Exposure-based Traffic Crash Injury Rates by Mode of Travel in British Columbia

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ABSTRACT

BACKGROUND: Traffic-related trauma is an important contributor to morbidity and mortality in Canada, especially among children and young adults. Comparing exposure-based injury rates between travel modes and jurisdictions is a valuable tool towards improving safety.

METHODS: We used injury data from the British Columbia Motor Vehicle Branch, trip diary data from the Metro Vancouver transportation authority, and population and provincial travel data from the Census to calculate crude fatality and injury rates for motor vehicle occupants, bicyclists, and pedestrians. We used three different denominators: population; person-trip; and distance travelled.

RESULTS: Motor vehicle occupants had the lowest fatality rates using exposure-based denominators: 9.6 per 100 million person-trips and 0.97 per 100 million km. Bicyclists and pedestrians had similar fatality rates using one denominator (13.8 vs. 14.7 per 100 million person-trips, respectively), but bicyclists had a lower rate using the other (2.60 vs. 7.37 per 100 million km). For injuries, pedestrians had the lowest rate and bicyclists the highest using the person-trip denominator, whereas motor vehicle occupants had the lowest rate using the distance denominator, and bicycling and walking had similar rates.

CONCLUSIONS: Risks of driving, walking and bicycling in British Columbia were similar to their risks in the United States. The injury and fatality rates for these three travel modes were intermediate compared to much higher rates among US motorcyclists and much lower rates among US bus passengers. Data improvements would enable transportation trauma rate calculations for Canada as a whole and for other modes of travel (transit, motorcycling).

KEY WORDS: Traffic accidents; walking; bicycling; automobile driving; active transportation

La traduction du résumé se trouve à la fin de l'article.

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Unintentional injuries are the fifth leading cause of death in Canada and the leading cause of death of those between the ages of 1 and 44.[1,2] Traffic crashes are the cause of about one quarter of these fatalities (estimates for 2008: n=2,628, Statistics Canada; n=2,419, Transport Canada).[3,4] Non-fatal injuries from traffic crashes affect many more Canadians, with about 176,000 police-reported injuries annually and between 12,000 and 20,000 hospitalizations (n=12,360 in 2008, Transport Canada; n=20,140 in 2005/6, Public Health Agency of Canada).[4,5]

Despite the importance of these injuries to public health, we have much to understand about traffic-related morbidity and mortality in Canada. International agencies, including the Organisation for Economic Co-operation and Development and the World Health Organization, have focused attention on road safety and have developed profiles by country to allow comparisons and provide opportunities to discover best practices.[6,7] One way to compare data is to examine mortality and morbidity rates for the population as a whole. Such rates are straightforward to calculate using death and injury numerators and census denominators, and Canadian contributions to international databases have included these rates (e.g., Figure 1).

Injury risks vary by mode of transportation (e.g., car, bicycle, walking, motorcycle, transit).[8-10] Understanding these differences is important for prevention. However, since travel modes are not used equally, injury rates calculated with a population denominator may reflect differences in the share of trips rather than differences in risk between modes. "Exposure-based" denominators take into account proportions of trips or distances travelled by each mode, and provide a better basis for comparisons. Some countries conduct national travel surveys that provide such denominator data.[6,8-10] In Canada, there is no national travel survey. The long-form Census includes a question querying the usual mode of travel to work, but it excludes those not in the workforce and non-work trips of those who are. This means that in international comparisons, we cannot benchmark rates of injury and death for each mode of travel.

To begin to provide exposure-based rates in Canada and show their value, here we use data from one province, British Columbia (BC), to calculate crude injury and death rates for three road user classes: motor vehicle occupants, pedestrians, and bicyclists. Incomplete data are provided for motorcyclists and transit users.

