Road traffic safety in Canada from 2003-2017

Moore, Jeremy

UNIVERSITY OF SPLIT
SCHOOL OF MEDICINE

JEREMY MOORE

ROAD TRAFFIC SAFETY IN CANADA FROM 2003-2017

Diploma thesis

Academic year: 2019/2020

Mentor:
Assist. Prof. Kristijan Bečić, MD, PhD

Split, July 2020

Table of Contents

Acknowledgements

Writing this diploma thesis would not have been possible without the guidance of my mentor, Kristijan Bečić.

A special acknowledgment should be made to my friends and family around the world. Without their help and support, this medical degree would never have become a reality.

Nobody can do everything alone!

Abbreviations

AB – Alberta

ABS – Anti-lock Braking System

ACP – Advanced Care Paramedic

BAC – Blood Alcohol Concentration

BC – British Columbia

CAD – Canadian Dollar

CCP – Critical Care Paramedic

EMS - Emergency Medical Services

ESC – Electronic Stability Control

ITF - International Transport Forum

MB – Manitoba

NB – New Brunswick

NHS - National Highway System

NOCP – National Occupational Competency Profile

NL – Newfoundland and Labrador

NS – Nova Scotia

NT – Northwest Territories

NU – Nunavut

OECD - Organization for Economic Cooperation and Development

ON – Ontario

PCP – Primary Care Paramedic

PE – Prince Edward Island

QC – Quebec

RSS - Road Safety Strategy

RSV - Road Safety Vision

RTA(s) - Road Traffic Accident(s)

SK - Saskatchewan

SSA - Safe System Approach

TCH - Trans Canada Highway

THC - Tetrahydrocannabinol

WHO - World Health Organization

WVC(s) - Wildlife Vehicle Collision(s)

YT – Yukon Territory

1. INTRODUCTION

1.1. Road Traffic in Canada

1.1.1. Canadian Roadways

Canada is the second-largest country in the world with the total area of 9,984,670 km^2 divided into ten provinces and three territories. The longest direct distance from East to West, from Cape Spear, Newfoundland and Labrador (NL) to the Yukon Territory (YT), and Alaska border is 5,514 km (1). The majority of Canada's population is settled toward the southern part of the country. The south is more hospitable and suitable for farming and agriculture. Also, the major trading partner has for a long time been the United States of America. Therefore, it was logical that settlements be made nearer to the American border (2). In 2011 alone, more than 55 million cars and about 10.5 million trucks crossed the Canada-USA border, showing the need for a close relationship with their neighbor to the South (3).

The first routes throughout Canada were not roads at all, but rivers and lakes used by the indigenous people traveling by canoe during the summer and following the frozen waterways during the winter months. All future settlers and invaders would use these same methods to traverse Canada's rough terrain. The first 'graded road' in Canada was built in 1606 by the French explorer and founder of the City of Quebec, Samuel de Champlain. This was a military road that ran only 16 km from Port Royal to Digby Cape, Nova Scotia (NS). By the year 1734, there was a 267 km road was built to link Quebec City and Montreal, Quebec (QC). It would take about 4.5 days to travel this road by horse and carriage. After that, there was not much road development until the 19th century. Most early roads in British North America were built out of military necessity (4).

As realized by Sir Sanford Fleming when he travelled from Toronto to Victoria in 1872, it took three months by oxcart, horse, and boat to cross the vast country of Canada. He made the trip to determine the course for the proposed trans-continental railway to link the newest province of the time, British Columbia (BC). After the completion of the railway in 1885, it would only take about a week for coast-to-coast travel via train. In the 1950s, the railway was still the gold-standard for Canada's transportation system. After WWII with the influx of millions of new immigrants and a significant increase in the number of vehicles in Canadian cities, the country was working to build and pave roads between major urban areas (5). *The Trans-Canada Highway Act* was passed by parliament in 1949. Construction of the Trans-Canada Highway (TCH) began in 1950, to ultimately become Canada's largest national highway. The TCH was officially opened in 1962 by then Prime Minister, John Diefenbaker, and construction would continue until 1971. Today's TCH consists of several routes diverging and parallel routes that cross the country. Each province takes responsibility for any construction, design, and maintenance for most of the TCH within their jurisdiction. The federal government of Canada, however, is responsible for any maintenance and repair within all national parks or roads that cross through other federal property (6).

In 1907 there were 2131 cars registered in Canada, and by the outbreak of WWI, there were more than 50 000 (4). Flashforward to today; we have almost 25 million vehicles traveling on more than 1.13 million kilometers of two-lane equivalent public highways in Canada (7). 38,000 km of this belongs to the National Highway System (NHS) (3). The NHS has subsequently divided this amount of highway into core routes, making up 72.8% of the NHS; feeder routes making up 11.7%; and northern and remote routes, 15.5% (8). Of the 13 provinces and territories in Canada, only four – Alberta (AB), Ontario (ON), QC and Saskatchewan (SK) - account for 75% of the total road length in Canada (9). Almost half of all roads in Canada belonging to AB and ON alone. Although, AB with 28.1% and SK with 23.9%, account for the majority of highway length in the country (10). Canada's road network is shared with multiple different types of road users. There are approximately 20 million light vehicles, 750,000 medium and heavy trucks, 10,000 public transit buses, motor-coaches, and motorcycles. These numbers do not include other types of vulnerable road users, such as pedestrians and cyclists (3).

Canada’s North is vast, but only contains a small portion of the nation's population and road traffic. The northern territories are YT, Northwest Territories (NT), and Nunavut (NU). They makeup 40 percent of Canada’s landmass and contains two-thirds of Canada’s marine coastline. The YT is over 483,000 km^2 containing only 17 communities with 31,000 residents and 4,800 km of road. Given its small population, the YT has the highest per-capita road network in the country, with more than 155 km of road for 1,000 residents. NT is 1.2 million km^2, which is 10% of Canada's landmass. It has 34 dispersed small communities with an undeveloped transportation system. There are 2,200 km of all-weather roads, plus 1,450 km of publicly constructed winter roads throughout the territory, in addition to several privately constructed winter roads dispersed to service oil, gas, and mineral mining companies (11). NU is Canada's newest territory, separating from NT on April 1, 1999 (12). It consists of 26 communities spaced along 40% of Canada's coastline with no roads outside the communities. NU’s border spans three time zones and makes up 23% of Canadas's land mass. It's 30,500 residents rely on air transport for their essential needs. It is the only jurisdiction in North America that remains isolated from the National Highway System and the North American Trade Corridor (11).

1.1.2. Traffic Regulations and Restrictions

Traffic regulations in Canada are governed by all three levels of government: federal, provincial, and municipal. The federal government is in control of most infractions committed under the *Canadian Criminal Code*. This includes dangerous driving, criminal negligence in the operation of a motor vehicle, criminal negligence causing death, and impaired driving involving drugs and alcohol. Each province is responsible for maintaining all roads and highways which run through it. The provincial government is also responsible for governing the conduct of drivers. Each provincial *Highway-Traffic Act* controls everything pertaining to the use of the roads. This includes licensing of drivers, registration of vehicles, safety and condition of motor vehicles and rules of the road. Municipalities have their own traffic rules created by bylaws in order to more specifically enforce their road users to better to serve their communities. They are also responsible for the maintenance of safe road conditions and can be held civilly liable to citizens if they are injured on a dangerous road. This allows the municipalities to conduct road closures for maintenance or police road traffic stops within their city limits (13).

The *Motor Vehicle Safety Regulations* under the *Motor Vehicle Safety Act* describes all standards and parameters vehicles must comply with in order to be sold legally. This includes standards such as lighting, breaks, tires, occupant protection, roof, and door strength. All new vehicles must have seat belts, as well as driver and passenger front airbags. Many new technologies are playing a role in evolving road traffic safety. The anti-lock braking system (ABS) and electronic stability control (ESC) have already been proven to reduce the number of fatal collisions. A Canadian study showed that ESC has decreased collisions by 41% in road traffic accidents (RTAs) where a driver lost control of the vehicle with 23% fewer injuries with this type of collision. As of 2011, ESC is required as a standard feature on all new vehicles sold in Canada (14).

On Canadian roadways, drivers drive on the right side of the road. Upon all two-way roadways of sufficient width, drivers are supposed to drive to the left of the center line, except when passing another vehicle when safe and permitted to do so, or if the right lane is obstructed or closed to oncoming traffic and crossing is safe (15). Drivers need to adhere to the speed limit posted. Unless otherwise posted, the speed limit is usually 50 km/h in a city, town, or village or 80 km/h in other locations (14). Conversely, drivers are not permitted to drive at such a slow speed that would interfere with the flow of traffic (15).

The consumption of alcohol or other mind-altering substances is prohibited while operating a motor vehicle. The blood alcohol concentration (BAC) that is considered prohibited to drive a vehicle is 80 mg per 100 mL of blood. Cannabis and other illicit drugs, such as LSD, psilocybin, psilocin, ketamine, PCP, cocaine, methamphetamine, are also illegal and unsafe to operate a vehicle. The first offence of driving while under the influence of drugs or alcohol comes with a mandatory minimum fine of $1,000 CAD (Canadian Dollar), with a maximum of ten years imprisonment. If the same driver is found committing a second offence, the mandatory minimum sentence is 30 days in prison, or a maximum of ten years. For a third offence, there is a mandatory minimum of 120 days in prison or again, a maximum of ten years (16).

In 1969 the Canadian parliament enacted the *Canadian Criminal Law Amendment Act*, commonly known as the *'Breathalyzer Legislation'*. This law that made it illegal to operate a vehicle with a BAC of more than 80mg of alcohol in 100 mL of blood. Over the years, this legislation has been amended to offer stiffer penalties and to allow the collection of a blood specimen if a breath specimen is unable to be obtained. Multiple programs and initiatives have been introduced to combat the continuing problem of impaired driving. Roadside check-stop programs and extensive public awareness programs have become standard practice around the country (17).

1.2. Road Safety Strategy in Canada

Making the roads safer for its citizens has long become a priority for the Canadian government. Each year in Canada, there are about 2,000 fatalities on the Canadian road transport system. Approximately 165,000 were injured, with more than 10,000 of them being seriously injured. This costs its citizens roughly $37 billion annually, which is 2.2% of Canada's GDP (18).

Canada was one of the first countries in the world to implement any type of national road safety strategy (18). Currently, 132 countries worldwide have some sort of funded national road safety program (19). There have been four nationally funded programs in Canada within the last 30 years (18). Since the introduction of its first national road safety program in 1996, Canada has had the vision of having the '*safest roads in the world'* (20).

1.2.1. History of Road Safety in Canada

With the introduction of the motor vehicle in the late 1800s, the novelty and social excitement of the automobile seemed to eclipse the thought of any risk associated with this new machine. It wasn't until 1866, when Father Antoine Belcourt, a parish priest in Prince Edward Island (PE), lost control of his steam-powered automobile and was involved in a rollover RTA, that people began to think about vehicle safety. Although there were no documented injuries, this was the first documented RTA in Canada. It is therefore marked as an important milestone in the evolution of the Canadian road safety strategy. At this time, most roadways were created and maintained by concerned citizens and were mostly unpassable by thin-wheeled vehicles during a heavy rain or after the winter ice melted. The main traffic concern in the early 1900s was vehicle speed, so legislation for maximum speed limits of 16 km/h were introduced. This speed was set to meet the equestrian counterparts that still shared the roads at that time. Some jurisdictions made legislation calling for motor vehicles to come to a full stop when meeting an equestrian on the road for fear of accidents with spooked horses (21).

In the 1930s road traffic safety became a national concern. Although much of the responsibility still fell upon the road users, local governments, civil engineers and road construction teams made significant strides to make road infrastructure safer for their citizens. The proposed model for construction of new roads laid the basis for a safer roadway. It consisted of following the shortest route (rather than the easiest one), maximum curvatures of three degrees, a minimum sight distance of 800-1,000 feet and a maximum gradient of five percent. During this time, a center line on a paved road was developed to decrease run-off RTAs in foggy areas. In addition, the first superhighway was constructed in ON, between Toronto and Hamilton. Ground-breaking features on this new highway were thought to better integrate accident minimization with the implementation of an interchange and a 30-foot median width (21).

The next major infrastructure advancements to improve road safety occurred around the end of World War II, due to the massive increase in vehicle ownership and road travel. The roads of the time were inadequate, and the loss of life and property was growing so high that a national response was needed. Because of this, in May 1955, the Canadian Good Roads Association along with multiple other national organizations convened the first *National Conference on Highway Safety*. This conference brought forth many more infrastructure additions and uniform standards pertaining to road traffic throughout the country. It also initiated post-graduate civil engineering programs concentrating on highway engineering. The programs and documents that laid the groundwork for Canada's current design standards and guidelines for highway design and traffic control and were put into place at this conference (21)

1.2.2. Road Safety Vision 2001

In 1996, Canada's first national strategy, *"Road Safety Vision (RSV) 2001*", was implemented. The four strategic objectives that were identified to help achieve the goals of this vision included: raising public awareness of road safety issues; improving communication, cooperation and collaboration among road safety agencies; enhancing enforcement measures; and improving national road safety data quality and collection. The two main focuses these objectives targeted in this inaugural strategy were to decrease the incidence of drinking and driving and to convince motorists to wear seat belts. The National Occupant Restraint Program (NORP) 2001 set its goal to have 95% of drivers to wear seat belts and properly restrain their children. The Strategy to Reduce Impaired Driving 2001 aimed to have 20% less serious injuries or road traffic fatalities by 2001 (20). Progress made by RSV 2001 can be measured by the 10% decrease in fatalities and 16% decline in serious injuries despite steady increases in vehicle registration and road users (18). It was unknown if the decline in injury and mortality could be attributed to this program, but it was evidence enough to formulate a new, subsequent strategy (20).

1.2.3. Road Safety Vision 2010

In 2001, "*Road Safety Vision 2010*" came into effect. This national target called for a 30% decrease in the average number of road user fatalities and serious injuries during the 2008-2010 period compared to the figures from 1996-2001. This was an ambitious target that ultimately wasn’t accomplished until 2011. The sub-targets' proposed reductions ranged from 20% to 40%, to address the specific areas of occupant restraints, impaired driving, commercial vehicle safety, vulnerable road users, speed and intersection safety, rural roadways, young drivers and high-risk drivers. Fatalities and serious injuries had decreased by 22.4% and 26.3%, respectively, during the 2008-2010 period compared to the 1996-2001 baseline period. The average number of road user fatalities due to RTAs during the final three years of RSV 2010 was the lowest on record in 60 years. The continuation of NORP into the RSV 2010 had established a 40% reduction in the number of unrestrained RTA fatalities compared to the 1996-2001 period. The overall target of 95% occupant seat-belt compliance was ultimately achieved. The development of the *National Child Passenger Safety Training Program* on the proper use and implementation of child safety seats was also implemented within RSV 2010. While always striving to become the safest roads in the world, Canada was ranked the tenth in terms of fatalities per billion vehicle kilometers traveled compared to other countries within the Organization for Economic Cooperation and Development (OECD) (20).

1.2.4. Road Safety Strategy 2015

As 2011 was termed the "Canadian Year of Road Safety", it brought into effect Canada's third national road safety strategy, *Road Safety Strategy (RSS) 2015* (15). It had a five-year timeframe from 2011-2015, compared to the ten years allotted for each of its predecessors. RSS 2015 was somewhat different from the two that came before, in that it gave the provinces and jurisdictions more flexibility to adopt their own road safety plans to address their specific priorities and target their own most critical road safety challenges (18). The strategy is similar in that it maintained the long-term vision that Canada will have the *safest roads in the world*. The four strategic objectives that was expected to result in safer road users, safer road infrastructure and safer vehicles were: raising public awareness and commitment to road safety; improving communication, cooperation and collaboration among all involved in implementation and enforcement of traffic regulations; enhancing enforcement; and, improving road safety information in support of research and evaluation. It no longer included targets set at the national level for each province or territory to follow. Rather, the success was measured by achieving yearly downward trending in fatalities and serious injuries, as reported at the national level. Progress was also determined by using rate-based measures, rather than the previous practice of setting percentage-based targets and translating these into actual numbers of fatalities and serious injuries (15). In 2013, the number of fatalities and serious injuries on Canada's roads both decreased by 21% when compared to the 2006 to 2010 period (18).

