 similarly found that speed is a risk factor.
Sixty-seven percent of these deaths occurred on roads with posted speeds above 50 km/h. In contrast, only 5% of traffic deaths of pedestrians occurred on roads with speed limits below 50 km/h.

**Helmet Use**

Cyclists are 8 times more likely to suffer a fatal injury per km of road travelled as compared to occupants of a motor vehicle.\(^{21}\) Wearing a helmet while riding bicycles or motorcycles is the single most effective strategy for children in reducing the risk of injury to the head.\(^{23}\) For cyclists of all ages, the appropriate use of a helmet reduces the risk of head injury by 69%. The appropriate use of a helmet reduces the risk of death by 40% and the risk of serious head injury by more than 70% for motorcyclists of all ages.\(^{23}\) Two systematic reviews evaluated the effectiveness of bicycle helmet legislation and use of helmets for preventing head and facial injuries in bicyclists. After enactment of legislation requiring the use of helmets, mortality for individuals aged 16 years and under was reduced by 52%, with a 45% reduction in head injuries.\(^{24}\) A second review found a reduction of 65% in upper and mid facial injuries, and a 68% reduction for head injury with a summary odds ratio (OR) of 0.31 with the use of a bicycle helmet (95% CI, 0.26-0.37).\(^{25}\) Helmet use in motorcycle riders reduced the risk of death by 42% (OR = 0.58, 95% CI 0.50-0.68) and the risk of head injury by 69% (OR = 0.31, 95% CI 0.25-0.38).\(^{26}\) (An odds ratio less than one means that the use of a helmet is associated with lower likelihood of an injury occurring and is thus protective against injury).

A review of cycling deaths in Ontario between 2006 and 2010 found that individuals who had suffered a head injury were 3x less likely to be wearing a helmet.\(^{21}\) Despite legislation mandating the use of bicycle helmets for person less than 18 years old in Ontario, the rate of helmet use for this age group was only 6.25% and only 26% for all fatalities, regardless of age.\(^{21}\) Expansion and greater enforcement of this protective measure will save more lives, and is in the social interest, since, although the unmeasurable costs are borne by the injured person, the costs of medical care and rehabilitation are borne by everyone.

**Setting and Enforcement of Alcohol Limits**

Alcohol consumption increases the probability of a road traffic injury or death for pedestrians and drivers. In 2010, 38.4% of fatally injured drivers in Canada had some level of alcohol in their blood and of these, 31.9% had blood alcohol concentration (BAC) greater than the legal 80 mg% threshold limit.\(^{7}\) Amendments to Canada’s Criminal Code in 1985 resulted in tougher penalties for impaired drivers.\(^{2}\) Maximum sentences in Canada for alcohol- and drug-impaired driving were increased in 2008.\(^{2}\) As of February 2015, Ontario Bill 31 was in its second reading.\(^{27}\) This proposed legislation increases further the penalties associated with impaired driving. Evidence for the effectiveness of increased police patrols for preventing alcohol-impaired driving is inconclusive.\(^{28}\) However, evidence has illustrated that the perceived risk of being caught is considerably more effective than the severity of the penalty in discouraging driving while under the influence of alcohol.\(^{4}\) Most effective in deterring drinking while driving is swift and specific punishment, such as disqualification from driving after failing a breath test.\(^{5}\) The effects of medicinal and recreational drug use on driving performance and crash involvement are much less well understood or researched.
Blood Alcohol Concentration Limits

The risk of a road traffic crash begins to rise significantly when blood alcohol concentration (BAC) is greater than 0.04 g/dl.4 Laws mandating a maximum blood alcohol concentration of 0.08 g/100 ml for drivers 21 years or over resulted in a decrease of 7% (interquartile range 4% - 15%) in alcohol-related motor vehicle fatalities.28 ‘Zero tolerance laws’ with lower blood alcohol concentration (BAC) limits for younger and inexperienced drivers (18-20 years old) have demonstrated a reduction of 9% to 24% and 3.8% to 17% respectively in fatal crashes and in injury crashes (fatal and not fatal).29 A second systematic review also reported a reduction in injury crashes (fatal and not fatal) of 11% to 33%.30 There is no evidence at this time to support the lowering the BAC limit in Canada to 0.05 g/dl in preventing road traffic injuries and fatalities, although this intervention may need to be studies further.31