METHODS

We gathered data about injuries, fatalities, and travel by each mode. The data were used to calculate injury and fatality rates using three

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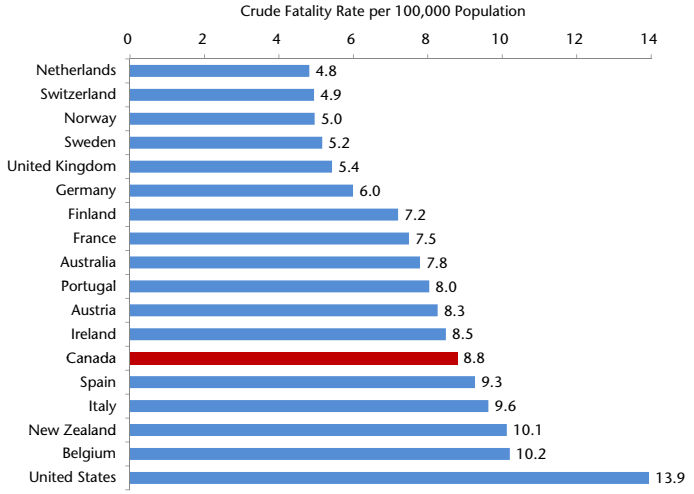
Figure 1. Crude road traffic fatality rates per 100,000 population, all transportation modes, selected countries[7]



commonly used denominators:[6,8,9] per 100,000 population; per 100 million person-trips; and per 100 million kilometres travelled.

We used three published data sources. Population-level injury data were abstracted from the British Columbia Motor Vehicle Branch "Traffic Collisions Statistics, Police-attended Injury and Fatal Collisions". The three most recent years for which data were available (2005, 2006, 2007) were used.[11-13] The 2008 Regional Trip Diary Survey (n=17,603 households) conducted by TransLink (the Metro Vancouver regional transportation authority) was used to provide the average number of trips by all modes, average distances travelled per trip by each mode, and the proportions of all trips by each mode in Metro Vancouver (including both work and non-work trips of employed persons, and trips by youth, the elderly and others not in the workforce).[14] The Census of Canada provided the population of BC in 2006.[15] Data from the long-form Census (20% of population) was used to adjust the Metro Vancouver trip data to the province as a whole, using the ratio of proportions of employed people travelling to work by each mode at the Metro Vancouver and BC levels.[16]

Annual crude fatality and police-reported injury rates were calculated by dividing the number of injury events, averaged over the three years, by one of the three denominators: BC population; person-trips; and km travelled. The latter two exposure-based denominators were calculated as follows:

Person-trips, mode 1 = $[\%A_{1,V} * T_V * P_{BC} * \%W_{1,BC}] / \%W_{1,V}$ [1]

where

$\%A_{1,V}$ = % of all Metro Vancouver trips by this mode;

T_V = average number of trips of all types per person per year in Metro Vancouver;

P_{BC} = population of BC;

$\%W_{1,BC}$ = % of BC working population usually using this mode to travel to work;

$\%W_{1,V}$ = % of Metro Vancouver working population usually using this mode to travel to work.

Distance travelled, mode 1 = $[\%A_{1,V} * T_V * D_{1,V} * P_{BC} * \%W_{1,BC}] / \%W_{1,V}$ [2]

where $D_{1,V}$ = average trip distance by this mode in Metro Vancouver.

Table 1. Annual Numbers of Fatalities and Police-reported Injuries (means and standard errors (SE)) in Traffic Crashes in British Columbia Over the Period 2005 to 2007 Inclusive, by Road User Class*[8-10]

	Fatalities		Injuries	
	Mean	(SE)	Mean	(SE)
Drivers and passengers	300.7	(16.2)	22,274	(624)
Pedestrians	70.7	(1.8)	1880	(18)
Motorcyclists and passengers	46.0	(1.5)	1061	(17)
Bicyclists	9.7	(1.5)	982	(46)

* Data not available for transit riders.

RESULTS

Table 1 presents the numerator data used for the rate calculations: the annual average numbers of fatalities and police-reported injuries of motor vehicle drivers and passengers, pedestrians, motorcyclists and passengers, and bicyclists in British Columbia in the period 2005 to 2007.[11-13] Motor vehicle drivers and passengers had the highest numbers of injuries, followed by pedestrians, motorcyclists and passengers, then bicyclists.

Table 2 presents the denominator data used for the rate calculations: the estimated annual number of person-trips and the estimated annual distance travelled by motor vehicle drivers and passengers, pedestrians, transit users, and bicyclists in British Columbia.[14,16] Motor vehicle drivers and passengers had the highest annual number of trips and distance travelled, followed by pedestrians or transit users (depending on the measure), then bicyclists.