1.2.5. Road Safety Strategy 2025

The latest and ongoing strategy, which came into effect in 2016, is Canada's *RSS 2025*. This updated strategy is guided by the principles laid out in the report from the International Transport Forum, entitled *Towards Zero: Ambitious Road Safety Targets and the Safe System Approach.* As with the previous generations, it retains multiple key principles to the success of the strategy that are aligned with the international best practices for road safety. The cornerstone of RSS 2025 relies on the following strategic objectives while focusing on safer road users, infrastructure and vehicles: Raising public awareness and commitment to road safety; improving communication, cooperation and collaboration among emergency and healthcare providers; enhancing legislation and enforcement; improving road safety information in support of research and evaluation; improving the safety of vehicles and road infrastructure; and leveraging technology and innovation. This strategy was developed based on the principles of a *Safe System Approach* (SAA), an internationally recognized and practiced tactic (18). As shown in Figure 1, it is a means of implementing evidence-based measures for safe drivers, safe roads, and safe vehicles. It views each of these layers as imperfect while attempting to fill the gaps of each of the imperfections (22). This system moves beyond a reactive approach based on analysis of post-RTA reports. Conversely, it takes a proactive approach to guide behavior while assessing the risks inherent a road network and identify critical interventions that prevent serious trauma when an RTA occurs (23).

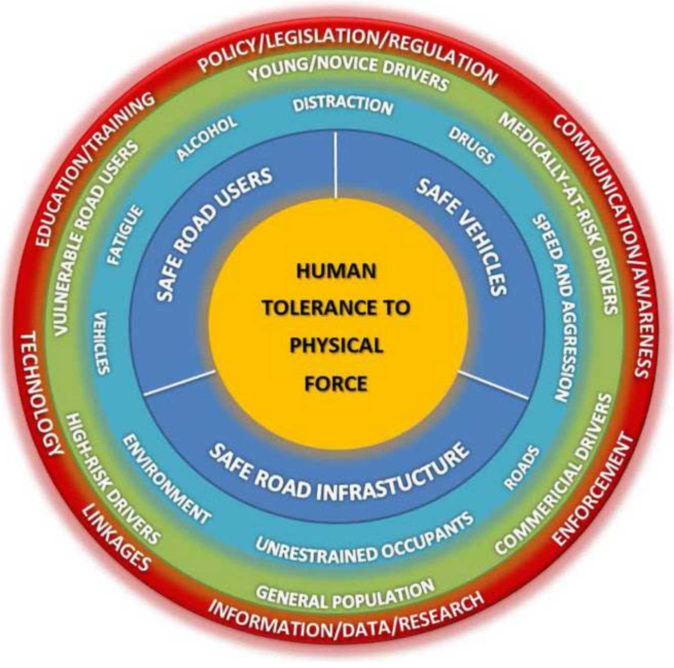

Figure 1. A *Safe Systems Approach*.
The Canadian version adapted from the 2009 WHO Report on the Global Status on Road Safety (18).

1.3.Global Burden and International Response to Road Traffic Accidents

RTAs are a major cause of injury and death globally. The incidence of RTAs has increased worldwide from 1990 to 2017, while mortality has actually decreased (24). RTAs are the number one cause of death for children and young adults age 5 to 29, and the eighth leading cause of death for people of all ages worldwide. It comes behind common diseases such as ischemic heart disease, stroke and COPD. The number of global deaths due to RTAs is still unrealistically high, at more than 1.35 million fatalities occurring each year, as of 2016 (19). This is up from 1.25 million which occurred in 2013 (25). Additionally, twenty to fifty more million people sustain non-fatal injuries from vehicle collisions worldwide (26). Although there is an increase in the absolute numbers, the rate of road traffic deaths has been fairly constant over the last 15 years. This is because the rate of death relative to the size of the world's population has stabilized and declined relative to the number of registered motor vehicles. It has been approximately 18 deaths per 100 000 population. In the same period of time the death rate per 100 000 vehicles has dropped from 135 to 64 deaths (19). The economic consequences of RTAs have been estimated to be between one and three percent of any respective country's gross national product. This would be a cost reaching over $500 billion globally (26). Almost 59% of global RTA fatalities are among participants between the years of 15 to 44, 77% of which are men (27).

The amount of RTA related fatalities varies significantly between regions and countries. The income level of a country is an important factor when related to morbidity and mortality of RTAs. The risk is more than three times higher in a low-income country than a high-income country. They have an average rate of 8.3 deaths per 100 000 population. Although only 1% of the world’s vehicles are found in low-income countries, they make up 13% of the road traffic fatalities (19). Low income countries have the highest proportion of deaths among the vulnerable population of road users, at 57%. These figures are lower in both middle- and high-income countries, at 51% and 39% respectively (27). Low- and middle-income countries account for 90% of total road traffic deaths (23). Rates of road traffic deaths are highest in Africa and South-East Asia, while countries in the Americas and Europe have the lowest regional rates of road traffic deaths (19). It is estimated that the global impact of RTAs will increase by as much as 50% in the next 20 years, especially in low- and middle-income countries, if intensive measures aren't taken to combat this global problem (15).

Vulnerable populations, including pedestrians, cyclists, and motorcyclists, make up more than half of the global road safety deaths. Worldwide, accidents involving pedestrians and cyclists represent 26% of all deaths. Deaths involving motorized two- and three-wheeled vehicles make up another 28%. 29% of global deaths involve car participants, showing how the vulnerable road population is disproportionately impacted (19). Globally, an estimated 12-million RTAs occur each year involving pedestrians. Compared to other road traffic injuries, pedestrian injuries carry the highest risk of a person being severely or fatally injured. The surge in pedestrian RTAs has much to do with rapid global urbanization and a large increase in the number of vehicles on the road (28).

As of 2018, 132 countries worldwide have implemented some sort of nationally funded road safety program. Of these countries, 109 have reported to set a national target for reduction of road traffic deaths while enacting and enforcing road safety regulations to meet their needs. As of the *World Health Organization (WHO) Global Status Report* of 2018, 46 countries have speed laws that align with best practice put forth by The WHO. This report shows that 45 countries have drink-driving laws that align with best practice, and 49 countries have crash-helmet laws that are also in-line. An even more impressive 105 countries have seat-belt laws aligning with the international best practice guidelines (19).

The *Safe System Approach (SSA*) was first introduced by Sweden and the Netherlands in the 1980s and 1990s. In order to adopt the Safe System, there had to be a shift in the mindset surrounding RTAs. The initial paradigm shift was accepting that no human should be die or be seriously injured as a result of an RTA. Once this is accepted, the blame can no longer be assigned to the victim or the driver but must focus on adapting the system itself into the safer one. This is achieved by following four guiding principles:

1. People make mistakes that can lead to road crashes.
2. The human body has limited physical ability to tolerate crash forces before harm occurs.
3. A shared responsibility exists amongst those who design, build, manage and use roads and vehicles and provide post-crash care to prevent crashes resulting in serious injury or death.
4. All parts of the system must be strengthened to multiply their effects; and if one part fails, road users are still protected.

Multiple countries have adopted the same SSA, including France, Australia and the United Kingdom (23). It was adopted in Canada as a part of the RSS 2010 and reinforced in each subsequent national safety strategy (15). Each nation had an ultimate goal of *"Toward Zero"*, *"Vision Zero"* or an equivalent end result (23). The SSA was so realistic that the

European Commission adopted the goal that they would move towards zero road traffic fatalities by 2050 (22).

In 2011, the United Nations initiated a global plan, the "*Decade of Acton for Road Safety 2011-2020"*. This global project had the aim of reducing the forecasted level of global road fatalities by increasing activities conducted at a national, regional and global levels (26). It had the overall goal of five million lives saved within this period (27). The action plan put forth, that countries were encouraged to implement, was based on a five-pillar strategy. Pillar one focused on road safety management; pillar two, safer roads and mobility; pillar three, safer vehicles; pillar four, safer road users; and pillar five focused on the post-crash response. Countries were urged to apply these pillars into their own national road safety framework (26).

1.4. Risk Factors

The occurrence of an RTA involves multiple risk factors that contribute to the event. These risk factors can complex and multiple. Risk factors can involve the traffic participant, such as behavior, speed or use of substances that could alter their ability to control a motor vehicle (29). Risk factors preceding an RTA can also be due to a vehicle-related issue or some environmental factors, such as weather or road conditions (29). The type of post-crash care or pre-hospital response can also play a large role in the outcome of a victim involved in a vehicle collision (29).

1.4.1. Factors related to vehicle participants

1.4.1.1. Speed

Speed is a contributing factor in all RTAs. As the average speed rises, as does the likelihood of a crash resulting in an injury (30). It is an accepted principle that every 1% increase in mean speed produces a 4% increase in the risk of a fatal crash and a 3% increase in risk of a crash resulting in serious injury (19). A 5% cut in average speed can result in a reduction of 30% in the number of fatal RTAs. A study of OECD countries showed that approximately 40% to 50% of drivers were driving above the posted speed limits. This reached up to 80% in some instances. A similar proportion of vehicles travelling at excessive speed were found in low- and middle-income countries (30). *'Excessive speed'* is defined as a vehicle exceeding the posted speed limit for a particular road. *'Inappropriate speed'* is when a vehicle travels at a speed that is unsuitable for the prevailing road, weather and/or traffic conditions but within the speed limits (30).

In order for speed laws to contribute to public safety, enforcement of these laws is essential. Enforcement of speed takes many forms and includes manual and automated approaches. Manual speed control usually involves a stationary observation unit fixed to a law enforcement vehicle, equipped with a speed measurement device and a second police unit tasked with stopping the vehicle and issuing a citation to the driver. Automated speed control uses either fixed or mobile cameras, installed on police vehicles (30).

1.4.1.2. Age

Young adults between ages 15- and 44-years account for more than 50% of all road traffic deaths. In high-income countries, adults aged between 15 and 29 years have the highest rates of injury, while in low-income and middle-income countries rates are highest among those over the age of 60 years. Of all the age groups, children under 15 years of age have the lowest mortality rates (both sexes), largely due to the lower rate of exposure they experience (29).

Children are especially vulnerable, as their physical size and cognitive skills are not fully developed. Their smaller stature makes it harder for them to see and to be seen while walking on or near the road. Road traffic-related trauma is a leading cause of injury to children. In high-income countries, child injury and road deaths rose sharply with industrialization in the 1950s and 1960s (29).

Road traffic injuries are not a major cause mortality for the geriatric population, overall. Nevertheless, relative to their proportion in the overall population, older people are often overrepresented in traffic fatalities. Older drivers face different types of RTAs than younger drivers. They are less likely to be involved in an RTA caused by dangerous acts, such as speeding or careless overtaking. They are more likely to experience a collision in a complex traffic situation, such as an intersection. Injury patters are also different, with older drivers suffering more fatal chest injuries than younger drivers (29). Their injury rates may also be affected by diseases such as osteoporosis, impaired hemostasis and poor tissue elasticity. Older pedestrians in particular are associated with very high road accidents and death rates. This is largely due to the increasing physical frailty and higher damage potential of older people. An older person is more likely to be injured or die than a younger person, given a similar type of impact (29).

1.4.1.3. Gender

When analyzed by country, road traffic injury mortality rates are substantially higher among males than among females. Morbidity rates are also considerably higher for males when compared to females. The gender difference in mortality rates is probably related to both exposure and increased risk-taking behavior. Studies of low- income and middle-income countries maintained that males predominated women in terms of involvement of RTAs. Males were involved in a mean of 80% of crashes, and 87% of drivers were male (29).

1.4.1.4. Vulnerable Road Users

More than half of all RTA fatalities are among vulnerable road users. These traffic participants include pedestrians, bicyclists, and motorcyclists (19). Pedestrians struck by motor vehicles can suffer a primary injury, caused by direct contact with the vehicle. They may then suffer subsequent, or secondary injury, which are caused by contact with the ground or other objects, after the primary contact with the vehicle. Primary injuries can often show recognizable patterns from the vehicle or the mechanism of collision. When an adult is hit by a frontal impact with a car, the impact site is usually around the knee. The patient's orientation, structure of the front of the car and speed of impact will determine the exact point of contact, either on the front, side or back of the legs. There are often additional primary injury sites on the thigh, hip or pelvis caused by the patient making contact with other parts of the car. Secondary injuries can vary greatly and are often more serious, and possibly more lethal compared to primary injuries. Secondary injuries can be as minor as a skin abrasion, or more serious skull or axial skeleton injury. Even with no evidence of a skull fracture, traumatic brain injury can often occur in fatally injured pedestrian RTAs (31).

At relatively low speeds (20 km/h), the pedestrian may be simply thrown off the bonnet or to the side. At more intermediate speeds (20-60 km/h), the patient may come in contact with the hood and there is a higher potential for the head to hit the windshield or other part of the vehicle exterior. At high speeds (60-100 km/h), the pedestrian may be thrown into the air or over the top of the vehicle. Forces from these impacts are enough to cause critical injuries, such as complex fractures or traumatic amputations (31). An adult pedestrian has more than an 80% chance of surviving if struck by a car travelling below 50 km/h. Conversely, there is almost a 60% risk of a fatal incidence if the pedestrian is hit by a car travelling 80 km/h (30). Over the period of 2004-2008, 13% of road traffic fatalities in Canada involved pedestrians. 75% of pedestrian RTA fatalities occurred on urban roads and 60% were caused by the pedestrian attempting to cross the road (15). A driver must exercise caution in order to avoid colliding with a pedestrian. If necessary, a warning can be sounded by using the car horn. If there is a sidewalk that is easily passable, a pedestrian should not walk along the roadway or shoulder. If there is no sidewalk, the pedestrian should walk with caution along the far-left side of the road, therefore walking facing oncoming traffic (16).

Most injuries to motorcyclists are caused by falling off the vehicle onto the road. Abrasions caused by the road surface or, road rash, are almost ubiquitous following an accident at sufficient speed. Injuries to the limbs, chest and spine commonly occur due to contact with objects or vehicles, entanglement with motorcycle or direct contact with the road. A unique motorcycle injury occurs when the motorbike is tailgating, driving under the rear of a truck. This mechanism is known to cause severe head injury or even, decapitation (31). The main cause of death and serious injury involved with motorized two-wheeled vehicles is head injury (29). Therefore, a major risk factor for motorcycle and other two-wheeled vehicles is neglecting to wear crash helmets. According to The WHO report on global road safety, correct use of a crash helmet can reduce the risk of fatal injuries by 42% and a 69% decrease in the risk of head injuries (19). The rate of compliance for using a crash helmet varies from country to country. Some low-income countries have just more than zero percent helmet use, while countries that have effectively enforced helmet laws reach almost full compliance (29).

1.4.1.5. Use of safety measures

Neglecting to properly fasten a seatbelt is a major risk factor for serious injury or death in an RTA (29). According to The WHO, wearing a seatbelt reduces the risk of death among front seat occupants by 45-50%, and risk of serious injuries and death among rear seat passengers by 25% (19). Head injuries are the most frequent and most serious injuries sustained in a frontal impact RTA with unrestrained occupants (29). A correctly installed and properly secured seatbelt should spread the deceleration forces at impact over the whole-body surface that is in contact with the straps. This ensures that the force delivered to the body per unit area is reduced. Seat belts are designed with a certain amount of stretch, in order to increase the time of deceleration, and reduces the force per unit time (31). Many new vehicles are now fitted with seatbelt pretensioners, which automatically remove the slack in the seatbelt at the time of impact. Many vehicles also have load limiters, which allow the belt to spool out, ensuring the occupants ride down the impact, without being injured by the seatbelt itself (14). Belts should restrain the body during abrupt deceleration, keeping it away from the steering wheel or windshield, while also preventing ejection from the vehicle onto the road or through broken windows (31).

Globally, two best practice criteria are used in the assessment of seat-belt legislation. These criteria are the presence of a national seat belt law and a law applying to both front and rear seat passengers. Of the 161 countries with seat-belt laws, 105 countries have seat belt laws that align with internationally recognized best practices (19). Canadian efforts to promote and enforce the use of seat belts began 1989 with the development of the previously mentioned, NORP. This program set a goal of 95% seat belt use by drivers by 1995. In 1996, the goal was extended to 95% seat belt to include all vehicle occupants, while the focus of NORP's 95 per cent by 1995 mainly focused on the driver (20). The focus of NORP 2001 was on all occupants with a particular emphasis on safely securing children in a vehicle (32). Over the last several years in Canada, seat belt use has been approximately 95% or more (33).