Minimum Legal Drinking Age

The effectiveness of legislation mandating a minimum legal drinking age (MLDA) has been reviewed. One systematic review reported a median decrease of 17% (range 7% - 30%) in fatal injury crashes and a median decrease of 15% (range: 6% to 33%) in injury crashes (fatal and not fatal) after raising of the MLDA from 18 to 21 years.29 A statistically significant inverse relationship between MLDA and injury crashes (fatal and not fatal) was demonstrated amongst 51% of included studies in a second systematic review.30

Alcohol and drug impairment not only affects motor vehicle drivers but also vulnerable road users. In Ontario, 23% of cycling fatalities were found to be under the influence of alcohol or drugs at the time of the incident.21 Limited data from a review of Canadian pedestrian fatalities over a five year period beginning in 2004, found positive toxicology for drugs, alcohol or both in 28% of the pedestrians. While 2% of pedestrians struck by a motor vehicle will die, the

Random and Select Breath Testing

Two systematic reviews have evaluated the effectiveness of random breath testing (RBT) checkpoints. One study reported a median decrease of 22% (range 13% - 36%) in fatal injury crashes and 16% decrease (range 11% - 20%) in injury crashes (fatal and not fatal).29 A similar decrease of 16.2% to 29% and 10% to 28% in fatal injury crashes and in injury crashes (fatal and not fatal) respectively was found in a second review.32 Widespread random breath testing applied to at least one in ten drivers every year achieves the highest compliance with laws setting BAC limits.4 Random breath and selective breath testing through sobriety check points enforces drinking and driving laws. There was a median decrease of 23% (range 20% - 26%) in fatal injury crashes and a median decrease of 20% (range 5% - 23%) in injury crashes (fatal and not fatal) as a result of selective breath testing checkpoints.29 This intervention works, but it needs to be done consistently, and not predictably to be effective.

Graduated Driver Licensing (GDL) Programs

Research evidence shows that GDL programs reduce fatal crashes by 36% (range 15% - 57%) and injury crashes (fatal and not fatal) by 14% (range 4% - 23%) in young teenager drivers at one year post completion of a GDL program.33 The effectiveness of GDL extends beyond the
first year, with reductions in fatalities of 18% (range 1% - 110%) and 20% (range 7% - 36%) in injury crashes (fatal and not fatal).34

Canadian Motor Vehicle Traffic Collision Statistics from 2011 showed that the largest percentage of passenger fatalities and serious injuries was in 15-19 year old persons, followed by 20-24 year olds.3 Although 15 to 24 year olds make up only 13% of the Canadian population, nearly 23% of Canada’s motor vehicle fatalities occurred in this age group in 2010.7 A graduated driver licensing (GDL) system for novice drivers between the ages of 16 to 19 was introduced in 1994 in Ontario.9 Based on five years of data from 2008 to 2012, Ontario experienced a 71 per cent decrease in the average fatality rate for young drivers in this age group, compared to the five years prior to the introduction of the GDL program.9 It was found in a review of Ontario cycling deaths involving a motor vehicle that the driver was less than 20 years of age in approximately 20% of these fatalities, further supporting the argument for GDL programs.21

Safety Education Programs

Problem drinking counselling in the clinical setting designed to reduce alcohol consumption and to prevent motor-vehicle related crash injuries resulted in a reduction of 27% to 65% in injury crashes (fatal and not fatal).35 Educational training of alcohol servers was shown to reduce injury crashes (fatal and not fatal) by 15% injury crashes, but had no effect in reducing fatalities.36

Multi-component, integrated and collaborative community-specific approaches to targeted education, and public safety interventions, such as traffic-calming measures, combined with enforcement and legislation are effective. For example, pedestrian injuries in children aged 0 to 14 years were reduced by a median of 45% (range 12% - 54%) as a result of a multi-component community based program.37

Evidence is inconclusive for the effectiveness of the following education programs alone in preventing road traffic fatalities and injuries: pedestrian safety education, motorcycle rider training and designated driving.38,39 As well, there is no evidence for the effectiveness of post-license driver education and school-based driver education programs in preventing deaths and injuries from MVCs.40,41 However, public education combined with enforcement increases compliance with laws.4

Road and Transportation Infrastructure

Marked Bicycle Lanes

During 2009 to 2013, 3.2% of Canadian fatalities involved bicyclists.3 Bill 31, which is currently in second reading in the Ontario legislature, proposes that “drivers of motor vehicles will have to maintain a distance of at least one metre when overtaking a bicycle.”27 This law also proposes for the “designation of a bicycle lane on one-way streets that goes in the opposite direction.” It is also stipulated that “bicycles should be permitted to be ridden or operated on the paved shoulder of a highway that is divided into two separate roadways.” Transportation infrastructure modifications, such as on-road marked bicycle lanes, compared to unmodified
roadways, have a positive safety effect resulting in an estimated reduction of 50% in cyclist injury rate. The most serious bicycle injuries are associated with motor vehicle involvement, one-ways streets and unlit roads at night. This legislation should be supported.

