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

Kay Teschke, PhD, M. Anne Harris, PhD, Conor C.O. Reynolds, PhD, Hui Shen, PhD, Peter A. Cripton, PhD, Meghan Winters, PhD

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
commonly used denominators:8,9,9 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 = [%A1V * T1V * P1BC * %W1BC]/%W1V [1]
where
%A1V = % of all Metro Vancouver trips by this mode;
T1V = average number of trips of all types per person per year in Metro Vancouver;
P1BC = population of BC;
%W1BC = % of BC working population usually using this mode to travel to work;
%W1V = % of Metro Vancouver working population usually using this mode to travel to work.

Distance travelled, mode 1 = [%A1V * T1V * D1V * P1BC * %W1BC]/%W1V [2]
where D1V = average trip distance by this mode in Metro Vancouver.

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...
may be more appropriate. Some commentators suggest that time spent using each mode would be the most appropriate denominator.\textsuperscript{8} 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.\textsuperscript{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 start. Such data are helpful for individuals deciding between modes, and for public policy-makers trying to decide between modes, and for public policy-makers trying to achieve 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).\textsuperscript{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.\textsuperscript{8}

Table 2. Estimated Percent of Trips, Annual Numbers of Trips, Average Trip Distances and Annual Distances Traveled, by Road User Class*, Data From 2008 Trip Diary Survey\textsuperscript{11} and 2006 Census\textsuperscript{12}

<table>
<thead>
<tr>
<th>Percent of All Trips</th>
<th>Annual Number of Trips</th>
<th>Average Trip Distance (km)</th>
<th>Annual Distance Traveled (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers and passengers</td>
<td>78.6</td>
<td>3,125,479,000</td>
<td>10.0</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>12.1</td>
<td>479,347,000</td>
<td>2.0</td>
</tr>
<tr>
<td>Transit riders</td>
<td>7.87</td>
<td>312,948,369</td>
<td>12.0</td>
</tr>
<tr>
<td>Bicyclists</td>
<td>1.76</td>
<td>70,214,000</td>
<td>5.3</td>
</tr>
</tbody>
</table>

* 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 Traveled Denominators

<table>
<thead>
<tr>
<th>Annual Fatalities per 100,000 Population†</th>
<th>Fatalities per 100 Million Person-trips</th>
<th>Fatalities per 100 Million km</th>
<th>Injuries per 100 Million Person-trips</th>
<th>Injuries per 100 Million km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers and passengers</td>
<td>7.31</td>
<td>9.6</td>
<td>0.97</td>
<td>713</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>1.72</td>
<td>14.7</td>
<td>7.37</td>
<td>392</td>
</tr>
<tr>
<td>Motorcyclists and passengers</td>
<td>1.12</td>
<td>13.8</td>
<td>2.60</td>
<td>1,398</td>
</tr>
<tr>
<td>Bicyclists</td>
<td>0.24</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

† Numerator data not available for transit riders, so no rates could be calculated.

- Denominator data not available for exposure-based rate calculations.
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.\textsuperscript{5,7} 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.\textsuperscript{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.\textsuperscript{11-13}

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.\textsuperscript{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 depend 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 whether fatalities or injuries were considered. Similarly, confidence intervals around the 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. 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.

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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