Child restraints have been proven to reduce injury and mortality to pediatric occupants. The use of child restraints can reduce deaths by 60% worldwide. For children age 8-12, the use of booster seats has been associated with a 19% reduction in the risk of injury, compared to using a seatbelt alone. The position of the child in the vehicle, in either front or rear seats, is another factor increasing the chance of injury. Front seats being associated with higher risk (19). There are four stages of child restraint use in Canada. They include rear facing, forward facing, booster seats, and a three-point seat belt in the rear seat. Advancing from one stage to the next is based on the seat being used and the height and weight of the child. The use of stage one and two is very high. But, not all provinces/territories have legislation requiring booster seats (33).

1.4.1.6. Distracted Driving

Distracted driving occurs when a driver's attention is diverted from the driving task by secondary activities; including activities such as eating, talking to passengers, talking or texting on electronic communication devices, grooming, reading, visual distractions outside the vehicle, among others (18). This diversion reduces awareness, decision-making or performance leading to an increased risk of driver error, crashes or near crashes. While many sources of distraction have always existed, there is a growing concern regarding newer forms of electronic devices being used by drivers on Canadian roadways (15). Distracted driving by electronic communication devices is a growing risk factor linked to serious negative outcomes in RTAs. Telephone use while driving increases the chances of being involved in an RTA by a factor of four. Driver reaction times have been proven to be 50% slower when a driver is distracted with a mobile phone. Enforcement of mobile phone laws are difficult to enforce due to challenges in detecting those committing the infractions. An impressive 150 countries have national mobile phone laws that prohibit the use of mobile electronic devices while driving (19). Statistics from 2017 in Canada showed that an estimated 22% of fatal collisions and 29% of collisions producing serious injuries were linked to a distracted driver. This shows an upward trend when compared to the decade prior, where distracted driving was a major cause of 17% of fatal RTAs and 23% of serious injury collisions (33).

1.4.1.7. Driving under the influence of alcohol or drugs

Impaired driving has been a serious public safety issue in Canada for decades, with approximately 2500 citizens dying each year due to impaired driving. At any given time, it is estimated that 25% of drivers on Canadian roads have been drinking; 6% of these drivers are legally impaired (17). In 2008, coroners' testing showed that almost 40% of fatally injured drivers have had some amount of alcohol prior to the collision. Unfortunately, the decade between 1998-2008, there was virtually no decline in the amount of fatally injured drivers due to alcohol impairment (15). The WHO estimates that 5-35% of all road traffic deaths are related to alcohol consumption. Because of this, they determined that reducing BAC from 0.1 g/dl to 0.005 g/dl may result in 6-18% decrease alcohol-related fatal RTAs. Three criteria considered to be best practice when assessing law surrounding alcohol and operation of a motor vehicle. They are: The presence of a national drink-driving law, BAC limit of 0.05 g/dl for general population. And BAC limit of 0.02 g/dl for young and novice drivers (19).

Impaired driving is Canada's leading criminal cause of death and injury. Despite laws, enforcement and public awareness, millions of people in Canada still drive impaired. Mandatory alcohol screening in Canada was implemented in 2018. This gave law enforcement the authority to demand a breathalyzer test to any driver lawfully stopped. This has been proven internationally as one of the best measures to reduce impaired driving (34). It is estimated that between 5-35% of all deaths related to road traffic accidents globally are alcohol-related (19). Males predominate within the group of impaired drivers. Although, females are notably recognized among cases, particularly within fatal RTAs (17). Drivers who police consider to be impaired based on their driving behavior or have more than 80mg of alcohol in 100 ml of blood are considered to have committed an offence under the Criminal Code of Canada (15).

Due to the legalization of recreational marijuana in October 2018, it was necessary to introduce drug-impaired driving laws. New driving limits for cannabis and other drugs, enforcement and screening tools were adopted at this time (15). The new legislation surrounding drug impaired driving came into effect by December 2018 (32). There are two prohibited levels of THC, the main psychoactive component of cannabis: between 0.002 g/L and 0.005 g/L offer a less serious offence. It is a more serious offence to have a level of 0.005 g/l or more. When found in combination, the prohibited level is 0.050 g/L or more of alcohol and 0.0025 g/L or more of THC (33).

1.4.1.8. Socioeconomic status

Socioeconomic status is a well-documented risk factor for injury. There are multiple factors that can be used to assess socioeconomic status. Two of the most common indicators being educational and occupational level. Individuals from underprivileged socioeconomic groups or living in poorer areas are at greatest risk of injury or death due to an RTA, even in high-income countries. Explanations for this difference in morbidity and mortality might relate more to exposure to risk, rather than a result of behavior. Drivers with low-status occupations and lower level education had a higher risk for RTAs (29).

1.4.1.9. Type of traffic accident

RTAs can be divided into four categories, depending on the mechanism of the collision: Front impact, side impact, rollovers, and rear impact. Front impact collisions occur when two vehicles collide head-on, or when a vehicle crashes into a fixed object. Unless the vehicle occupants are wearing a seatbelt, they will continue with forward momentum, even though the car has stopped. Unrestrained drivers can strike their knees on front panels, their head on the windshield or chest on the steering wheel. Striking the knees can cause a patella fracture or fracture of distal femur or dislocation at the hip joint. Unrestrained front seat passengers have similar injuries, except their impact will be with the dashboard instead of the steering wheel. Passengers can also come up against the windshield or sun-visor area. If the occupant is properly restrained, but without an airbag, the knees still strike the instrument panel but the head flexes forward. Impacts with the windshield can cause abrasions or avulsions on the head. Blunt impact with the windshield can also cause severe soft tissue injuries with potential life-threatening bleeding. The most common fatal injuries in the neck are upper cervical fractures or dislocation at the atlanto-occipital junction. This can cause complete transection or crushing of the cord. Alternately, the cord can be pulled down, with partial or complete avulsion of the brain stem on the ventral side of the ponto-medullary junction. A frontal collision can cause a driver's chest to impact the steering wheel. The most common fatal injury to the thoracic region is transection of the aorta. Other potential injuries include a transverse fracture of the sternum, bilateral rib fractures or rupture of the heart (35). For occupants wearing a seat belt, in the best designed cars, the threshold for severe and fatal injury is 70 km/h in a frontal car-car RTA (19).

Side Impact collisions often occur at intersections when the car is struck by another vehicle going through the intersection a right angle. They can also occur when a car skids sideways, striking a stationary object such as a telephone pole or a tree. In car-car collisions when the impact is on the driver' side of the vehicle, force is applied from the shoulder then downward. There may be lateral flexion of the neck through the side window with possible impact with the striking vehicle. A seatbelt or front airbags serve virtually no purpose in these forms of RTAs. External injuries tend to be on the left side of the body, abrasions, lacerations, avulsion or possible fracture of the left arm or leg. Transection of aorta can also occur in this type of RTA. As well as possible rupture of the heart, lacerations of the liver and possibly spleen or left kidney. If the collision occurs on the passenger's side (right) of the vehicle, the injuries tend to be more severe. Lacerations of the heart, liver, spleen; fractures of the neck or base of the skull. Fatalities usually occur in the car receiving the impact, rather than the car impacting vehicle. This is partly due to the engine protecting the impacting car's occupants (35). In Car-to-car side impact vehicle collisions, the mortality risk for driver and passengers is 85% at 65 km/h (19)

Rollover collisions are usually less fatal than frontal impact or side impact collisions, assuming the occupant is not ejected, and the vehicle is not rolling into a stationary object. Any feature that prevents occupant ejection will increase the possibility of surviving the RTA. The doors of newer vehicles usually do not open during a rollover RTA. The unrestrained occupant will be more likely to be ejected through a window. Wearing a seatbelt is very helpful in these types of collisions. If an occupant is unrestrained, the injury patters are quite unpredictable. The patient is thrown about the inside of the vehicle, impacting with multiple surfaces. Therefore, there is no specific injury patterns. It is possible that the patient doesn't show any external signs of trauma if the patient is ejected and the vehicle rolls over the patient's trunk. But autopsy will show massive injury to the heart, lungs, liver, spleen and mesentery. Rollovers make up an estimated 19% of all fatal RTAs. Most single vehicle rollover RTAs involve a vehicle running off the road, followed by an abrupt overcorrection of the steering wheel. A rollover is more likely to occur on a dirt road rather than pavement (35).

Rear impact collisions are the least common form of fatal RTA. The front seat occupants are usually protected from impact by the trunk and rear portion of the vehicle. Impacting vehicles are again protected by the car engine. This form of RTA is a major cause of whiplash injuries (35). Whiplash injuries cause cervical strain from indirect trauma to the neck due to acceleration-deceleration and back and forth abrupt motion of the head (36). Although there this is a risk in most types of vehicle collisions, rear impact RTAs especially hold the potential for ignition of fuel due to rupture of the gas tank. Rear impact collisions can also cause seatback failure, making the front seat go to the horizontal position. The occupant can then be abruptly moved backwards or upwards, possibly impacting the roof or ejecting from the vehicle. This can cause serious or fatal head injuries (35).

1.4.1.10. Fatigue

Fatigue or sleepiness is associated with a variety of factors, including sleep deprivation, long-distance driving and alteration of normal circadian rhythm. According the WHO, there are three high-risk groups for a possible RTA caused by fatigue: young people aged 16-29, males in particular; shift workers whose irregular hours cause a disruption; and people with untreated sleep apnea syndrome or narcolepsy. Fatigue-related RTAs have their peak level during the nighttime, occurring ten times more often than during the day (29). In Canada, it is estimated that approximately 20% of fatal collisions involved driver fatigue. This estimation was made after eliminating causes such as alcohol intoxication, speeding, unsafe overtaking, etc. (14).

Some warning signs of fatigue that can be noticed by the driver include closing eyes or losing focus; yawning or blinking frequently; breaking too late; drifting over the center line; among others. The body's circadian rhythm makes it, so a person is less alert during particular times of day. This is usually between 0200-0400hrs and 1400-1600hrs. Taking breaks from driving during these hours can reduce the risk of RTA due to fatigue (14). Most fatally injured drivers due to fatigue were males and are spread among various age groups. The automobile is the most common type of vehicle involved in fatigue-related RTAs. This is notable since a common misconception would be that truck drivers and other commercial drivers would have a higher rate of fatigue-related RTAs, which is not the case (37).

1.4.1.11. Disease and Medication

There are certain diseases that require a driver to have regular checkups and be without symptoms in order to maintain their driver's license in Canada. These include some cardiovascular illnesses, epilepsy, diabetes and dementia. Certain jurisdictions offer a conditional or graduated delicensing of drivers suffering from physical or mental impairments. This includes limitations on driving conditions. Prohibitions against night driving, long distance driving, or driving only in specific area during specific time periods (14).

1.4.2. Factors related to vehicles and equipment

The severity of an RTA can be increased by some risk factors related to the vehicle involved. Inadequate in-vehicle crash protection or the non-use of protective devices in vehicles can be detrimental to the occupants. Many engineering advances that are becoming the standard in vehicle engineering in high-income countries are not as widely available in low-income countries (29). Many of these safety features were first introduced as expensive optional features in high-end vehicles. They are now much more affordable and considered a basic requirement in most vehicles. There are seven international standards that are now considered the basic minimum standards for vehicle manufactures. These include standards on frontal and side impact, electronic stability control, pedestrian protection (softer bumpers), seatbelts and seat-belt anchorage regulations, child restraint regulations (38).

The last half-century has seen many improvements in vehicle safety standards in Canada. These advances have prevented a large number of serious injuries and death on Canadian roadways. All new vehicles sold in Canada must be equipped with seatbelts and driver and passenger front air bags (19).

The massive increase in the number of vehicles throughout the years has become a major determinant to global problems such as pollution, depletion of natural resources, and road traffic safety. While there was major economic growth, industrialization and motorization in the first half of the 20th century, there was also a rapid increase in fatalities caused by RTAs. The second half of the century still saw in increase in the amount of motor vehicles, while the rate of fatalities decreased. The increase in the number of vehicles in towns and cities has shown to put vulnerable road users, such as pedestrians and unprotected occupants such as motorcycles and bicycles, at higher risk for a road traffic injury. The majority of motorization occurring in high-income countries came with an increase in automobiles, while low-income countries showed an increase in motorcycles and minibuses (29).

1.4.3. Environmental factors

1.4.3.1 Geography

Approximately two-thirds of fatal RTAs and 30% of RTAs causing injuries in Canada occur in rural jurisdictions, and often involve excess speed, alcohol use and neglecting to use seatbelts (15). Analysis of Canadian road traffic fatalities in 2017 showed that 33% of deaths occurred on rural roads, 31% on urban roads and 15% on motorways. Showing that rural roadways accounted for the highest number of deaths. For about 20% of road deaths, the road category was not identified in the crash data system (33).

Geographic considerations are a major determinant of the level and standard of care provided by Emergency Medical Services (EMS). Aside from the vast distances and sparse population in rural and remote Canada, these areas often lack health care services, including high-performance EMS that urban Canadians take for granted. In rural and remote locations, EMS is clearly positioned to play a larger role in providing adequate health care, especially in areas such as paramedicine and primary health care (39).

1.4.3.2. Weather

One undisputed environmental risk factor related to RTAs in Canada is the always changing weather. Various forms of weather can cause reduced friction, decreased visibility and can make vehicle-handling much more difficult. Collisions related to weather, especially in the form of rain or snow, are estimated to cost Canadians approximately one billion dollars a year. Collision risk can increase from 50-100% during a time of precipitation. The risk varies depending on the form and intensity of said precipitation. The increased risk during a rainfall seems to be related to visibility. Once the rain has stopped, collisions rates return to near-normal, even if the roads remain wet. In comparison, RTA risk remains elevated even after snowfall has stopped. This suggest that road friction effects play a bigger role than visibility. Snow has an even bigger risk associated with RTA than rainfall. Although injury rates increase during snowfall compared to other conditions, the extent of the injuries seem to be less severe. The risk seems to be greatest for freezing rain/sleet and the first snowfall of the season. The lowest risk is associated with light drizzle or snow flurries (40).

1.4.3.3. Wildlife Vehicle Collisions (WVCs)

Canada's diverse selection of wildlife creates a problem on the nation's roadways. WVCs prove to have a significant socioeconomic, traffic safety and environmental consequences. Not only do they cause significant death and injury, but WVCs are also playing a role in the disappearance of endangered species. The estimated 53,000 collisions involving wildlife per year, as of 2012, costed Canadians approximately $200 million CAD (41). Many of the animals involved in these collusions include moose, deer, elk, bison, antelope, bears, wolves, coyotes and foxes. Many of the reported WVCs include larger animals because these are the incidents that involve personal injury or damage to vehicles. During the 15-year period from 2000-2014, there were a total of 474 fatalities due to WVCs, demonstrating 1.18% of all motor vehicle collision fatalities. The majority of WVCs occur in the summer (June-July) and fall (September-November) months. Animal migration times, hunting and mating season correspond to the secondary spike in WVCs in the fall months. The increase in WVCs in the summer months can be attributed to the larger number of people travelling on the Canadian roads for vacation, particularly through more rural areas for cabins and summer homes, where larger animals reside (42).

Most fatal collisions involving wildlife occur during the times of 2100-0000 where there is decreased visibility, especially in rural, unlit areas. Darkness may also be a major factor during the next peak of WVC fatalities during between 1800-2100. The increase of WVC during the hours of 1800-0000 can also be attributed to driver fatigue, slower reaction time and impaired decision making. Dusk and dawn are periods of the day with increased activity for deer and moose. Deer typically avoid open areas during daylight. Many large animals use valleys along highways as migration paths since they are flat terrain with access to shrubbery and other food sources. This contributes to highways the having the highest number of fatal WVCs compared to other roadways nationwide. The increase presence of wildlife on the roads and especially highways increase the risk of a fatal WVC. Most fatal WVCs occur by direct impact with an animal. A WVC can also occur by a vehicle abruptly changing direction to avoid striking an animal, only to still cause a collision with another vehicle or some other nearby road hazard. Multiple reports have also been filed for vehicle that hit another car that previously collided with a wild animal or swerved to avoid one. Swerving to avoid an animal is often more dangerous and is not recommended in most situations. The species involved in the WVC depends largely on the jurisdiction that the collision occurred. Six provinces (BC, AB, ON, QC and NB) share the moose as the most common animal involved in a fatal WVC. While in SK, Manitoba (MB) and NS, more people died in collisions with a deer than any other animal. The majority of fatal WVCs in Canada occur in the province of QC. This is no surprise, given that QC has such dense forests compared to other provinces. QC forests cover 45.6% of the province's land mass and is home to many large mammals, including caribou, moose and white-tailed deer (42).