Street Lighting

Environmental infrastructure initiatives that have been evaluated for their effectiveness in preventing road traffic injuries include street lighting. A systematic review found that street lighting showed a 22% reduction (RR = 0.78, 95% CI 0.63-0.97) in injury crashes (fatal and not fatal), as compared to no street lighting. When compared with a day-time control, street lighting showed a 66% reduction (RR = 0.34, 95% CI 0.17-0.68) in RTC fatalities and a 32% reduction (RR = 0.68, 95% CI 0.61-0.77) in RTC injuries.

Area-wide traffic calming measures

A systematic review looked at the effectiveness of various area-wide calming measures (road humps, speed cushions, raised crosswalks, road surface treatment, audible measures, permanent or temporary blocking of road, creation of one-way streets, reduced speed limit zones) for preventing traffic accident related injuries. It showed a reduction of 15% (pooled RR = 0.85, 95% CI 0.75 -0.96) in road traffic injuries (fatal and not fatal) and a 21% reduction (pooled RR = 0.79, 95% CI 0.23-2.6) in road traffic deaths.

Roundabouts

The Canadian Public Health Association has stated that "Changing intersections with stop signs or traffic signals to roundabouts can reduce the number of intersection crashes by 40%, and fatal and injury-related crashes by 80%". This is supported by the results of two systematic reviews. The first paper showed that roundabouts are associated with a reduction of 50% to 70% for fatalities, and 30% to 50% for injuries, associated with traffic accidents. A second study reported that “single-lane roundabouts have been shown to be particularly effective, leading to reductions in collisions and personal-injury collisions in the order of 61% and 77% respectively when they replace stop signs, and of 35% and 74% respectively when they replace traffic lights”.

Community Design

A review of pedestrian traffic fatalities in Canada between 2004 and 2008 found that 76% occurred on urban roads and 75% occurred on wide arterial roads with high traffic volumes. A systematic review showed that reducing the need to drive, by providing alternative modes of non-vehicular transportation (public transit, walking, cycling), and reducing travelling distances with the design of complete streets, and compact communities, has the potential to reduce RTCs. Another review showed an association between reducing traffic volume through community design, and deaths and injuries from RTC’s.

Road User Visibility
Approximately 57% of pedestrian traffic fatalities in Canada between 2004 and 2008 occurred at night or during dimly lit conditions, suggesting that increasing the visibility of vulnerable road users might prevent road traffic casualties.\textsuperscript{10} Evidence is inconclusive for the effectiveness of interventions aimed at increasing pedestrian and cyclist visibility in preventing road traffic accident related fatalities and injuries.\textsuperscript{50}

**Vehicle Design**

Many of the gains in lives saved that have occurred over the last decades have been owing to the ever-improving design of cars from a safety point of view. From a host, agent and environment perspective, the most gains have been made by making the agent less dangerous, and except for the advent of driverless cars, most of the gains possible may have been realised already. Some of these gains are outlined below.

**Airbags**

The combined use of an airbag with seat belt has a protective effect for the risk of cervical spine and facial injuries (OR = 0.19, 95% CI 0.12-0.30) in adults.\textsuperscript{51} It was also reported in this review that motor vehicles with side air bags offered better protection in terms of lower head injuries.

**Daytime Running Lights (DRL)**

The use of DRL in vehicles has been required for all vehicles made or imported since January 1, 1990 in Canada as an intervention for preventing road traffic collisions.\textsuperscript{2} One systematic review demonstrated that the use of DRL on cars was indeed associated with a 10% to 15% reduction in day time accidents.\textsuperscript{50} However, the study did not report on the evidence for its effectiveness in preventing MVC fatalities and injuries.

