



## Fatal and serious injuries related to vulnerable road users in Canada

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### ABSTRACT

**Introduction:** The goals of this study were to analyze possible trends of fatal and serious injuries related to vulnerable road users in Canada (pedestrians, cyclists and motorcyclists) from 1990 to 2012 and the role of alcohol and drugs in these cases. Drugs have rarely been documented with respect to vulnerable road users. **Method:** The Traffic Injury Research Foundation's National Fatality and Serious Injury Databases and the Public Health Agency of Canada's Canadian Hospitals Injury Reporting and Prevention Program databases were used. Numbers and rates of fatalities and serious injuries among vulnerable road users were analyzed and regression models were used to assess changes over time. **Results:** The analyses show that while the absolute number of fatalities and the rate per 100,000 population among vulnerable road users may be decreasing, no such trends are apparent when looking at the proportions of these road user fatalities out of all motor-vehicle fatalities. The trend for the proportion of motorcyclist fatalities is significantly increasing (coef. = 0.16,  $p < 0.001$ ). The elderly (76 years or older) are overrepresented among pedestrian fatalities, and serious injuries (they represent 18.5% of all pedestrian fatalities but only 5.8% of the population), while those 15 years or younger are overrepresented among cyclists (they represent 23.3% of cyclist fatalities but 19.5% of the population), and those 16 to 25 years old are overrepresented among motorcyclists (27.2% of motorcyclists fatalities and 13.6% of population). Alcohol and drug use among fatally injured vulnerable road users were significant problems, especially among pedestrians. Among fatally injured pedestrians tested for alcohol and drugs, 39.7% and 43.4% tested positive, respectively. **Conclusions:** With the promotion of walking and cycling as forms of exercise and the popularity of motorcycling, the safety of vulnerable road users is an important issue. The results corroborate previous research and extend our understanding about the influence of alcohol and drugs in vulnerable road user injuries. **Practical applications:** These findings can help better inform prevention and mitigation initiatives for vulnerable road users.

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### 1. Introduction

Modern motor vehicles have a variety of safety features that protect occupants in the event of a crash. Seatbelts, airbags, and crumple zones are among the built-in features designed to increase survivability of vehicle occupants during a motor-vehicle collision. In contrast, road users who do not have the benefit of this level of protection, like pedestrians, bicyclists, and motorcyclists, face potentially devastating consequences when involved in crashes. Due to the relative safety disadvantages of this group, they are often referred to as vulnerable road users (VRUs).

The vulnerability of pedestrians, cyclists, and motorcyclists is demonstrated by their overrepresentation in the total number of road user injuries and fatalities. According to the World Health Organization (WHO), 50% of global fatal road traffic injuries are sustained by VRUs (WHO, 2015a). VRUs account for a greater proportion of road traffic

deaths in low-income (57%) and middle-income (51%) countries, than in high-income countries (39%; WHO, 2013). In Canada, in 2013, the share of VRUs among road traffic fatalities was 29.1%, below the WHO reported average for high-income countries. Specifically, 15.6% of all road traffic deaths were pedestrians, 10.3% were motorcyclists, and 3.2% were bicyclists according to Transport Canada and the Canadian Council of Motor Transport Administrators (2015). Although the proportion of VRU fatalities in Canada was below the global proportion, the 2013 numbers increased in comparison to the percentages of VRUs among all road traffic deaths recorded in 2010. In that year, 13.7% of all road traffic deaths were pedestrians, 8.6% were motorcyclists, and 2.8% were bicyclists, according to Transport Canada and CCMTA (2015).

Pedestrians are generally the least protected VRUs and older persons are overrepresented among injured pedestrians. Specifically, in Canada during the period of 2004–2008, 35% of fatally injured pedestrians were 65 years of age or older, while this age group made up only 13% of the total population (Transport Canada, 2011). Seniors are at a higher risk for a variety of reasons, including their relative physical frailty; natural declines in visual and perceptual capacities; and limits to their mobility,

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which lengthen the time required to cross the road (Robertson & Vanlaar, 2008). People aged 56 and older are the least likely to be injured in a bicycle-related crash, but have the worst prognosis in the event of a crash (Kim, Kim, Ulfarsson, & Porrello, 2007). Children and teens under 18 are most often injured in bicycle crashes, particularly children aged 10–16, however their prognoses are generally the best (Siman-Tov, Jaffe, Israel Trauma Group, & Peleg, 2012; Kim et al., 2007). Of all the VRUs, motorcyclists are arguably the most susceptible to very severe injury in the event of a collision. This is largely due to the speeds reached by motorcycle riders compared to bicyclists and pedestrians, and their physical proximity to motor vehicles (as opposed to bicyclists and pedestrians who may also use bike lanes/paths and sidewalks). Motorcyclists have been estimated to be seven times more likely to crash than drivers of motor vehicles in Alberta (Monk, Buckley, & Dyer, 2009). In New Zealand comparing new motorcycles with new cars, the odds of fatal or serious injury to a motorcycle rider involved in an injury crash were almost eight times the odds for a car driver (Keall & Newstead, 2012). In the United States, the fatality rate per registered vehicle for motorcyclists in 2013 was 6 times the fatality rate for passenger car occupants (NHTSA, 2015).