1.4.3.4. Road Type

There are strong links between road infrastructure and serious and fatal injuries due to an RTA. Safe road engineering can help in reducing the frequency and severity of RTAs, while poor engineering can contribute to the incidence of a crash (29). An evaluation of over 60 countries by the WHO showed that more than 50% of the roads assessed lacked the basic infrastructure for the safety of all road users, including vehicle occupants as well as vulnerable road users. Implementation of footpaths, bicycle paths, motorcycle lanes and safe speed-controlled crossing areas can help to decrease the risk of injury or death on the roadways (38). RTAs do not normally occur evenly throughout the road network. They tend to occur in clusters at single sites, along particular sections of road, or dispersed across whole residential neighborhoods. It is important that some sort of action be taken at high-risk crash sites, which are often well known and highly documented (29).

Improvements to Canadian roadways have helped contribute to road safety improvements over the last few decades. Increased implementation of median barriers and divided highways decreased the incidence of high-speed frontal impact collisions (19). There are also more guard rails and increasing use of rumble strips on road edges and center lines. Rumble strips help alert drowsy drivers that are drifting out of their lane by creating a vehicle vibration to alert the inattentive or fatigued. In addition, and the implementation of more passing lanes on two-lane highways have reduced severe collisions by up to 29%. The increased number of highways with paved shoulders have also decreased the risk of a vehicle running off the road. There is an increased conversion of four-way intersections to roundabouts occurring throughout Canada. They require all drivers coming into the roundabout to slow down and yield to vehicles already in them. Roundabouts are a very successful infrastructure change that reduce fatalities by as much as 60-70%. In addition, they reduce fuel consumption because vehicles do not have to stop and start as often as they would by using a 4-way intersection (14).

1.4.4. Prehospital Response

Emergency medical care is often an essential aspect of post-crash response. There are multiple time-sensitive interventions needed to provide proper care of RTA victims (19). Timely post-crash response has been proven to save lives and decrease disability worldwide. Some risk factors influencing the severity of post-crash injury include delay in detecting the RTA, the presence of fire on scene, leakage of hazardous materials, the presence of mind-altering substances, prolonged extraction time, and lack of an adequate pre-hospital or hospital emergency response (29).

The first line of response in a many RTAs involves nearby bystanders. People on the scene of an accident can call EMS or other forms of help, help to secure the safety of the scene and can provide first aid. Many deaths occur as a result of severe external bleeding, cervical spine injury or airway obstruction, and can be avoided by aid of bystanders on scene (29). In many low- and middle- income countries without adequate ambulance response, bystanders are sometimes the main or only source of post-crash healthcare (29).

The aim of prehospital care is to evade and limit preventable injury, disability and death, while ensuring the crash survivor's best possible recovery and rehabilitation (28). It was shown that in high-income countries that about 50% of deaths from RTAs occurred within minutes, either at the scene or while en route to the hospital. For those patients taken to hospital, approximately 15% of deaths occurred within the first four hours after the RTA, but a much greater proportion, around 35%, occurred after four hours of the event (29).

Among the countries evaluated by the WHO, 55% have a formal process to train and certify prehospital responders (19). Mortality rates are drastically lower in high-income countries that have a well-developed EMS system (38). Canada's EMS system is a consists of a complex coordination among various departments, each striving to preserve public health and safety. Road and air ambulance services, dispatchers, law enforcement and fire rescue each serve a vital role at the scene of an RTA. The level of care provided by Canadian ambulance services varies depending on standard of care required by the jurisdiction. Emergency Medical Responder (EMR) is the lowest level of training found working on a Canadian road ambulance, followed by Primary Care Paramedic (PCP), Advanced Care Paramedic (ACP) and Critical Care Paramedic (CCP) (43). The term 'paramedic' is often used to be inclusive of all four levels (41). Paramedic competencies and scope of practice is governed by the Canadian National Occupational Competency Profile (NOCP) for Paramedics. The NOCP provides a national standard for educational programs and provide a tool to assist paramedic regulators to help establish workplace standards and competencies, while aiding to enhance labor mobility from province to province (43).

1.5. Definitions

Fatal Collisions - All reported RTAs that resulted in at least one death, where death occurred within 30 days of the collision. QC is an exception prior to 2007, where the documented death occurred within eight days of the RTA (44-58).

Serious Injury - Persons admitted to the hospital for treatment or observation following an RTA (44-58).

Fatalities - Include all those who died as a result of a reported RTA within 30 days of the event. QC is an exception prior to 2007, where the documented death occurred within eight days of the RTA (44-58).

Injuries - Include all reported injuries due to an RTA with severity levels ranging from minimal to serious (44-58).

Urban Roads - include metropolitan roads and streets and other urban areas. It also encompasses sites where speed limit at RTA is 60 km/h or less. In AB, NB, MB, and SK, 'urban' includes any area within the corporate boundaries of a city, town, village or hamlet (44-58).

Rural Roads - Primary or secondary highways, as well as local roads. It also encompasses sites where speed limit at RTA is more than 60 km/h. In AB, NB, MB, and SK, 'rural' is any area that falls outside the definition of 'urban' (44-58).

Vulnerable Road Users – Pedestrians, motorcyclists and bicyclists, which have increased risk of danger when involved in a road traffic conflict. They are not protected by the structure of the vehicle and lack appropriate safety restraints (20).

2. OBJECTIVES

- This study's primary aim is to analyze conditions relating to road traffic safety in Canada from 2003 to 2017. This will investigate the RTAs resulting in fatal or serious injuries by comparing three five-year time clusters.
- As a secondary aim, we will describe the high-risk age groups, geographic and road user demographics relating to serious and fatal road traffic collisions.
- This study hypothesizes that there is decrease in the number of fatalities and serious injuries caused by road traffic accidents, within the timeframe of 2003 to 2017, divided into three consecutive five periods.

.

3. SUBJECTS AND METHODS

This work was organized as a retrospective study. Data was collected by using the Canadian Motor Vehicle Traffic Collision Statistics reports from 2003 to 2017, which is offered for public access (44-58). Information regarding impaired driving in Canada was obtained from the Canadian Centre on Substance Use and Addiction (59), while seatbelt usage was obtained from the Canadian Council of Motor Transport Administrator's National Occupant Restraint Program annual reports (32).

The research focuses on three consecutive five-year periods: 2003-2007, 2008-2012, and 2013-2017. This breakdown shows the trends of serious and fatal road traffic injuries in accordance with Canadian national safety programs. The investigation included data from important high-risk groups and contributing factors relating to morbidity and mortality following an RTA. Age, type of road user, type of road, and the use of a seatbelt restraint for both drivers and passengers. The data has a breakdown of RTA distribution throughout Canada, organized by each province's incidence in order to view the geographic correlation to RTAs.

Tables and graphs were produced using Microsoft Excel. All presented data was inserted into the electronic spreadsheet and descriptive statistics were calculated using MedCalc (version 11.5.1.0, MedCalc Software, Ostend Belgium). Statistics were performed using the Kruskal-Wallis test to compare the difference among the three time-period clusters (2003-2007, 2008-2012, and 2013-2017) and expressed as median and interquartile range. The major RTA outcomes: fatal collisions, fatalities, injuries and serious injuries were analyzed and presented using a box and whisker plot.

4. RESULTS

Collisions and Casualties

Between the period of 2003 to 2007, there was a total of 12,515 fatal collisions in Canada, as shown in Table 1. The median fatalities during this initial five-year time period was 2,768 (2,755.8-2,877.0). The median number of serious injuries during the 2003 to 2007 timeframe was 15,605 (14,930.5-15,870.0). 2008 to 2012 saw a total of 9,914 fatal collisions, causing 10,984 fatalities. This is a decrease of 3,039 fatalities when compared to the 2003 to 2007 period. This timeframe had a median of 2,216 (2,062.8-2,286.3) fatalities within a total of 9,914 fatal collisions. From 2013 to 2017 had 1,711 fatal RTAs causing a total of 9,427 deaths, with a median of 1,889 (1,846.3-1,909.8). This is 1,557 less total fatalities than the previous five-year period, and 4,596 less than the initial period of 2003-2007. The median number of serious injuries from 2013 to 2017 was 10,662 (10,306.5-10,783.8). The comparison of the median number of fatal collisions, fatalities, injuries, and serious injures between each of the three clusters of five-year periods proved a statistically significant decrease (*P*=0.002).

Table 1. Collisions and Casualties

	2003-2007			**2008-2012**			**2013-2017**			
	Total	Median	Range	Total	Median	Range	Total	Median	Range	*P*-value*
Fatal Collisions	12515	2486	2448.8-2565.0	9914	2007	1847.8-2064.0	8855	1695	1678.75-1741.3	0.002
Fatalities	14023	2768	2755.8-2877.0	10984	2216	2062.8-2286.3	9427	1889	1846.3-1909.8	0.002
Serious Injuries	76975	15605	14930.5-15870.0	58658	11796	11072.0-12179.0	52659	10662	10306.5-10783.8	0.002
Injuries	103513	204751	198168.3-208696.3	853858	170770	167523.8-173159.3	800053	161061	155973.5-163565.0	0.002

Data is presented as median and interquartile range.

*Kruskal-Wallis test to compare the three cluster of time periods.

The median and interquartile range for fatalities and serious injuries are depicted in Figure 2 and Figure 3, showing the statistically significant trend decrease between the three clusters of five-year periods for fatalities and serious injuries. It clearly displays the decrease from a median of 2,768 (2,755.8-2,877.0) fatalities from the initial timeframe of 2003 to 2007, to a final median fatality rate of 1,889 (1,846.3-1,909.8) in the final 2013-2017 cluster.

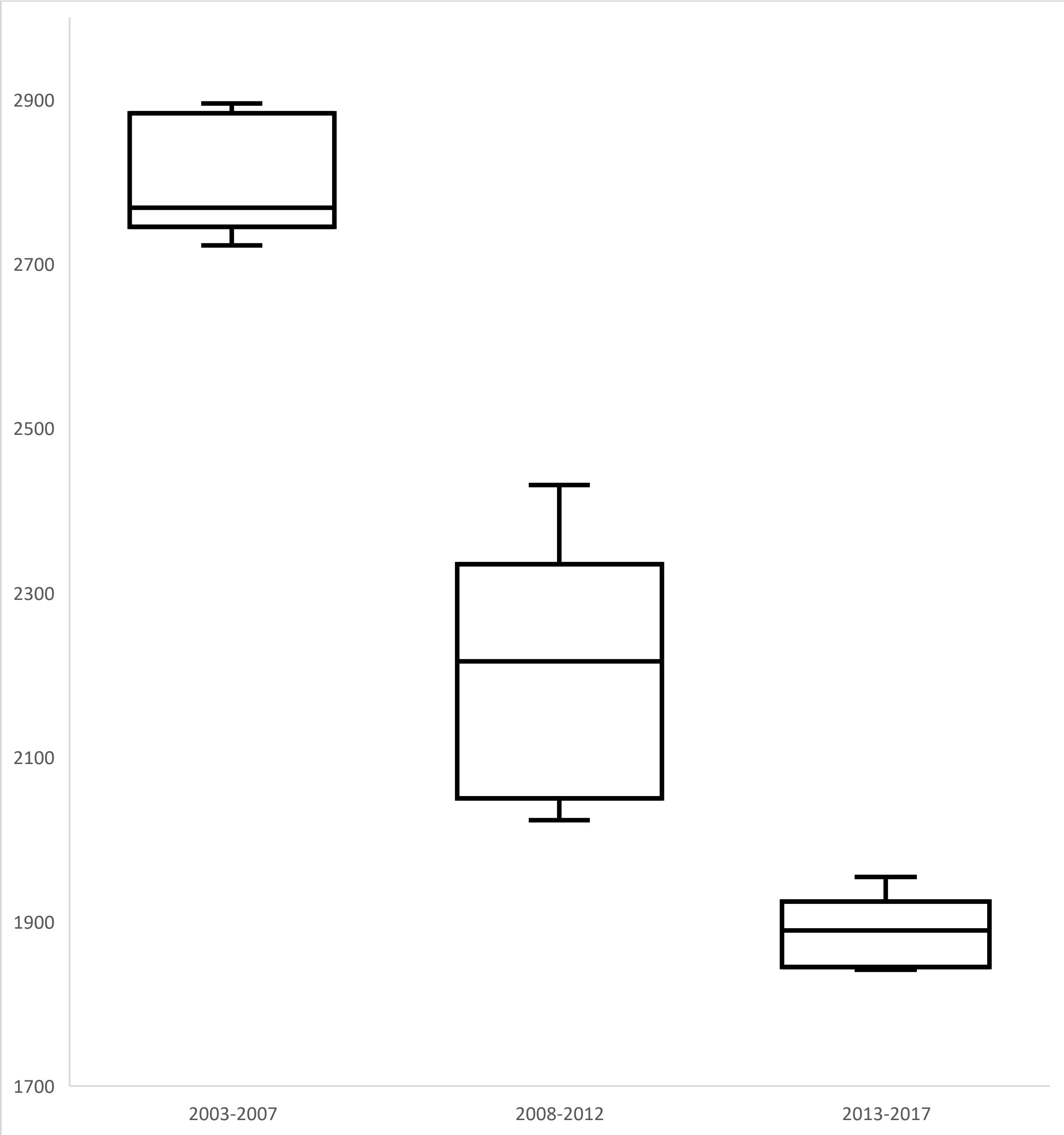

Figure 2. RTA Fatalities
*Kruskal-Wallis test to compare the three cluster of time periods and expressed in median and interquartile range (*P*=0.002)

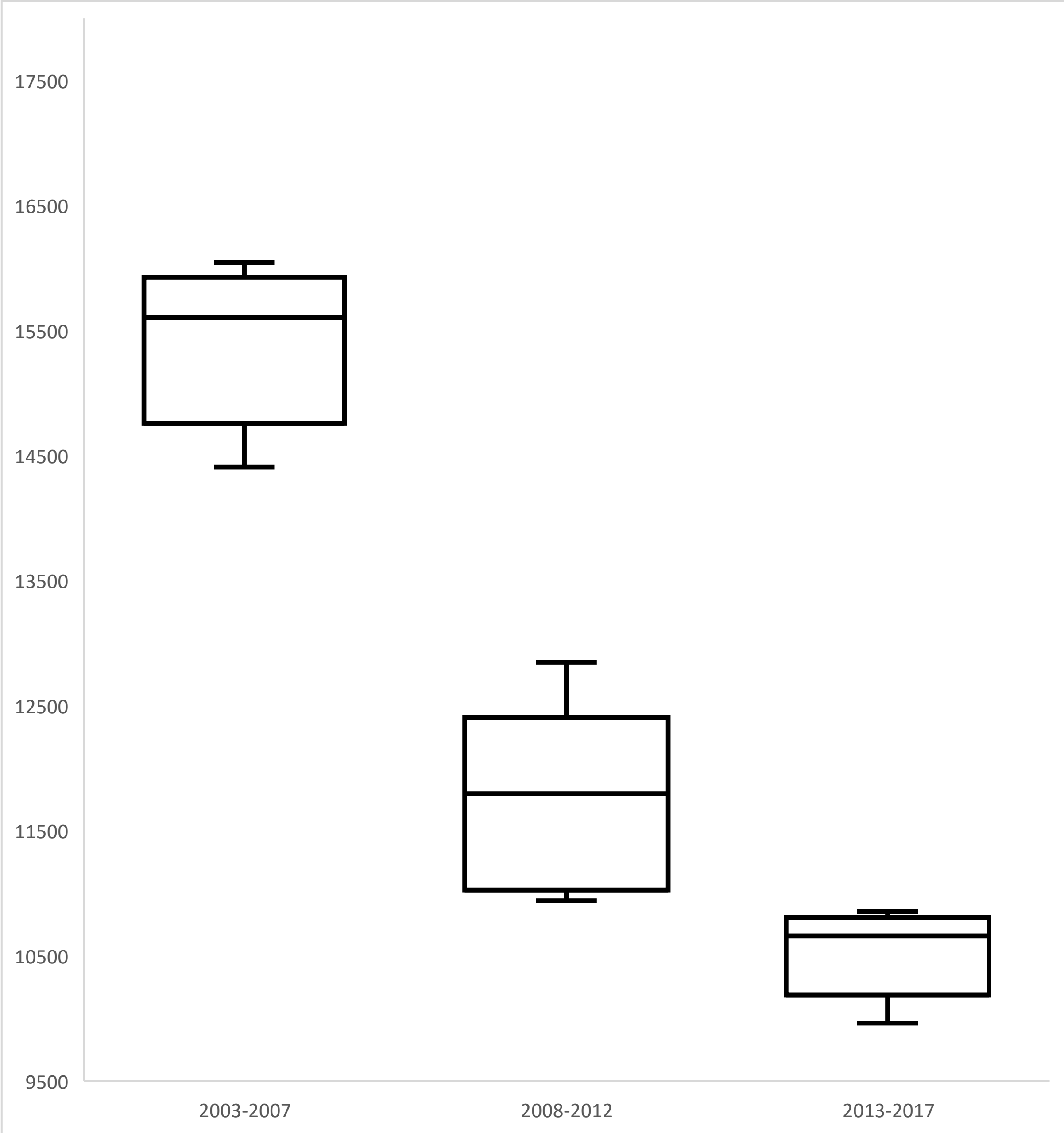

Figure 3. Serious Injuries Caused by RTAs.
*Kruskal-Wallis test to compare the three cluster of time periods and expressed in median and interquartile range *(P*=0.002)

Figure 4 shows the three consecutive five-year periods with respect to fatal and serious injuries caused by RTAs in Canada. It also depicts the trend decrease of total fatalities, and serious injuries when viewed as a comparison between each five-year timeframe. In the initial timeframe, there was a total of 14,023 fatalities and 76,975 serious injuries. The following time cluster had 10,984 RTA-related fatalities and 58,658 documented serious injuries. The 2013 to 2017 period had 9427 fatalities and 52,659 serious injuries. There is a clear and obvious drop in total number of fatalities and serious injuries. Between the initial 2003 to 2007 cluster compared with the final 2013 to 2017 times.