**Alcohol Ignition Interlock**

An alcohol-ignition interlock system is a technological device designed to modify driver behaviour for high risk road drivers with a recalcitrant history of driving while impaired offenses.\textsuperscript{4} Detection of alcohol on the breath of a driver results in the ignition’s being locked to prevent use of the vehicle. A relative reduction of 64% (RR = 0.36, 95% CI 0.21-0.63) in recidivism rates of drinking and driving was reported with use of alcohol ignition interlock programs.\textsuperscript{52} However, this systematic review did not evaluate the impact of this engineering intervention on vehicular-related deaths and injuries.

**Other Engineering Technology**

Reviews evaluating public policy or interventions aimed at regulating the trend by manufacturers of introducing increasingly more entertainment distractions and devices in vehicles were not found.

**Distracted and Inattentive Driving**
Research studies have confirmed that distracted driving is a risk factor for RTC's because of the multiple consequences associated with the use of hand-held devices on driving.\textsuperscript{53-55} It increases reaction time by 0.5 to 1.5 seconds, makes it more difficult to drive properly, to maintain appropriate speeds, to respond, and also impairs judgement.\textsuperscript{4} Drivers of non-commercial vehicles with hand-held devices were 2.8 times more likely as undistracted drivers to have a crash.\textsuperscript{55} Research has found that young drivers who text have a six fold greater odds of a collision, since they spend more time with their eyes off the road than those drivers who don’t text.\textsuperscript{56} Even drivers with hands-free phones are less attentive to surrounding traffic and have slower reaction times than those without use of these mobile devices. A meta-analysis showed no differences in the risk of impaired reaction time between hands-held and hands-free phones.\textsuperscript{57}

The number of traffic fatalities in Ontario involving an inattentive driver increased approximately 16.7% from 2011 to 2012.\textsuperscript{9} Distracted driving accounted for approximately 14.8% of all Ontario traffic-related fatalities in 2012.\textsuperscript{9} Driver inattention was a contributing factor in 28% of cyclist deaths in Ontario.\textsuperscript{21} It is postulated that road user distraction with mobile device use may negatively affect their own safety. For example, 15% of bicyclists involved in Ontario traffic fatalities over a five year period were distracted with a music player or cell phone at the time of the accident.\textsuperscript{21} In addition, approximately 20% of pedestrian fatalities in Canada may have involved some form of distraction, including the use of a cell phone or MP3 player.\textsuperscript{16}

**Legislation**

As of 2010, the use of a hand-held cell phone while operating a motorized vehicle was banned in most Canadian provincial jurisdictions.\textsuperscript{2,7} Presently, it is illegal for drivers in Ontario to talk, text, type, dial or email using hand-held cell phones, and other hand-held communications and entertainment devices.\textsuperscript{9} This legislation, however, has not consistently been strictly enforced. Legislation does not currently exist in any Canadian jurisdiction prohibiting drivers from using hands-free cellular devices.\textsuperscript{7}

Research evaluating the impact of distracted driving on the incidence of traffic-related morbidity and mortality, and whether legislation impacts driver distraction is presently lacking. This situation most likely reflects the relatively recent implementation of such regulations.

There has been some action on this issue by the government of Ontario, with new, increased penalties enacted as recently as 2015.06.02. Even these increased measures, however, may not be enough, as enforcement and conviction are problematic, and the message that this behaviour is unacceptable on the road may not yet be strong enough.

**Engineering Technology**

Quebec is launching a Smart-phone application which will allow the driver to block phone calls and text messages when the vehicle is in motion.\textsuperscript{7}

**Education**
One focus of Canada’s 2015 Road Safety Strategy for road users is on impaired driving that includes distraction.\textsuperscript{11} “Leave the Phone Alone” is a road safety awareness campaign encouraging compliance with legislation banning the use of hand devices while driving.\textsuperscript{7}

**SUMMARY**

Canada has had progressive reductions in road traffic collisions (RTC), and road traffic fatalities and injuries since the 1970s as a result of concerted efforts by both government and non-government organizations. Between 2000 and 2011, there was a 30% reduction in Canadian fatalities from the road. However, one person still dies every 4 hours on Canadian roads, with the loss of one young life every 12 hours. In 2012, there were 568 deaths in Ontario alone from RTCs. In 2010 alone, the costs of road collisions represented 2% of Canada’s GDP which would be considered unacceptable for a communicable disease.

Canada’s 2015 Road Safety Strategy aims “to make Canada’s roads the safest in the world.” To achieve this goal, there needs to be a shift in our present road safety paradigm, with a particular focus on changing the attitudes of drivers. Unfortunately, some people are not as attentive as they should be on the road, while others are willing to take risks that put themselves and others at risk. As long as these attitudes continue to exist, even greater regulation may have limited effect, as enforcement of aggressive or distracted driving is expensive without the use of technology and police or other enforcement agencies have other priorities.