Alcohol and drug use among VRUs, particularly the involvement of drugs, has not been the subject of many studies. In 2010, 45.8% of fatally injured pedestrians tested positive for alcohol on Canadian roadways (Brown, Vanlaar, & Mayhew, 2013). Thirteen percent of motorcyclists fatally injured in Canada between 2004 and 2006 had consumed alcohol prior to their crash, and this was highest at 23% among the 25–34 age group (Transport Canada, 2009). Little is known about the influence of alcohol in bicycle crashes in Canada (Vanlaar, Marcoux, & Robertson, 2009). As a comparison, in 2013 in the United States, 24% of fatally injured pedalcyclists (cyclists powered solely by pedals) and 28% of fatally injured motorcyclists were alcohol-impaired (blood alcohol concentration (BAC) of 0.08 g/dL or higher; NHTSA, 2015). In 2011 in the United States, 37% of fatally injured pedestrians had a BAC of 0.08 g/dL or higher (Eichelberger, Cicchino, & McCartt, 2013).

The goal of this paper is to investigate VRU injuries in Canada over an extended period of time (from 1990 until 2012) and to gain an understanding of possible injury trends among these road users. A previous study that focused on off-road vehicles was conducted using similar Canadian data between 1990 and 2010 (Vanlaar et al., 2015). Furthermore, this paper seeks to investigate the role of alcohol and drugs in fatal VRU crashes.

## 2. Methods

### 2.1. Data sources

#### 2.1.1. TIRF databases

This study involved the analysis of data on VRUs from 1990 to 2012 contained in two databases managed by the Traffic Injury Research Foundation (TIRF). The first, TIRF's National Fatality Database, includes information on persons fatally injured in motor vehicle collisions in Canada derived from both coroner medical examiner files and police collision reports. This database contains toxicological data for fatally injured victims. Toxicological data on alcohol use among victims are obtained from files in coroners' and medical examiners' offices. The alcohol data are the results of chemical tests performed on body fluid samples (typically blood). Specific to drug use, the data collected contain approximately 500 codes for different drugs and have been consistently collected since 2000. The drug types can be more broadly classified into seven groups according to the Drug Classification Evaluation categories (i.e., cannabis, CNS-depressants, CNS-stimulants, narcotic analgesics, hallucinogens, dissociative anesthetics, and inhalants; Brown, Vanlaar, & Robertson, 2015). The second database, the Serious Injury Database, includes information on seriously injured persons (i.e., a person admitted to a hospital after being involved in a crash) in Canada and is based on police-reported data. This database does not

contain toxicological data. Both of these databases contain the "population" of fatalities and injuries in Canada, rather than a sample. A more detailed description of how these data are collected and the procedures used to create both databases (including definitions) is available in Mayhew (2011).

#### 2.1.2. Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP)

CHIRPP data from 1990 to 2010 were also analyzed. CHIRPP is an emergency department based injury surveillance system operated by the Public Health Agency of Canada (PHAC), in which there are currently 11 pediatrics and 6 general hospitals participating (although for this study data from only 4 general hospitals and the 11 pediatrics were available). Almost 3 million records have been collected nationally since CHIRPP's establishment in 1990 (Crain et al., in press, Mackenzie & Pless, 1999). This database does not contain toxicological data. Although not population-based, a number of studies have shown CHIRPP to be representative of Canada in some contexts such as sport and recreational injury data in Calgary, when compared to regional health administrative data (Kang, Hagel, Emery, Senger, & Meeuwisse, 2013); injuries at Montreal Children's Hospital that were not injuries resulting in admissions, poisonings, and those presenting overnight (Macarthur & Pless, 1999a); younger children or children with severe injuries at the Children's Hospital of Eastern Ontario (Macpherson et al., 2008); and external causes of injury and injury patterns suggesting priorities for intervention in Canadian youth aged 11–15 (Pickett et al., 2000).

#### 2.1.3. Other data

Readily available exposure data for VRUs is limited. In this regard, information on population and registered motorcycles was obtained from Statistics Canada (Statistics Canada, 2014, 2015) and from the Motorcycle and Moped Industry Council (MMIC, 2013). To compare data for VRUs with data for passenger vehicles (PV: automobile, vans and light trucks), PV data from the TIRF databases on fatally and seriously injured were also used.

### 2.2. Data analysis

The data analyses used Stata software (StataCorp, 2013) and involved trend analysis of the frequencies, rates and proportions of fatalities and serious injuries; the characterization of the victims in terms of gender, age and type of VRU; the nature of the serious injuries; and, the level of alcohol or presence of drug found in fatal victims. Note that data from TIRF do not include British Columbia (BC) as data for some years for BC were missing. For the same reason, analysis of the serious injury data excludes information from Nunavut (NU) and Newfoundland and Labrador (NL).

Fatalities and serious injuries per 100,000 population were presented as crude rates as well as age-specific rates. Motorcycle fatality and serious injury rates per registered motorcycles were also presented. Linear regression models were estimated to assess possible significant trends over time on these rates for each type of VRU and on the proportion of VRU fatalities and serious injuries among all fatalities and serious injuries in road crashes. A logistic regression model determined the association of VRU type, sex and age with a fatal outcome among all fatalities and serious injuries. Results were considered significant if corresponding p-values were below 0.05. Age and gender distribution of VRUs involved in fatal and serious injuries are presented for each type of VRU.

The most common types of serious injuries were analyzed based on CHIRPP data. Three CHIRPP narrative (free text) fields allowed for a detailed level of classification and identification of very specific injury circumstances. Records of injuries sustained by VRUs were identified using the CHIRPP's Injury Group variable, and an extensive bilingual (English and French) narrative-based search was used to verify that identified cases met the study criteria, including the removal of ineligible cases.

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