Figure 5 gives an overview of serious injuries as an annual measure, to be able to pinpoint the peaks and valleys of Canada's road safety vision. There was a large decrease in serious injuries following the graph's peak in 2006 with 16,044 serious injuries, dropping to 10,940 by 2011. A closer look at the fatality rate can be viewed in Figure 6, showing a similar peak and decrease in the rate of fatalities starting after a peak of 2,895 deaths in 2005, and continues to drop to 2,216 fatalities in 2009. The rate of fatalities does not decrease at such a steep rate as the rate of serious injuries from Figure 5. After a steady decrease in both fatalities and serious injuries, there is a slight increase going into 2010, where the amount of fatalities slightly increased at 2,238 deaths. This only 22 more fatalities than the year before. There is an overall downward trend in both figures, reaching their lowest point in 2017, with 1,841 fatalities and 9,960 serious injuries. This is 927 less fatalities and 5,144 less serious since the beginning of our data compilation.

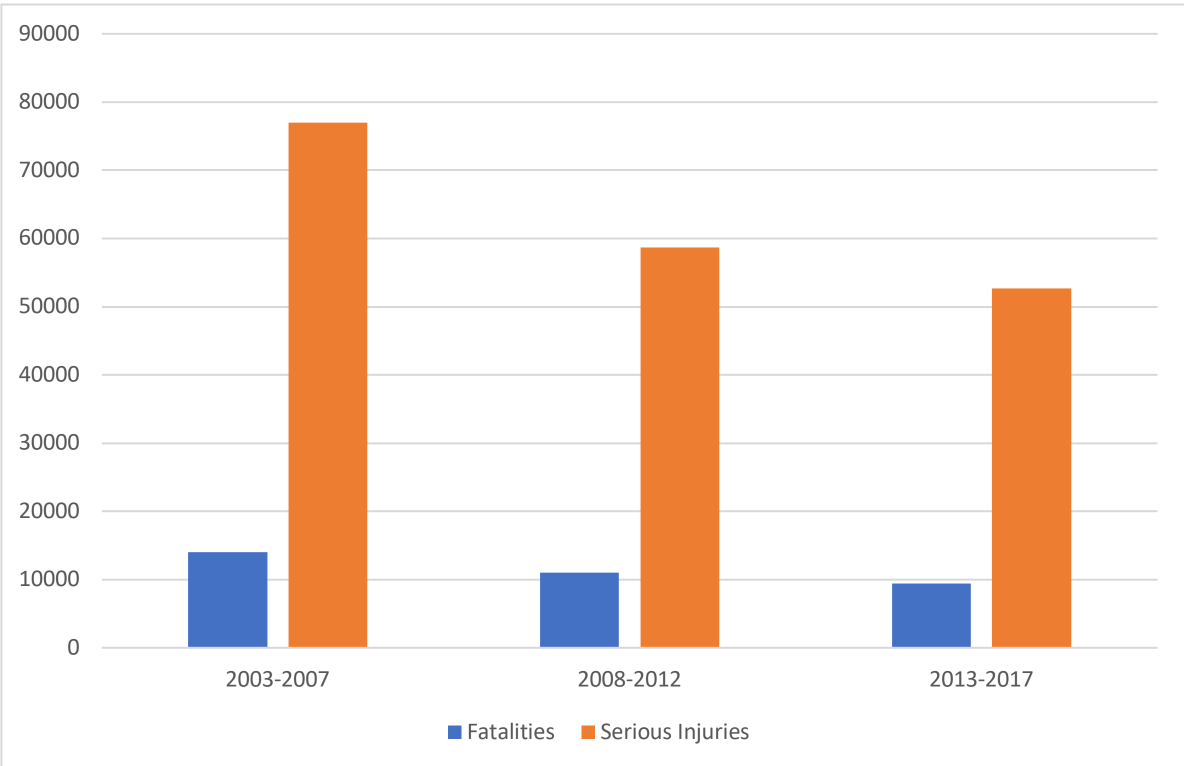

Figure 4. Fatalities and Serious Injuries during three consecutive five-year periods.

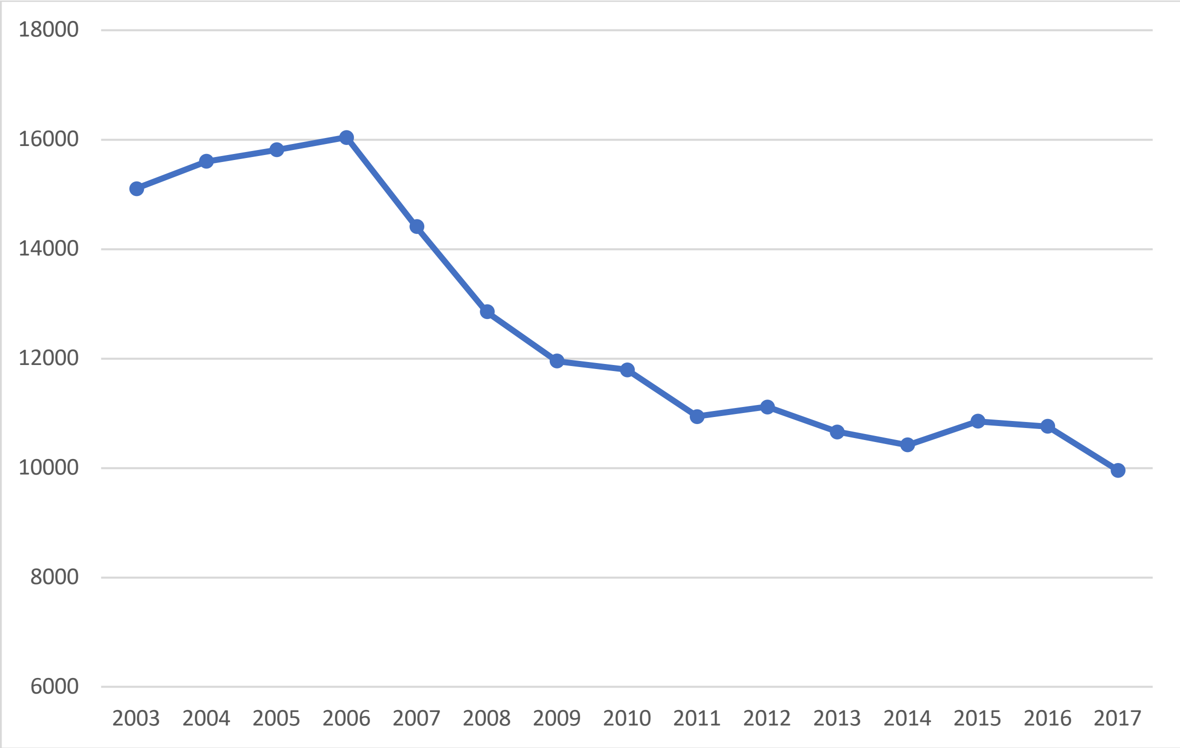

Figure 5. Serious Injuries on a yearly basis, from 2003 to 2017.

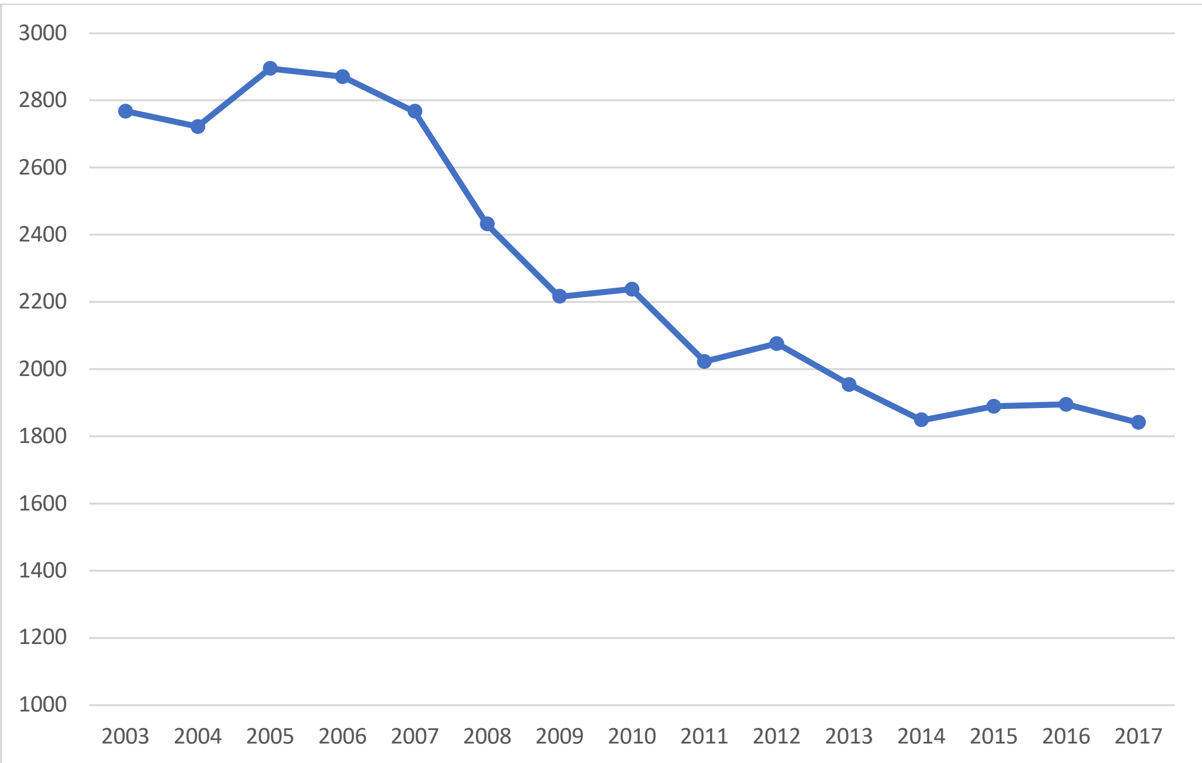

Figure 6. Fatalities due to RTAs on a yearly basis, from 2003 to 2007

Age

As a descriptive depiction of fatalities due to RTAs in Canada, we can break down the number of deaths based on age group, as shown in Table 2. Maintaining the comparison between the three clusters of five-year timeframes. The average number of deaths was highest among road traffic participants that were 65 years or older in all three clusters of five-year periods with an average number of road deaths being 469.4, 403.2, and 406.6 for 2003-2007, 2008-2012, and 2013-2017, respectively. This was shortly followed by the 25 to 34-year-old age group with an average of 438.4, 335, and 299 for 2003-2007, 2008-2012, and 2013-2017, respectively. The lowest number of fatalities occurred in the zero to four age group or was among the category of unstated or unknown age group.

Table 2. Road Traffic Fatalities by Age Group.

Age	2003-2007		2008-2012		2013-2017	
	Total	Mean	Total	Mean	Total	Mean
0-4	112	22.4	83	16.6	108	21.6
5-14	385	77	222	44.4	195	39
15-19	1612	322.4	1150	230	195	141.4
20-24	1867	373.4	1411	282.2	707	197.6
25-34	2192	438.4	1675	335	988	299
35-44	2015	403	1324	264.8	1495	231.8
45-54	1964	392.8	1672	334.4	1159	254.2
55-64	1417	283.4	1274	254.8	1271	265.4
65+	2347	469.4	2016	403.2	2030	406
Not Stated	176	35.2	111	22.2	74	14.8

A clear visualization of the age distribution of fatal RTAs can be viewed in Figure 6. This reinstated the previously mentioned 65+ age group as the highest number of deaths due to RTAs in all three clusters of five-year periods. This graph also helps to show the decreasing number of fatal RTAs through the progression of each time-period for almost all age groups. This decrease is not evident in the over 65 age group or the 55 to 64 age group, where there is a slight increase when comparing 2008-2012 and 2013-2017.

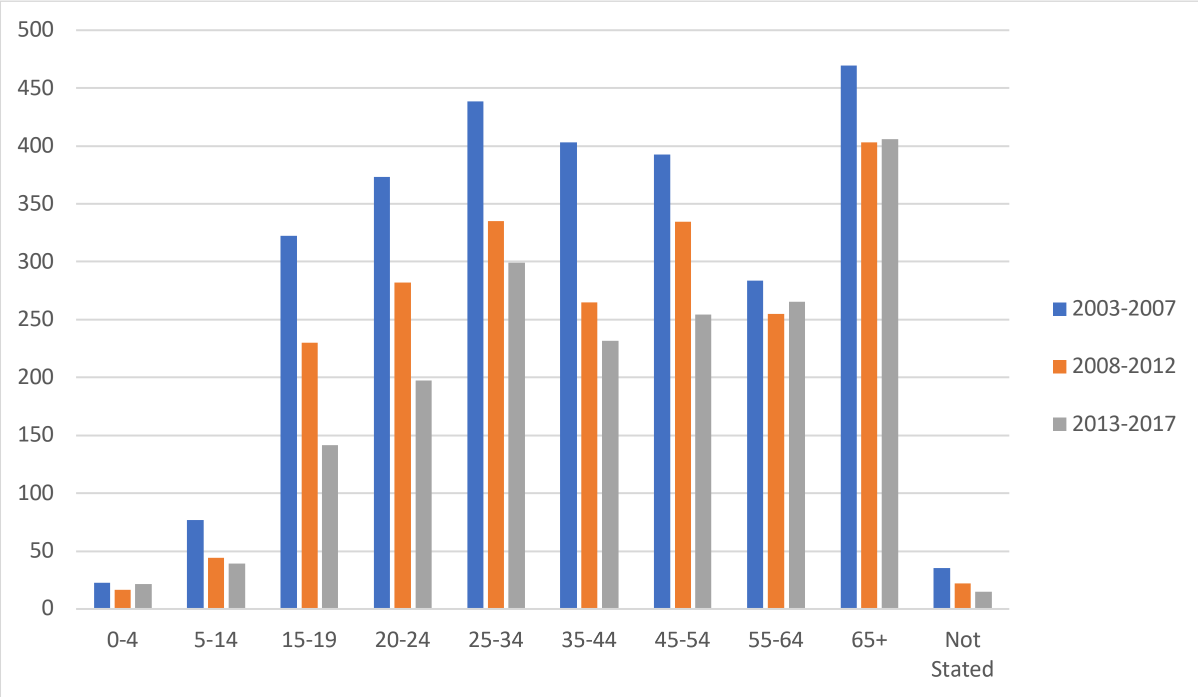

Figure 7. Road Traffic Fatalities by Age group.