Table 3 presents the crude fatality and injury rates per 100,000 population, per 100 million person-trips and per 100 million km travelled by travel mode. Using the population denominator suggests that driving was the least safe travel mode, more dangerous even than motorcycle travel. However, rates using the population denominator reflect burden, not risk. Using the exposure-based denominators provides risk estimates. Based on either person-trips or distance travelled, motor vehicle occupants had the lowest fatality rates of the three travel modes for which these denominators were available. Bicyclists and pedestrians had similar fatality rates based on the person-trip denominator, but bicyclists had a lower rate using the distance denominator. For injuries, the picture is somewhat different: pedestrians had the lowest rate and bicyclists the highest using the person-trip denominator, whereas using the distance denominator, motor vehicle occupants had the lowest rate and the other two modes had similar rates.

DISCUSSION

This analysis allows comparisons of risk between modes of travel in British Columbia. It makes clear that the reason motor vehicle occupants have the highest numbers of injuries, followed by pedestrians, then bicyclists is that the numbers of person-trips and the distances travelled by these three modes follow that order. Once exposure-based denominators are taken into account, the injury rates by mode of travel are not ordered the same way for fatalities and injuries, nor for the two different denominators.

The relative merits of the two exposure-based denominators can be debated. If a trip is a prescribed distance (e.g., a trip to work or school), then the distance denominator is likely best for comparing risks. But if a trip destination is selected differently based on the mode of travel (e.g., where to buy groceries), the trip denominator

Table 2. Estimated Percent of Trips, Annual Numbers of Trips, Average Trip Distances and Annual Distances Travelled, by Road User Class*, Data From 2008 Trip Diary Survey[11] and 2006 Census[13]

	Percent of All Trips	Annual Number of Trips	Average Trip Distance (km)	Annual Distance Travelled (km)
Drivers and passengers	78.6	3,125,479,000	10.0	31,107,465,000
Pedestrians	12.1	479,347,000	2.0	958,694,000
Transit riders	7.87	312,948,369	12.0	3,755,380,434
Bicyclists	1.76	70,214,000	5.3	372,132,000

* Separate data not available for motorcyclists and passengers.

Table 3. Estimated Crude Traffic Crash Fatality and Injury Rates in British Columbia, by Road User Class*, With Population, Person-trip and Distance Travelled Denominators

		Exposure-based Fatality and Injury Rates			
	Annual Fatalities per 100,000 Population†	Fatalities per 100 Million Person-trips	Fatalities per 100 Million km	Injuries per 100 Million Person-trips	Injuries per 100 Million km
Drivers and passengers	7.31	9.6	0.97	713	72
Pedestrians	1.72	14.7	7.37	392	196
Motorcyclists and passengers	1.12	–	–	–	–
Bicyclists	0.24	13.8	2.60	1,398	264

* Numerator data not available for transit riders, so no rates could be calculated.
† Population of British Columbia, 2006 Census = 4,113,487.[12]
– Denominator data not available for exposure-based rate calculations.

may be more appropriate. Some commentators suggest that time spent using each mode would be the most appropriate denominator.[9] Such data are rarely collected, but rates based on a trip denominator would provide an inter-modal comparison similar to a time denominator, since trips by each mode are more comparable in time than in distance. A recent study in Belgium provided rates in terms of years of life lost (YLL) and disability adjusted life years (DALY) per distance travelled by each mode.[10] It takes into account both age distribution and injury type.