It must be recognized that traffic collisions are largely preventable. The development of a safe systems framework to road safety involving vehicles, users, and the environment (physical, social) is paramount. Systematic reviews for the effectiveness of public health interventions and policies were identified from the literature for the following areas: 1. Legislation and enforcement, 2. Safety education programs, 3. Road and transportation infrastructure, 4. Vehicle design and 5. Distracted or inattentive driving.

Legislation and enforcement have demonstrated unequivocal reductions in road crash fatalities and, injuries, or both for
1. Seat belt and child safety laws
2. Speed limits and enforcement
3. Safety cameras
4. Helmet use
5. Setting and enforcement of alcohol limits
6. Minimum legal drinking age
7. Random and select breath testing
8. Graduated driver licensing programs

Safety education programs were effective only for problem drinking counselling and for educational training of alcohol servers. Multi-component community interventions that combine strategies such as education and training programs, legislation and traffic calming measures in preventing road traffic accident related injuries and fatalities were effective. Educational alone did not seem to have an impact on reducing morbidity and mortality associated with RTCs.
Specific road and transportation infrastructure initiatives were also found to be effective in preventing traffic-related deaths and injuries. These include marked bicycle lanes, street lighting, area-wide traffic calming measures such as roundabouts and community design.

Vehicle designs including airbags, daytime running lights and the alcohol ignition interlock were effective in reducing traffic-related injuries, road traffic collisions and rates of recidivism respectively.

With the increasing use of hand-held devices, distracted driving too has become a risk factor for RTCs, and traffic fatalities and injuries for drivers, cyclists and pedestrians. Traffic fatalities in Ontario involving an inattentive driver accounted for approximately 15% of all road deaths. Unequivocal research evidence confirms that distracted driving reduces one’s judgement, response time and ability to drive, cycle and walk appropriately. The use of hands-free devices while driving also appears possibly to have a negative impact on reaction times and attention. Although there is legislation in Ontario prohibiting the use of hand-held devices while driving, this legislation is not consistently enforced. As well, there is no legislation across Canada banning the use of hands-free devices while driving. An educational awareness campaign, “Leave the Phone Alone”, is encouraging drivers to be compliant with distracted driving regulation. There is a phone application that will allow the driver to block phone calls and text messages in a moving vehicle. However, research is currently lacking in the area of distracted driving to determine the effectiveness of legislation, education and technology to address this emerging trend.

Road safety is a public health issue. Collisions, especially those causing death or disability, need not happen, if drivers take their responsibility while driving as seriously as they take the health and safety of their own families. In public health, we have learned that to make gains in health, there sometimes is a need for a change in culture. We learned in the area of tobacco that better health is not possible until attitudes in the community change. Before 1985, people smoked everywhere: in offices, in restaurants, even on aeroplanes. Today, this situation seems foreign to us, because the community reduced its tolerance for second hand smoke because of the harm that it causes. To make gains in reducing deaths on the road, there needs to be the same kind of cultural shift. Right now, deaths on the roads are accepted as normal—it’s part of the price that society pays for driving. Future generations will think that this is madness, in the same way that many people today think that it was madness to allow smoking in enclosed public places. People have to change the way that they think about driving—that the risky things that people do—speeding, tailgating, or any form of aggressive or distracted driving, are not okay. People have to understand that, when behind the wheel of a car, drivers have a responsibility, not only to our own families to stay alive, but to every other person on the road. The most dangerous thing that most of us do is to get behind the wheel of a car. The statistics prove that what kills young people and contributes the most to years of life lost in our society, is driving. Every year in Canada, over 2000 people, or 7 every day on average are killed in collisions involving motor vehicles and thousands more are injured, some suffering permanent disability. But people don’t think of driving as particularly dangerous, and too many people have a cavalier attitude to it. Society seems to be inured to the fact that the vehicles that people drive are capable of significant harm to others, whether they be other drivers, cyclists, or pedestrians.
The shift in thinking must be that everyone who gets behind the wheel of a car, should have no other priority except to get to her or his destination without harming one’s self or others.

The cost of injuries from collisions is huge in Canada—costing hundreds of millions of dollars a year, for hospital care and rehabilitation, that could be spent on other important health issues. But the personal costs and heartbreak of losing a loved one or the life-changing injuries that families suffer, cannot be measured. The carnage on the roads will not disappear until drivers’ attitudes change, and every driver behaves as though they hold the safety and well-being of others as their most important priority.