Province and Territory

Another descriptive method of viewing the Canadian collision statistics was to review the geographical distribution of Road Traffic Accidents throughout the country. Viewing each province and territory's road traffic fatalities per 100,000 population as shown in Figure 8. As the graph clearly shows, during all three time clusters, YT had the highest average number of fatalities compared to the rest of Canada. During 2003 to 2007, YT had an average of 23 RTA fatalities per 100,000 population. This dropped to 17.5 per 100,000 in 2008 to 2012, and even further to 12.2 during the final 2013-2017 time period. The initial timeframe's second highest provincial fatality occurred in AB, with 21.7 per 100,000, while the lowest was in NU with 6.1 per 100,000 population. As the timelines progress into the 2013-2017 time-period, the number of fatal RTAs begins to level out a bit more throughout the country, with the exception of the few outliers, such as YT and ON. ON has the lowest number of fatal RTAs during this final time-period, with 3.7 deaths per 100,000 population. Some provinces showed a significant decrease in fatality rate as the time clusters progressed, while others such as NL or NT stayed relatively constant throughout.

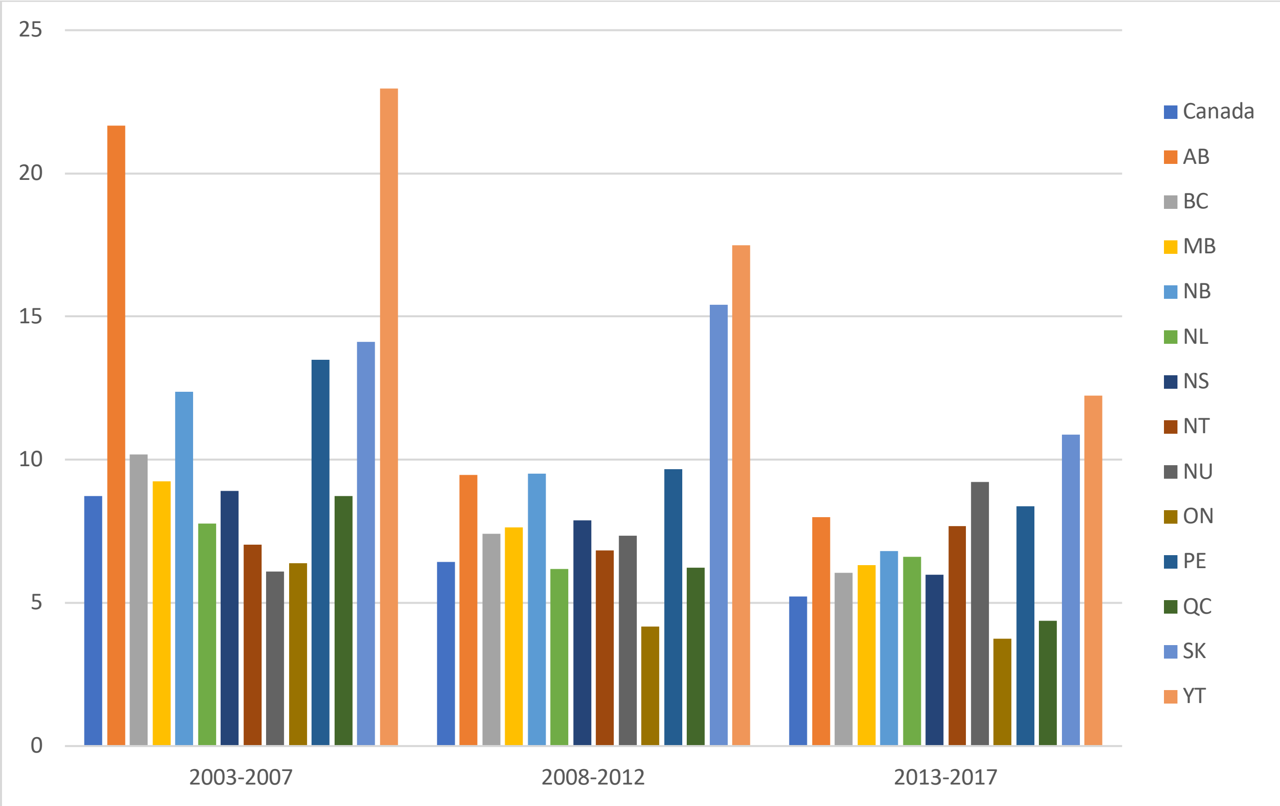

Figure 8. Provincial Distribution of RTAs in Canada per 100,000 population. AB – Alberta; BC – British Columbia; MB – Manitoba; NB – New Brunswick; NL – Newfoundland and Labrador; NS – Nova Scotia; NT – Northwest Territories; NU – Nunavut; ON – Ontario; PE – Prince Edward Island; QC – Quebec; SK – Saskatchewan; YT – Yukon Territory.

Location

Another way to describe the location of a fatal RTA is to divide the road system into urban and rural road traffic fatalities, as shown in Figure 9. During all three time periods, rural roads had a higher average number of fatal collisions, compared to urban roads. This graph again shows the trend decrease of fatal RTAs in Canada on all roads, when comparing each of the three-time clusters to one other. This reaffirms the premise made in previously, showing the total decrease in fatal RTAs in Canada. During the 2003 to 2007, there was an average of 925 fatal RTAs in urban roads in Canada, while an average of 1572.8 fatal RTAs occurred on rural roads. In the second time period of 2008 to 2013 showed 781 fatal RTAs taking place on urban roads and 1156.6 taking place on rural roads. The final time period showed an average of 715.6 urban fatal RTAs and 954.6 on rural roads.

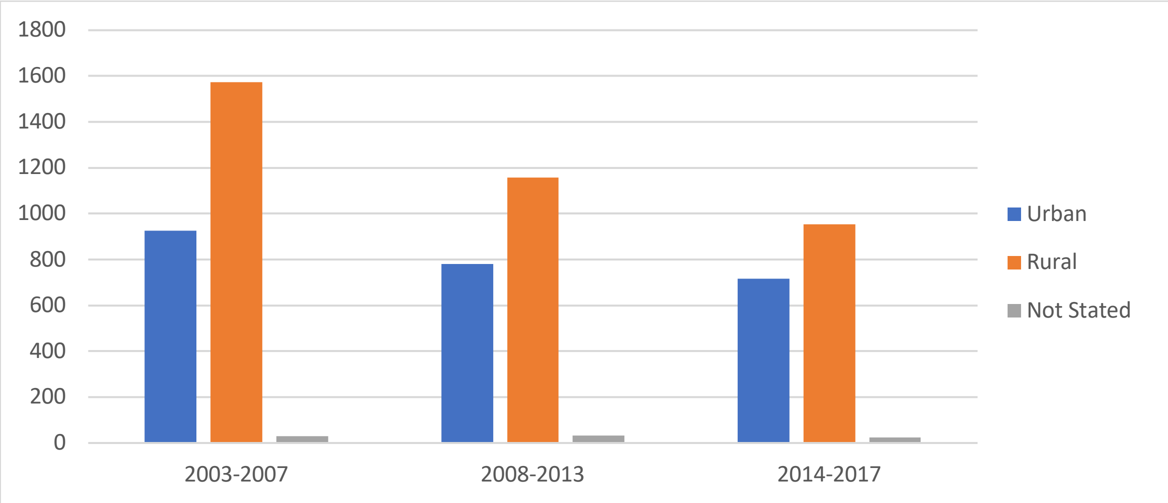

Figure 9. Fatal RTAs by Location. Divided into Rural and Urban road systems.

Road User Class

Road traffic fatalities can be viewed by class of road user dispersed throughout each consecutive five-year period, as illustrated in Figure 10. Drivers were consistently the highest percent of road users fatally injured through each of the five-year periods. During the 2003 to 2007 period, drivers accounted for 51.8% of road traffic fatalities. The 2008 to 2012 period brought a negligible decrease to 51.5%, while the 2013 to 2017 period had 50.0%. Passengers were a constant runner up, followed by other vulnerable and unprotected road users, such as motorcyclists and bicyclists. Comparing each of the five-year periods, the vulnerable road user categories all have a slight increase in percent of RTA fatalities. Pedestrians, beginning with 13.1% in 2003 to 2007 and increasing to 16.3% in the final time cluster of 2013 to 2017. The percent of fatalities by motorcyclists begins at 7.4% during 2003 to 2007 and increases to 10.5% fatalities during 2013 to 2017. The unstated category remains fairly stable at only a couple of percent throughout the three time periods. Bicyclists accounted for the lowest percentage of fatalities in each of the time periods, again with only a 2 to 2.5%.

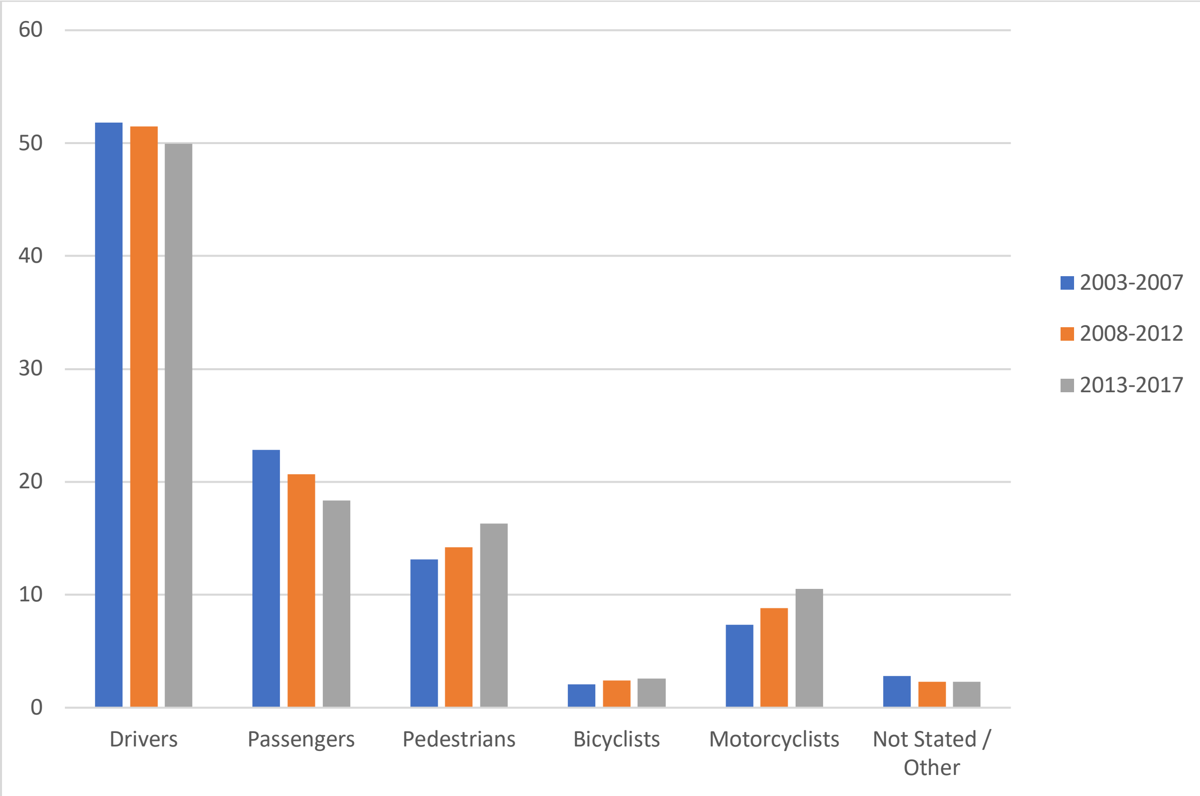

Figure 10. Total percent of RTA Fatalities by Road User Class

Seatbelt

Another way to express the collision statistics in Canada was to break down the percentage of fatalities and serious injuries of those victims not wearing a seatbelt. This can be subsequently divided into both drivers and passengers. Figure 11 shows that 37.2% of drivers in the 2003 to 2007 time period were not wearing a seatbelt, while during the same time cluster, there was 38.4% of fatalities by passengers not wearing a seatbelt. The 2008 to 2013 had a small decrease in fatalities, with 33.1% of drivers not using proper restraint, while 37.1% of fatally injured passengers neglected to wear a seatbelt. The final time cluster has an even further decrease in the number for fatally injured drivers, down to 28.8%. The number of fatalities among the passenger group was down to 29.6%. In this case, there was a drop of 8.4% of unrestrained drivers and a decrease of 8.8% passengers suffering fatal injuries.

Serious injuries among unrestrained victim were overall lower than fatalities in all three time periods. There was less drivers sustaining serious injuries than passengers who were not wearing a seatbelt. In the 2003 to 2007, there was 15.7% of drivers sustaining serious injuries that were unrestrained, while 22.7% of passengers were not wearing a seatbelt. The decrease in percent of unrestrained road users continued to drop into the second- and third-time cluster.

During the final period, there was 10.9% of unrestrained drivers sustaining serious injuries, and 17.2% of passengers. This gave an over decrease of 4.8% unrestrained drivers suffering serious injuries and a 4.9% decrease in the number of seriously injured passengers not wearing a seatbelt.

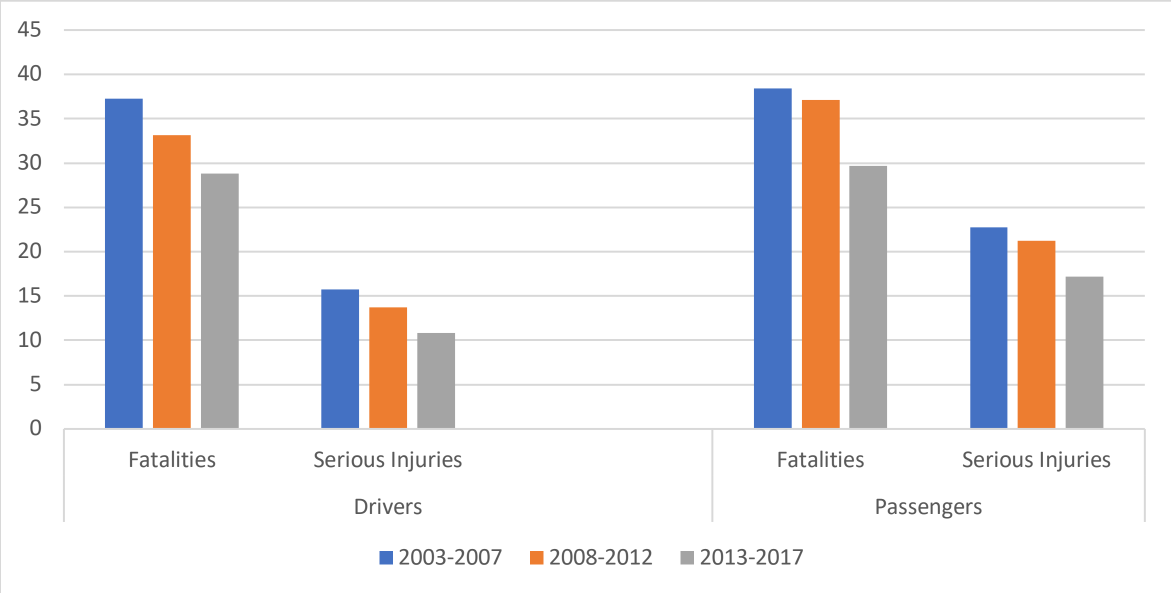

Figure 11. Percent of Fatalities and Serious Injuries where the victim was not wearing a seatbelt.

Impaired Driving

An interesting descriptive breakdown of fatal RTAs takes into account the use of alcohol or drugs by driver, as viewed in Figure 12. The percentage of drivers fatally injured in an RTA due to alcohol has been quite varied throughout the years. After it reached its most recent peak of 38% in the year 2010, it then decreased substantially to a low of 28.4% in 2014. In recent years, fatally injured drivers testing positive for drugs has been increasing and surpassing that of alcohol-related fatalities. A peak of 44.7% of drivers involved in fatal RTAs testing positive for drugs occurred in 2013. Approximately 15% of drivers involved in fatal RTAs test positive for both drugs and alcohol (59).