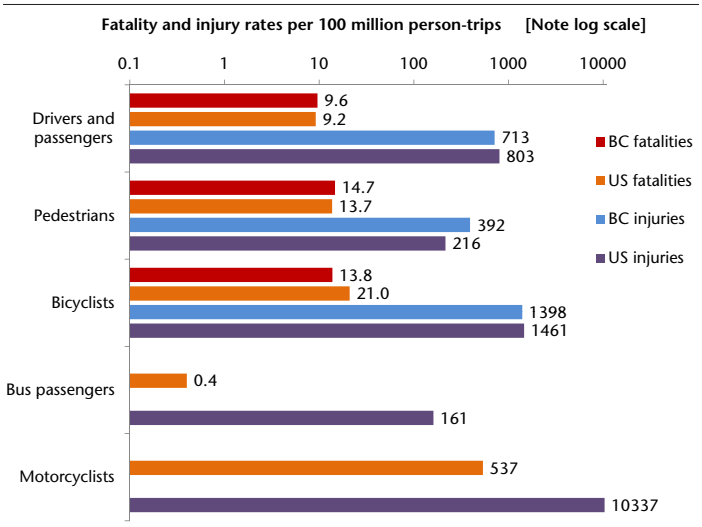
Questions that might arise from our analysis include whether the differences between modes are large or small, and how the rates in BC compare to other jurisdictions. Since road infrastructure, vehicle models, and mode shares are similar between the United States and Canada, comparisons of our results to the US are a useful starting point. A team at the Centers for Disease Control and Prevention calculated injury rates for various modes of travel in the United States over the period 1999-2003 inclusive, using a person-trip denominator.[8] Figure 2 compares the BC and US rates (note the log scale). It includes US data for two additional modes of travel: bus and motorcycle (data were not sufficient to calculate rates for these modes in BC). This comparison shows that injury and fatality rates for drivers and passengers, pedestrians, and bicyclists were very similar in BC and the US. Differences include a somewhat lower fatality rate for BC bicyclists and a somewhat higher injury rate for BC pedestrians. Striking features of the US analysis are that bus travel had a much lower fatality rate than any other mode (over 20 times lower), and that motorcycle travel had much higher fatality and injury rates than any other mode (over 25 and 7 times higher, respectively). These broader comparisons help to situate fatality and injury rates for drivers and passengers, pedestrians, and bicyclists as intermediate between a much safer and a much more dangerous mode of travel. Such data are helpful for individuals deciding between modes, and for public policy-makers trying to promote safe and active travel.

The data in Table 3 can be used to calculate the numbers of trips or distances travelled for each fatality or injury. For example, in BC from 2005 to 2007, one car driver or passenger died per 10,416,667 person-trips by that mode, 1 pedestrian died per 6,802,721 person-trips and 1 bicyclist died per 7,246,377 person-trips. Using the US data for the other two travel modes, 1 bus passenger died per 250,000,000 person-trips and 1 motorcyclist died per 186,220 person-trips.[8]

Broader international comparisons are more difficult because few countries have calculated rates by mode.[6] Reports from the United States, Belgium, and the Netherlands, like ours, found that injury rates for motor vehicle occupants are usually lower than those for bicyclists and pedestrians, supporting the designation of the latter as "vulnerable road users".[6,8,10] The data in Figure 1, comparing crude fatality rates per 100,000 population, suggest that Canada has an opportunity to reduce traffic deaths by examining strategies used in safer jurisdictions like the Netherlands.[7] Data from 2004 to 2008 in the Netherlands indicate that there were 0.3 fatalities per 100 million km among motor vehicle occupants (vs. 0.97 in BC) and 1.1 fatalities per 100 million km among bicyclists (vs. 2.6 in BC).[6] Achieving these lower rates would result in dramatic reductions in traffic crash deaths in BC (using average numbers from Table 1, a reduction of over 200 deaths per year).

To our knowledge, this is the first study to calculate exposure-based injury rates by travel mode in a Canadian jurisdiction. The analysis had a number of limitations deriving from the availability of data. Analyses could not be done for the country as a whole because of the lack of trip diary data. Differences between the Census and TransLink Trip Diary data for Metro Vancouver show that Census travel-to-work data overestimates transit trips (16.5% vs. 11.5%, respectively) and underestimates walking trips (6.3% vs. 10.5%, respectively).[14,16] This may be because non-work trips are likely to be closer to home so walking is used instead of transit. Without full trip data, the risk of pedestrian trips would be overestimated. Here we used Metro Vancouver data to calculate denominators, using adjustments based on Census data to allow extension to the province as a whole. The Metro Vancouver area includes over half the population of the province, but the extrapolation has unknown errors given potential differences in numbers and lengths of trips, and availability of sidewalks, bike routes, and transit between the Metro area and the province. Despite the problems with the data, we were encouraged by the similarity of the BC and US rates based on person-trips.[8]

Figure 2. Fatality and injury rates per 100 million person-trips by road user class, British Columbia and the United States[14]