RECOMMENDATIONS

1. Education
   a. Support ways to change road users’ attitudes and behaviours with regards to traffic safety, including:
      i. targeted public educational awareness programs that highlight the impact of impaired driving (alcohol, drugs, distracted, fatigue) on road safety (government of Ontario (GO))
      ii. messages to the public that re-enforce that a driving license is privilege, rather than a right, that can be revoked if for chronic distracted or aggressive driving (GO)

2. Enhanced enforcement of legislation:
   a. Stringent and consistent enforcement of current regulations that enhances safety for all road users, including drivers, cyclists and pedestrians (Police)
   b. Increase the number of RIDE programmes across the province, at variable times and locations, to increase the public’s sense that the risk of being stopped in a RIDE programme is high (Police)
   c. Support for Bill 31 to increase penalties for impaired driving (GO)
   d. With regards to Ontario’s new regulations for distracted driving, review the effect of new penalties, and consider suspension of driving licences on a graduated basis, with a lifetime suspension after a third conviction (GO)
   e. Advocate for the widespread re-institution of photo radar, both on highways, and in residential areas, as an effective and cost-effective method of reducing speed (GO)
   f. Reduce vehicle speed limits on residential and high volume traffic roads and roadways to 30-40 km/h (GO & municipalities (M))
   g. Support helmet use for motorcyclists, cyclists and recreational off-road vehicle users regardless of age (GO), and enforce legislation in Ontario for helmet use in those less than 18 years of age (Police)
   h. Increased enforcement of the use of seat belts (Police)

3. Support continued surveillance and research on traffic road safety in areas such as:
   a. Whether re-testing for driving licenses improves the attitudes and behaviours of drivers (Researchers in public health (RPH))
   b. The effectiveness of interventions to eliminate distracted driving, where research evidence is lacking (RPH)
c. Evaluation of whether raising the age at which driving licenses may be earned decreases risky driving (RPH)
d. Research into strategies and technologies that will decrease the impact of driving while impaired by drugs other than alcohol (RPH)
e. More definitive research on the factors that cause roads in rural areas to be riskier (RPH)
f. Research into whether creating roads that are, and are perceived to be, safer increases the use of active transportation (RPH)

4. Develop changes in the road system to increase safety, to increase the feasibility of active transportation, or both, in all new and reconstructed roads, such as:
   a. Implementing roundabouts for any newly proposed roadways as part of the transportation infrastructure (GO & M)
   b. Installing traffic calming measures on all residential streets, to re-enforce and to effect lower speed limits (M)
   c. Ensuring physical separation of pedestrians, cyclists and motorised vehicles to the extent possible (M)
   d. Better lighting of streets at night, to improve safety on the roads (note that this measure has the added benefit of making neighbourhoods safer as well) (M)

These recommendations have a number of different targets, indicated in brackets after each one is listed. The strategies are primarily for advocacy to the listed organisation, but will need to be embellished before advocacy is undertaken.

CONCLUSION

Over the past four decades, there have been significant improvements in Canadian road traffic safety as a result of governmental policy and legislation, and the efforts of public health and other multi-sectoral community partners. However, road traffic collisions continue to occur, affecting individuals, families and society. Given the preventable nature of these fatalities and injuries, a shift in Canada’s present road safety paradigm is required. It is imperative for Ontarians to recognize and to acknowledge that the we must all contribute to road safety and that one death or injury is still one too many. The recommendations listed here are multi-faceted, feasible and based on evidence. Some, such as changes in legislation, may be less expensive than others, although enforcement can have significant costs attached to them. One mechanism of funding some of these measures would be to use the proceeds of fines to support interventions, such as education and RIDE programmes. For the research projects and changes to the infrastructure, advocacy to invest in safety will be required.

Using the triad of host, agent and environment, changes to reduce deaths and injuries on the road have mostly occurred in the area of the agent, namely the automobile. The main gains that can be made now are in the area of the host, and largely in the area of how the hosts’ attitudes and behaviours increase their risk of morbidity and mortality. While deaths on the roads account for only 1% of deaths annually in Canada, most of these deaths are preventable, unlike many of the other deaths, and contribute significantly to the potential years of life lost. If we are to make any further progress in reducing these risks to life and well-being, sustained action on these recommendations needs to be undertaken.
REFERENCES