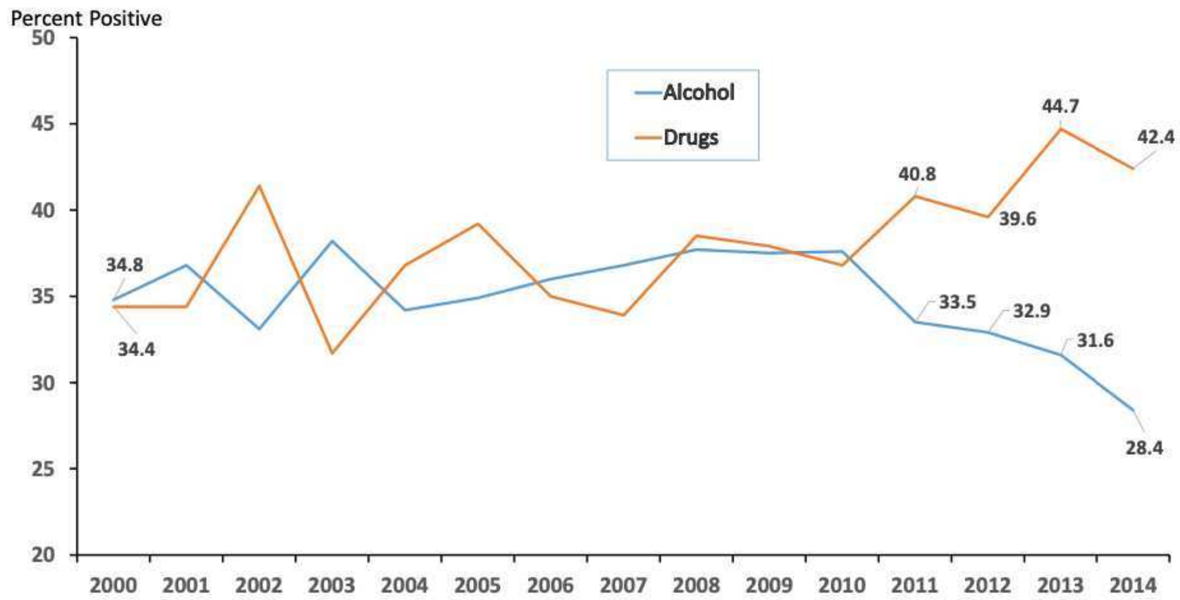

Figure 12. Percentage of Fatally Injured Drivers Positive for Alcohol or Drugs according from 2000-2014.
Figure retrieved from the Canadian Centre on Substance use and Addiction (59).

5. DISCUSSION

Road traffic safety has been national priority for the Canadian government and law enforcement since the 1930s (21). There are approximately 165,000 people injured and roughly 2000 victims fatally injured in RTAs in Canada. RTAs are also costing Canadians approximately 37 billion CAD. Canada was one of the first countries to implement a national road safety strategy. The first of these strategies was introduced in 1996, called the RSV 2001. Although this timeline was outside the frame of this study, it was a noteworthy strategy, with its inaugural outcome of a 16% decrease in serious injuries and a 10% decrease in fatalities during the ten-year timeframe (18). The second national strategy, which partially encompasses the first two time clusters of this study, was RSV 2010, was implemented in 2001. This program had a vision of 30% decrease in serious injuries and fatalities during the 2008 to 2010 time period. This vision was not met by the proposed deadline, but shortly thereafter in 2011 (20). The third national strategy, RSS 2015, was introduced in 2010, and correlated with the United Nations' *Decade of Action for Road Safety*. This time period brought about a paradigm shift towards a '*Safe Systems Approach',* which was ultimately adopted as a part of Canada's fourth and current national strategy. Attempting to take the blame off the road user and alter the system, in order to decrease RTA fatalities in Canada (14). The current strategy in place in Canada was implemented in 2015, RSS 2025, has similar objectives to its predecessors. By finally adopting the safe systems model of road safety management, Canada is still working toward its vision of zero road traffic fatalities (18).

During the first analyzed time period, 2003 to 2007, there was a total of over 12,500 fatal RTAs in Canada. Among these collisions, there was more than 14,000 fatalities. This shows that in several occasions, there were multiple victims fatally injured in a single RTA. During this time period, the median number of fatalities was 2,768 (2,755.8-2,877.0). This number made a significant decrease going into the second time cluster with a median of 2,216 (2,062.8-2,286.3). This is a decrease in 552 fatalities when comparing these two time clusters. When the final time period is taken into account, with a median of 1889 (1846.3-1909.8), there is a decrease of 879 fatalities. The total number of fatalities due to RTAs observed in the first time cluster was 14,023, while the final period of 2013 to 2017 was 9,427. This was a significant decrease of 4,596 fatalities when comparing the initial period of our study to the last (44-58).

The initial five-year time period showed a median of 15,605 (14,930.5-15,870.0) serious injuries. There was a notable decrease to 11,796 (11,072.0-12,179.0) in the second data cluster from 2008 to 2013. The third time period showed 10,662 (10206.5-10783.8) fatalities.

When comparing the initial time period to the final one, there was a difference in 4,943 median fatalities. The total number of serious injuries occurring during the first-time cluster was 76,975 victims. The period from 2013 to 2017 had a total of 52,659 seriously injured patients due to RTAs. This was a significant difference of 24,316 seriously injured victims when looking at the first and the last time periods. It should be noted that the data collection for serious injuries in Canada was considered to be an estimation between 1998 to 2017, as several jurisdictions under-reported these numbers (44-58).

To describe the number of fatalities caused by RTAs in accordance with national road safety strategies, the yearly number of fatalities show a trend decrease from 1999 to 2018 (44-58). The steepest decrease in fatalities occurred between 2005 and 2011, where there was a 30% decrease in fatalities (33). This decrease correlates with final half of the second national road safety strategy, RSV 2010 (20). To look at a long -term trend, from the year 2000 to 2017, there was an average 37% decrease in annual road traffic fatalities (33). The graph begins to flatten out around the year 2012, but with the implementation of the RSV 2015 in 2010, the decline begins to steepen again nearing the end of that national program. During our final study cluster, between 2013 and 2017, there was an average of only 2.3% drop in fatalities per year (33).

In the final years of the study, from 2016 to 2017, there was a 2.8% decrease in fatalities due to RTAs. A decrease from 1,895 fatally injured victims to 1,841. This same timeframe saw a 7.4% decrease in serious injuries, from 10,760 down to 9,960. Canada reached the lowest number on record for number of fatalities per 100,000 population at 5.0. This was a decrease from 5.2 as seen in 2016 (58).

The age of victim involved in fatal road traffic accidents is an interesting descriptive parameter. In all three-time clusters, the 65 and over category have had the highest average number of fatalities, when broken down into age groups. This was shortly followed by the 25 to 34 age groups. Analysis has shown that injuries were mostly sustained by the 25 to 34 age group, followed by the 35 to 44 categories, in all time periods. This shows that the elderly are at a higher risk of mortality when involved in an RTA, while a younger person would have a higher risk of suffering an injury when involved in a vehicle collision. This discrepancy between injuries and fatal injuries may be due to the increased frequency of additional comorbidities contributing to severity of RTAs in the elderly population, but more study would be needed to confirm (44-58). When compared to the WHO's *Global Status Report on Road Safety*, this differs from the global statistic, which implies that ages five to twenty-nine have a higher rate of fatal injuries when involved in a vehicle collision (19). When viewing long-term trend, from 2000 to 2017, the number of RTA fatalities reduced in all age groups. The steepest reduction in fatalities during this time period occurred among the 15 -to 17- year old's, who had approximately 70% fewer deaths. Young Canadians in general have seemed to benefit from Canada's national safety programs, with every age category up to 24 years of age seeing a minimum decrease of 50% or more. The older age group of over 65 years saw a decrease in mortality rate by 17.1% between 2016 and 2017 (33).

Geography is also an interesting descriptive parameter that could be used to compare RTA fatalities across Canada between provinces and territories. But, due to Canada's vast landmass and diverse population demographics, it is not of statistical significance. For example, the northern territory of YT has a small population of 31,000 residents and only 4,800 km of road. It therefore has the highest per-capita road network in the entire country of more than 155 km of road for 1000 residents (11). When compared to the other provinces with much higher populations and lower per-capita road network, YT seems to have a skewed increase in fatal RTAs. When viewed as number of fatalities and serious injuries per 100,000 licensed drivers, rather than 100,000 population, YT still remains high, there is greater representation from provinces and territories such as NT, NU, and SK.

The type of road user makes a considerable difference in how to aim the national strategies. Although our study showed that in each of the five-year timeframes, drivers were consistently representing the majority of fatalities in an RTA. This sector should also take into account the vulnerable road user. This category of road user is generally unprotected and are often not using the roads at the same velocity as most other vehicles. In 2006, vulnerable road users made up 24% of road users seriously or fatally injured in an RTA. Among this population, pedestrians accounted for 56% of fatally injured vulnerable road users and 50% of those with serious injuries. During this same year, motorcyclists made up 33% of vulnerable road user fatalities and 36 percent of seriously injured. Finally, bicyclists during 2006 made up 11% of fatally injured road users and 13% of serious injuries (60). As of 2017, pedestrians made up 16% of RTA fatalities, motorcyclists accounted for 11% and bicyclists made up only three percent of road traffic fatalities. The largest decrease occurred by pedestrians in 2007, where they suffered 13.3 fewer deaths compared to the year before (33).

When seatbelts are worn correctly, they can reduce the chances of death following an RTA by 47%, while decreasing the chance of serious injury by 52% (14). The NORP sub-committee has been standard committee in each of Canada's national road safety programs since the initial RSV 2001. The target if this committee is to obtain 95% seatbelt compliance of all occupants in a motor vehicle. Each annual NORP monitoring report gives a list of commentary and recommendations for each jurisdiction in order to increase the amount of people using this life-saving measure. During the period from 2004 to 2008, 36% of fatally injured drivers and 38% of fatally injured passengers were not wearing their seatbelts. It was estimated that during this time approximately 300 lives could have been saved from a fatal RTA by wearing a seatbelt (14). By 2010, the national compliance rate for seatbelt use was 95.3%. It is worth noting that in 2002, Transport Canada significantly modified the way it estimates rates of seatbelt usage. There was a more widespread representation of the urban and rural communities in all statistics thereafter. Therefore, the data represented in our analysis is all from the more current and updated methodology for measuring seatbelt compliance. NORP 2010 made a particular focus on the proper usage of child restraints in addition to its 95% of all occupant restraints. Provinces that territories that had seatbelt compliance rates above the national average of 95.3% at the time of the NORP 2010 report were, ON, SK, QC and BC (32). It is a clear and obvious fact that that as there was an increase in the use of seatbelts, the rate of vehicle occupant fatalities declined.

Speed has always been a contributing factor when assessing the manner and severity of an RTA. As of 2009, approximately 40% of speeding drivers in Canada involved in a fatal RTA were between ages of 16 and 24. Most of those fatally injured were the ones doing the speeding. In addition, approximately one-third of those speeding drivers involved in a fatal RTA have been drinking, according to the 2009 report. Urban roads at night were the primary location of fatal RTAs involving speed, young drivers and alcohol (14). In 2017, the final year of our analysis, approximately 22% of fatal crashes involved speeding. The last decade has seen a dramatic decline in RTAs related to inappropriate or excessive speed. In 2017 there was a 36% reduction in speed-related RTAs compared to the previous 2006 to 2010 time period (33).

Impaired driving, either by alcohol or mind-altering drugs has been an ongoing problem implicated in multiple fatal RTAs. In Canada, the maximum BAC in which a person is legally permitted to drive is 0.8 g/L. Most provinces and territories have a zero-tolerance BAC limit for novice drivers or those under the age of 21 (33). The rate of impaired driving had consistently decreased since 1986 until 2011, when it has since declined. The rate of impaired driving in 2015 was 65% lower than the rate measured in 1986. In contrast to alcohol-related RTAs, the number of drug-related driving incidents have been rising since 2009, as seen in

Figure 12 (61). Recent legislation for the recreational use of marijuana require the proper roadside and clinical methods of determining intoxication (33). Beginning in 2008, oral fluid specimens were collected as part of a roadside impaired driving investigation (59). In many Canadian jurisdictions, those who have been convicted of impaired driving may choose to have an alcohol ignition interlock placed on their automobile before being reissued their suspended driver's license, after a period of time decided by the court. If the ignition interlock is refused by the driver, they must complete their full suspension. It is possible to have a mandatory ignition interlock program in place for nine months before some drivers are reissued their license (14).

This analysis would be incomplete without discussing the limitations of this study, some of which have already been mentioned above. This analysis had a major focus on the number and median amount of fatalities and serious injuries due to road traffic accidents. In order to remove any population bias, the increased rate of motorization and use of alternate modes of transportation, such as public transport, should be noted. When analyzing the decrease rate of serious injuries between the three consecutive time periods, it should also be noted that the number of serious injuries is an estimation based on hospital admissions, due to underreporting of some jurisdictions. There was a noticed discrepancy in the national collision statistics as the reports progressed. Although the major parameters discussed in our study were revised for the most current reports, the descriptive data did not come with revision for previous reports as newer reports were released. Therefore, some of the descriptive parameters may have been analyzed using outdated statistics (44-58). Underreporting can also cause a grave limitation on this analysis, especially in more rural areas where law enforcement presence isn't as prevalent, creating an information bias. Many RTAs, especially if considered minor by the driver, go unreported, and therefore any injuries that might ensue would not be presented in the study. More analysis of the Canadian collision statistics and the national collision database, with updated data collection methodology, and inclusion of data such as weather and time of RTA, could help to pinpoint the exact demographics in which to focus Canada's next national safety strategy and guide future Canadian legislation.

Canada is among multiple other countries, such as Australia, Netherlands, France and Sweden, which have been on a steady decline in fatalities due to vehicle collisions. Even still, the number of fatalities due motor vehicle collisions are still unreasonably high. There are approximately 1.35 million deaths worldwide each year due to RTAs. Fatal collisions are the eighth leading cause of death of people all ages, and the number one cause of mortality for victims ages five to twenty-nine, globally (19). Much more study and intensive national and international programs are still needed for Canada, and the world to reach the ultimate goal of *Vision Zero.*

6. CONCLUSION

1. When viewed as a series of three consecutive five-year periods, there was a decrease in the median of fatal and serious injuries due to RTAs in Canada. A statistically significant decrease was observed when comparing serious injuries and fatalities between the three consecutive time clusters.
2. The age group with the highest average fatality rate was the elderly population of 65 and over. Conversely, there is a higher rate of injury among the 25 to 34 age group.
3. YT has the highest number of fatal RTAs per 100,000 population. Due to YT's small population and small length of road system, this comparison would not be of any worth.
4. In all three time periods, it was more likely for a fatal RTA to occur on a rural roadway when compared to urban roads.
5. The road user most likely to be fatally injured in an RTA is the driver in all three time periods. Followed by passengers, and then by the vulnerable road users.
6. Seatbelt compliance has become increasingly evident through the three time periods.
7. The rate of impaired driving due to alcohol has been decreasing throughout the time period analyzed. Unfortunately, the rate of impaired driving due to drugs has been rising.

7. REFERENCES

1. Statcan.gc.ca [Internet]. Statistics Canada: Geography [cited 2020 May]. Available from: https://www150.statcan.gc.ca/n1/pub/11-402-x/2012000/chap/geo/geo-eng.htm.
2. Britannica.com [Internet]. Encyclopedia Britannica: Demographic Trends [cited 2020 May]. Available from: https://www.britannica.com/place/Canada/Demographic-trends.
3. Tc.gc.ca [Internet]. Transport Canada. Road Transportation [cited 2020 May] Available from https://www.tc.gc.ca/eng/policy/anre-menu-3021.htm.
4. Thecanadianencyclopedia.ca [Internet] Gilchrist CW. Roads and Highways. The Canadian Encyclopedia. [updated 2015 March; cited 2020 June]. Available from: https://www.thecanadianencyclopedia.ca/en/article/roads-and-highways#.
5. Transcanadahighway.com [Internet]. Trans-Canada Highway: Trans-Canada Highway History [cited 2020 May]. Available from: https://www.transcanadahighway.com/General/highwayhistory-overview.asp.
6. Tc.gc.ca [Internet]. Transport Canada: The Trans-Canada Highway: Backgrounder [cited 2020 May]. Available from: https://www.tc.gc.ca/eng/policy/acg-acgd-menu-highways-2153.htm.
7. Statcan.gc.ca [Internet]. Statistics Canada: Vehicle registrations, by type of vehicle [cited 2020 May]. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=2310006701.
8. Tc.gc.ca [Internet]. Transportation in Canada 2018: Overview Report [cited 2020 May]. Available from: https://www.tc.gc.ca/documents/Transportation_in_Canada_2018.pdf.
9. Tc.gc.ca [Internet]. Transport Canada: Road Transportation - National Highway System [cited 2020 May]. Available from: https://www.tc.gc.ca/eng/policy/anre-menu-3042.htm.
10. Statcan.gc.ca [Internet]. Statistics Canada: Canada's Core Public Infrastructure Survey: Roads, bridges and tunnels, 2016 [cited 2020 May]. Available from: https://www150.statcan.gc.ca/n1/en/daily-quotidien/180824/dq180824a-eng.pdf?st=Xrr0PN7J.
11. Gov.nu.ca [Internet]. Government of Nunavut: Northern Connections: A Multi-Modal Transportation Blueprint for the North [cited 2020 May]. Available from: https://gov.nu.ca/sites/default/files/files/Northern_connections.pdf.
12. Dobbins HA. Nunavut, A Creation Story. The Inuit Movement in Canada's Newest Territory [dissertation]. Syracuse University; 2019.
13. Klar L. Traffic Law in Canada. The Canadian Encyclopedia 2016. Available from: https://thecanadianencyclopedia.ca/en/article/traffic-law.