Some data problems were not possible to overcome. Both pedestrians and bicyclists may have traffic crashes that do not involve motor vehicles and these are less likely to be recorded unless a fatality is involved.[6,7] We were unable to calculate rates for motorcycle travel because denominator data were not available. We were unable to calculate rates for bus or transit travel because numerator data were not available. Finally, the data available to us were published summary data. Denominators were not available by age or sex, preventing adjustment by or calculation of specific rates for these variables. Similarly, confidence intervals around the injury rates could not be calculated because raw data from the TransLink Travel Diary were not available.[14] The annual injury data were at the population level, and the proportions of trips by each mode of travel were calculated based on large samples (~200,000 employed persons and 17,603 households), so variances should be low.[11-15]

It is important to note that this analysis examines injury risks of transportation modes but does not consider other health outcomes associated with travel. Studies have consistently shown that active modes of transportation such as walking and bicycling have important health benefits (e.g., reduced ischaemic heart disease, cerebrovascular disease, depression, dementia, and diabetes) that greatly outweigh injury risks.[17]

In summary, this analysis shows that in British Columbia, motor vehicle occupants have lower traffic-crash fatality rates than pedestrians and bicyclists, two groups often designated as vulnerable road users. Differences between pedestrians and bicyclists depended on whether person-trips or distance travelled was used as a denominator and whether fatalities or injuries were considered. Bicyclists had a much lower fatality rate using the distance denominator and pedestrians had the lowest injury rate using the person-trip denominator. International comparisons suggest that bus travel is much safer and motorcycle travel much more dangerous than driving, walking and bicycling.[8,10] In addition, such comparisons suggest there are opportunities for dramatic reductions in fatalities from traffic crashes in British Columbia. Given the importance of traffic-related injuries to public health and the potential for large reductions in such injuries, it would be valuable to institute a national trip diary survey to allow injury rate calculations on a countrywide basis for all modes of travel.

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RÉSUMÉ

CONTEXTE : Les traumatismes liés aux accidents de la circulation contribuent de façon importante à la morbidité et à la mortalité au Canada, surtout chez les enfants et les jeunes adultes. La comparaison des taux de blessures par exposition selon le mode de transport et selon la province/le territoire est un outil précieux pour améliorer la sécurité.

MÉTHODE : Nous avons utilisé les données sur les blessures de la Direction générale des véhicules automobiles de la Colombie-Britannique, les données sur les trajets de l'Administration du métro de Vancouver et les données provinciales et populationnelles sur les déplacements tirées du Recensement pour calculer les taux bruts d'accidents mortels et de

blessures pour les occupants de véhicules automobiles, les cyclistes et les piétons. Nous avons utilisé trois dénominateurs différents : la population; les déplacements-personnes; et la distance parcourue.

RÉSULTATS : Les occupants de véhicules automobiles avaient les taux d'accidents mortels les plus bas selon les dénominateurs par exposition : 9,6 p. 100 millions de déplacements-personnes et 0,97 p. 100 millions de km. Les taux d'accidents mortels des cyclistes et des piétons étaient semblables selon un dénominateur (13,8 c. 14,7 p. 100 millions de déplacements-personnes, respectivement), mais le taux des cyclistes était inférieur selon l'autre dénominateur (2,60 c. 7,37 p. 100 millions de km). Pour les blessures, les piétons avaient le taux le plus bas et les cyclistes le taux le plus élevé selon le dénominateur des déplacements-personnes, tandis que les occupants de véhicules automobiles avaient le taux le plus bas selon le dénominateur de la distance; cyclistes et piétons avaient des taux semblables.

CONCLUSION : Les risques de la conduite automobile, de la marche et de la bicyclette en Colombie-Britannique étaient semblables à ceux aux États-Unis. Les taux de blessures et d'accidents mortels pour ces trois modes de transport étaient moyens comparativement aux taux des É.-U., qui sont beaucoup plus élevés pour les motocyclistes et beaucoup plus faibles pour les passagers d'autobus et d'autocars. En améliorant les données, il serait possible de calculer les taux de traumatismes liés aux transports pour l'ensemble du Canada et pour les autres modes de déplacement (transports en commun, motocyclette).

MOTS CLÉS : accidents de la circulation; marche; bicyclette; conduite automobile; transport actif