14. Crss-2015.ccmta.ca [Internet]. Canadian Council of Motor Transport Administrators: Canada's Road Safety Strategy 2015 [cited 2020 Jun]. Available from: http://crss-2015.ccmta.ca/index.php.
15. Tac-atc.ca [Internet]. Transportation Association of Canada: Canadian Model Rules of the Road 2018 [cited 2020 June]. Available from: https://www.tac-atc.ca/sites/default/files/site/doc/Bookstore/english_for_publishing.pdf.
16. Justice.gc.ca [Internet]. Department of Justice: Impaired Driving Laws [cited 2020 June]. Available from: https://www.justice.gc.ca/eng/cj-jp/sidl-rlcfa.
17. Thecanadianencyclopedia.ca [Internet]. Walker K. Impaired Driving [updated 2013 December; cited 2020 June]. Available from: https://www.thecanadianencyclopedia.ca/en/article/impaired-driving.
18. Canadian Council of Motor Transportation Administrators. Canada's Road Safety Strategy 2025: Towards Zero: The Safest Roads in the World. CCMTA; 2016. 14 p.
19. World Health Organization. Global status report on road safety 2018. Geneva: World Health Organization; 2018. 424 p.
20. Canadian Council of Motor Transportations Administrators. Road Safety Vision 2010; Canada. CCMTA. 2013. 26 p.
21. Noxon G. Transportation in Canada: Transforming the Fabric of our Land. Ottawa: Transportation Association of Canada; 2013
22. Visionzero.ca [Internet]. The Safe Systems Approach for Road Safety [cited 2020 June]. Available from: https://visionzero.ca/the-safe-systems-approach-for-road-safety/#safe_systems.
23. International Transport Forum. Zero Road Deaths and Serious Injuries: Leading a Paradigm Shift to a Safe System. Paris: OECD Publishing; 2016.
24. James SL, Lucchesi LR, Bisignano C, *et al.* Morbidity and mortality from road injuries: results from the Global Burden of Disease Study 2017. *Inj Prev*. 2020. doi:10.1136/injuryprev-2019-043302.
25. Who.int [Internet]. Geneva: Global Health Observatory Data [cited 2020 June]. Available from: https://www.who.int/gho/road_safety/mortality/traffic_deaths_number/en/.
26. Who.int [Internet]. Geneva: Global Plan for the Decade of Action for Road Safety 2011-2020 [cited 2020 June]. Available from: https://www.who.int/roadsafety/decade_of_action/plan/global_plan_decade.pdf.

27. World Health Organization. Global Status Report on Road Safety 2013. Geneva: WHO Press; 2013. 318 p.
28. Khan MA, Grivna M, Nauman J, Soteriades ES, Cevik AA, Hashim MJ *et al*. Global incidence and mortality patterns of pedestrian road traffic injuries by sociodemographic index, with forecasting: findings from the Global Burden of Diseases, Injuries, and Risk Factors 2017 Study. Int J Environ Res Public Health. 2020. doi: 10.3390/ijerph1706213.
29. Who.int [Internet] World Report on Road Traffic Injury Prevention 2004 [cited 2020 June]. Available from: https://www.who.int/publications/i/item/world-report-on-road-traffic-injury-prevention.
30. Who.int [Internet}. World Health Organization. Managing 2017 [cited April 2020]. Available from: http://www.who.int/violence_injury_prevention/publications/road_traffic/managing-speed/en/.
31. Payne-James J, Jones R, Karch SB, Manlove J. Simpson's Forensic Medicine. 13th ed. Great Britain: Hodder Arnold; 2011. p. 142-150.
32. Ccmta.ca [Internet]. National Occupant Restraint Program 2010: Annual Monitoring Report 2010 [cited 2020 May]. Available from https://ccmta.ca/images/publications/pdf//norp_report10.pdf.
33. Itf-oecd.org [Internet]. International Transport Forum: Road Safety Annual Report 2019; Canada [cited 2020 June]. Available from: https://www.itf-oecd.org/sites/default/files/canada-road-safety.pdf.
34. Madd.ca [Internet]. Mothers Against Drunk Driving: Ideas, Action, Change: 2018-2019 annual report [cited 2020 May]. Available from: https://madd.ca/pages/wp-content/uploads/2019/10/19-MADD-0033-Annual-Report-2018-2019-FINAL_LORES_SINGLES.pdf.
35. DiMaio VJ, DiMaio D, Forensic Pathology. 2nd ed. Practical Aspects of Criminal and Forensic Investigation. CRC; 2001.
36. Emedicine.medscape.com [Internet]. Medscape: Cervical Sprain and Strain [cited 2020 June]. Available from: https://emedicine.medscape.com/article/306176-overview.
37. Brown S, Vanlaar WGM, Robertson RD. Fatigue-Related Fatal Collisions in Canada, 2000-2016. Traffic Injury Research Foundation; 2020.
38. World Health Organization. Save Lives - A Road Safety Technical Package. Geneva: WHO; 2017. License: CC BY-NC-SA 3.0 IGO.

39. Emergency Medical Services Chiefs of Canada. The Future of EMS in Canada: Defining the New Road Ahead. Calgary; 2006.
40. Andrey J, Mills B, Vandermolen. Weather Information and Road Safety. Institute for Catastrophic Loss reduction; 2001. Paper Series No. 15.
41. Traffic Injury Research Foundation. Wildlife-Vehicle Collisions in Canada: A Review of the Literature and a Compendium of Existing Data Sources. Ottawa; 2012.
42. Tirf.ca [Internet]. Wildlife Vehicle Collisions: 2000-2014; Canada [cited 2020 June]. Available from: https://tirf.ca/wp-content/uploads/2017/10/WRRC-Wildlife-Vehicle-Collisions-2000-2014-Factsheet-5.pdf.
43. Paramedic.ca [Internet]. Paramedic Association of Canada October 2011: National Occupational Competency Profile for Paramedics; Canada [cited 2020 June]. Available from: https://www.paramedic.ca/uploaded/web/documents/2011-10-31-Approved-NOCP-English-Master.pdf.
44. Tc.gc.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2003 [cited 2020 June]. Available from: https://www2.tc.gc.ca/media/documents/roadsafety/3322e03s-2003.pdf.
45. Tc.canada.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2004 [cited 2020 June]. Available from: https://tc.canada.ca/sites/default/files/migrated/st2004e.pdf.
46. Tc.canada.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2005 [cited 2020 June]. Available from: https://tc.canada.ca/sites/default/files/migrated/st2005es.pdf.
47. Tc.canada.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2006 [cited 2020 June]. Available from: https://tc.canada.ca/sites/default/files/migrated/tp3322e.pdf.
48. Tc.canada.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2007 [cited 2020 June]. Available from: https://tc.canada.ca/sites/default/files/migrated/tp3322_2007.pdf.
49. Tc.canada.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2008 [cited 2020 June]. Available from: https://tc.canada.ca/sites/default/files/migrated/tp3322_2008.pdf.
50. Tc.gc.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2009 [cited 2020 June]. Available from: www.tc.gc.ca/eng/roadsafety/tp-tp3322-2009-1173.htm.

51. Ccmta.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2010 [cited 2020 June]. Available from: ccmta.ca/images/publications/pdf//2010-Collision-Brochure-English.PDF.
52. Tc.gc.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2011 [cited 2020 June]. Available from: https://www2.tc.gc.ca/media/documents/roadsafety/trafficcollisionstatisitcs_2011.pdf.
53. Tc.canada.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2012 [cited 2020 June]. Available from: www2.tc.gc.ca/media/documents/roadsafety/cmvtcs2012_eng.pdf.
54. Tc.gc.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2013 [cited 2020 June]. Available from: https://www2.tc.gc.ca/en/services/road/documents/cmvtcs2013_eng.pdf.
55. Tc.gc.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2014 [cited 2020 June]. Available from: http://www.tc.gc.ca/media/documents/roadsafety/cmvtcs2014_eng.pdf.
56. Tc.gc.ca [Internet]. Transport Canada: Canadian Motor Vehicle Traffic Collision Statistics 2015 [cited 2020 June]. Available from: https://www2.tc.gc.ca/media/documents/roadsafety/canadian_motor_vehicle_traffic_collision_statistics_2015-en.pdf.
57. Tc.gc.ca [Internet]. Government of Canada: Canadian Motor Vehicle Traffic Statistics 2016; Canada [cited 2020 June]. Available from: https://www.tc.gc.ca/en/services/road/publications/canadian-motor-vehicle-traffic-collision-statistics-2016.html.
58. Tc.gc.ca [Internet]. Government of Canada: Canadian Motor Vehicle Traffic Statistics 2017; Canada [cited 2020 June]. Available from: https://www.tc.gc.ca/eng/motorvehiclesafety/canadian-motor-vehicle-traffic-collision-statistics-2017.html.
59. Canadian Centre on Substance Use and Addiction. Impaired Driving in Canada. Canada. 2019. 7p.
60. Canadian Council of Motor Transportations Administrators: Vulnerable Roads Users Strategy; Ottawa, Canada. CCMTA's Standing Committee on Road Safety Research and policies. 2009. 12 p.

61. Www.150/statcan.gc.ca [Internet]. Statistics Canada: Impaired Driving in Canada, 2015. Canada [cited 2020 July]. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/161214/dq161214b-eng.htm.

8. SUMMARY

Objective: The objective of this study was to analyze conditions relating to road traffic safety in Canada from 2003 to 2017. We investigated the RTAs resulting in fatal or serious injuries by comparing three five-year time clusters, 2003 to 2007, 2008 to 2012, and 2013 to 2017, in accordance with Canadian national road safety strategies.

Subjects and Methods: This was a retrospective study. Data was collected by using the Canadian Motor Vehicle Traffic Collision Statistics reports from 2003 to 2017. Information regarding impaired driving in Canada was obtained from the Canadian Centre on Substance Use and Addiction, while seatbelt usage was obtained from the Canadian Council of Motor Transport Administrator's NORP reports. The research focuses on three consecutive five-year periods: 2003-2007, 2008-2012, and 2013-2017. Analysis done to compare the difference among the three time-period clusters for the major RTA outcomes: fatal collisions, fatalities, injuries and serious injuries. Descriptive data such as age, location and driving impairment, helped illustrate RTA demographics to aid in future study methodologies.

Results: During 2003 to 2007, the median number of fatalities was 2,768 (2,755.8-2,877.0). This number made a significant decrease going into the second time cluster with a median of 2,216 (2,062.8-2,286.3). When the final time period is taken into account, with a median of 1889 (1846.3-1909.8), there is a decrease of 879 fatalities. The initial five-year time period showed a median of 15,605 (14,930.5-15,870.0) serious injuries. There was a decrease to 11,796 (11,072.0-12,179.0) in the second data cluster from 2008 to 2013. The third time period showed a median of 10,662 (10206.5-10783.8) serious injuries. When comparing the three five-year periods in terms of fatal collisions, fatalities, injuries and serious injuries with the Kruskal-Wallis test, each was statistically significant (P=0.002).

Conclusion: There was a significant decrease in the amount of injuries, serious injuries, fatal collision and fatalities when compared as three consecutive sets of five-year clusters. The average age of fatalities due to motor vehicle collisions is the 65 and over age group, where more injuries were sustained mostly by the 24 to 34 age group. Impaired driving due to alcohol has seen a decrease, while drug-induced road fatalities unfortunately made an increase.

9. CROATIAN SUMMARY

Naslov: Sigurnost cestovnog prometa u Kanadi u razdoblju 2003-2017.

Cilj: Cilj studije bio je analizirati uvjete koji su povezani sa sigurnošću prometa na cestama u Kanadi u razdoblju 2007. do 2017. Analizirane su prometne nesreće sa smrtnom posljedicom u tri petogodišnja razdoblja (2003.-2007., 2008.-2012. i 2013.-2017.) u skladu sa obuhvatom kanadske "Nacionalne strategije sigurnosti prometa na cestama".

Materijal i metode: Rad je napravljen kao retrospektivna studija. Podaci su prikupljeni iz kanadskih "Statističkih izvještaja o prometnim nesrećama" iz razdoblja 2003.-2017. Podaci koji su obuhvaćali vožnju pod utjecajem pribavljeni su iz "Kanadskog centra za ovisnosti" dok su se podaci o korištenju sigurnosnog pojasa dobili iz "NORP" izvještaja Kanadskog vijeća za motorna vozila. Istraživanje se fokusira na tri uzastopna petogodišnja razdoblja (2003.-2007., 2008.-2012. i 2013.-2017.). Statistička obrada je izvedena koristeći Kruskal-Wallis test za usporedbu navedenih razdoblja po ishodima prometnih nesreća (broj smrtonosnih nesreća, žrtve, ozljede i teške ozljede). Deskriptivni podaci kao što su dob, lokacija i vožnja pod utjecajem su analizirani kako bi se prikazala demografaka slika cestovnih prometnih nesreća u svrhu budućih istraživanja i metodologije.

Rezultati: U razdoblju 2003.-2007. medijan nesreća bio je 2,768 (2,755.8-2,877.0). Ovaj broj se značajno smanjio u drugom analiziranom razdoblju sa medijanom od 2,216 (2,062.8-2,286.3). I u trećem analiziranom razdoblju pad je bio još veći (za 879) sa medijanom 1889 (1846.3-1909.8). Prvo petogodišnje razdoblje pokazalo je medijan od 15,605 (14,930.5-15,870.0) ozbiljnih ozljeda sa padom na 11,796 (11,072.0-12,179.0) u drugom i 10,662 (10206.5-10783.8) u trećem istraživanom razdoblju. Kada se usporede tri petogodišnja razdoblja u smislu nesreća sa smrtnom posljedicom, žrtava, broja ozlijeđenih i teško ozlijeđenih koristeći Kruskal-Wallis test, svaki je bio statistički značajan ($p=0.02$).

Zaključak: Postoji značajan pad u broju ozljeda, teških ozljeda, broja smrtno stradalih i nesreća sa smrtnom posljedicom tijekom istraživanih uzastopnih petogodišnjih razdoblja. Analiza je također dala i nekoliko zanimljivih deskriptivnih rezultata. Prosječna dob smrtno stradale osobe u prometu je bila u dobnoj skupini 65 i više, dok je najviše ozlijeđenih bilo u skupini 24-34 godine. Prometne nesreće su bile češće na ruralnim cestama nego u urbanim sredinama. Tijekom godina je primiječen stalni porast korištenja sigurnosnog pojasa u Kanadi. Opažen je i pad vožnje pod utjecajem alkohola dok su se slučaji vožnje pod utjecajem drugih sredstava ovisnosti na žalost povećali.

10. CURRICULUM VITAE

Personal information

Name: Jeremy Moore

Date and place of birth: May 24, 1988, St. John's, Canada.

Citizenship: Canadian

Address: St. John's, Newfoundland, Canada

E-mail: jermoore20@gmail.com

Education:

2014-2020. Medical Studies in English, University of Split School of Medicine, Split, Croatia.

2012-2013. PPA-International. EMT-Paramedic, Aalborg, Sarajevo, and Pula

2008. College of the North Atlantic. Primary Care Paramedic

2002-2006. Laval high School. Placentia, Newfoundland, Canada

Employment History

2010-2014. College of the North Atlantic-Qatar, Doha Qatar. Instructor, Paramedicine

2009-2010. Moores' Ambulance Service, Harbour Grace Canada. Primary Care Paramedic.

2008-2009. Industrial Paramedic Services, Whitecourt Canada. Primary Care Paramedic.

Language:

English (mother language)

Croatian (A2)