TORONTO BICYCLE COMMUTER SAFETY RATES

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Transportation Research Board
77th Annual Meeting
January 11-15, 1998
Washington, D.C.

INTRODUCTION

In order to properly plan for the bicycle as an urban mode of transportation, a measure of the relative safety of on- and off-road bicycle travel is needed. The debate over the relative merits of provision of special bicycle infrastructure, such as paths, has raged for decades. There are contradictory results among the few existing studies, some finding special bicycle infrastructure safer than roads while others finding the opposite. Until recently, the only comprehensive study, which produced accident rates based on estimates of travel exposure on different types of infrastructure, suggested that it was less safe to travel on bike paths than on roads [1]. Very recent research [2] using a similar nation-wide survey of bicycle club members found accident rates highest on sidewalks, followed by paths and then various categories of roads. The previous application of the analysis method used in this paper [3] to a sample of Ottawa commuter cyclists found the same event rate pattern: highest on sidewalks followed by paths and then roads. All three sets of results are in direct contradiction with the subjective perception of many bicyclists and non-bicyclists who feel cycling away from traffic is safer [4,5]. Although, this perception of safety and the associated enjoyment level for some cyclists is an important factor for bicycling, there is still a need for comprehensive quantitative analysis to measure actual bicycle event rates. This paper presents results of a comprehensive bicycle safety survey of bicycle commuters in downtown Toronto, Canada. The objective of this paper is to present the Toronto on and off-road event rates as well and to compare them with earlier results from Ottawa [3].

Before presenting the details of the analysis and findings, the next section of this paper reviews the survey methodology and the characteristics of the study area. The subsequent two sections each have two subsections, one dealing with methodology and procedures, and the second reporting the results. These subsections describe the estimation of travel exposure and the relative event rates for travel on roads, off-road paths and sidewalks. The final section of the paper presents possible interpretations for the results and points to the direction of further work.

THE SURVEY DATA AND CHARACTERISTICS OF THE STUDY AREA

There are two key limitations that hinder bicycle safety analysis: lack of complete incident databases; and lack of travel exposure information. For this study, the known limitations of police and emergency room accident databases were overcome through use of a survey that asked cyclists to indicate their accident history. Only 12% of the self-reported collisions had been reported to the police. The need for route-specific exposure data to determine the amount of travel undertaken on different facilities and thus facility-specific incident rates is obvious. Accident counts must be corrected by the amount of travel that occurs in different locations. In this case the study was limited to the bicycle commute to work or school. By focusing on this trip, the exact regular route could be collected on a map of the area. Analysis of the routes in a Geographic Information System (GIS) provided an estimate of the overall exposure on different types of infrastructure. With this more complete incident database and detailed estimates of exposure, 12 incident rates per 100,000 kilometres were calculated: collisions, falls, injuries and major injuries; for travel on roads, off-road paths and sidewalks. The large database allowed for statistical analysis that revealed statistically different relative rates on different infrastructure.

There are three categories of previous work that involve analysis of bicycle incidents: accident frequency or count analysis; accident rates per bicycle volume or population; and accident rates per travel distance. Accident frequency analysis is the most common of the three and it involves presenting summary statistics or counts of different categories of accidents. These types of analysis do provide a measure of some of the more serious events and in some cases even provide a valuable relative measure of the occurrences for different groups. Incidents corrected by bicycle volume counts or cyclist population, while an improvement over event counts alone, does not allow for a measure of absolute rates per travel distance or per trip. The third category where accident rates are calculated per distance traveled is beneficial in three ways and is therefore used in this survey. First, it allows for comparison between travel on different types of facilities that might be used within the same trip. Second, it allows comparison of rates for different groups that may travel different distances. Finally, it allows for comparison to automobile travel.

Between July 10 and July 14, 1995 3,000 copies of the Toronto Bicycle Safety Study questionnaire were distributed onto the cross-bars of parked bicycles at employment locations and post-secondary institutions in a subsection of the study area. The questionnaire package consisted of a postage-paid return envelope and a questionnaire including a map of the study area. The study area consisted of 130 square kilometres of metropolitan Toronto which has a total population of 2 million. The surveys were distributed in the center of the study area: the downtown core of Toronto.

The study area contains 1624 kilometres of road and 74 kilometres of paths. The street pattern is primarily grid-like and the downtown area would be considered busy and alive with activity. Locals consider the traffic congestion, streetcar tracks and on-street parking hindrances to cycling. Although the land rises gradually away from Lake Ontario the landscape is not overwhelmingly hilly. The deep Don River Valley in the east of the study area represents somewhat of a barrier to bicycling and long bridges span across it. The study area contains 19 kilometres of bicycle lanes along streets including some on the Don Valley bridges. This analysis does not consider these sections independently from roads in general. A total of four collision records contained a comment that the event had occurred in a bicycle lane, but a complete cross referencing of location of accidents and bicycle lanes in the GIS will be necessary before bicycle lane event rates can be calculated with this database.

Questions regarding the participants' bicycle travel patterns, their collision and fall history, and some personal characteristics were included. In addition, cyclists were asked to trace their regular route to and from work or school on the map provided. Information on collisions experienced by the cyclists over the previous three years was collected. A collision was defined as "an event in which the bicycle hits or is hit by any other object regardless of fault." Information was also collected for falls. A fall was defined as "an event where without colliding with an object the bicycle or the cyclist lands on the ground." A fall includes an event incurred while avoiding a collision, but falls subsequent to an actual collision were cross-matched using dates and times and were removed from the fall database. Only falls during the previous 12 months were of interest as it was felt that falls were not as serious as collisions and would not be recalled for as long into the past. Information on injuries resulting from collisions in the past 12 months was combined with injuries from falls to obtain the total number of injuries and major injuries for use in the rate analysis. A major injury was defined as requiring medical attention. The cyclist was also asked if his/her collisions or falls had occurred on the way to their commute destination, which was traced on the map. This question is key as it was used to separate the incidents into commuter and non-commuter events. Only the commuter events are of interest for use to estimate event rates with the detailed exposure information obtained through analysis of the regular commuter routes in the GIS.

In addition to the fall and collision tables, two other types of questions in the questionnaire were used for this analysis: exposure estimation questions; and personal characteristic questions. The method used to estimate the total amount of exposure or travel on different types of infrastructure is described later. The personal characteristics are used in this analysis to weight subgroups for the relative rate analysis. However, there is also a need to disaggregate information by subgroup to further the understanding for the need for specific countermeasures for particular target groups. This has not yet been conducted for the Toronto database.

A total of 1360 questionnaires (45.3%) were received back from the Toronto survey. These cyclists reported 666 collisions in the previous 3 years and 482 falls in the previous 1 year. Only 1196 cyclists could be included in the rate analysis as they provided both their commuter route on the map provided and answered the two exposure questions. These cyclists indicated a total of 300 collisions and 203 falls during their commute. A total of 182 injuries to the cyclists were reported to have occurred during incidents while commuting. A total of 15 of these injuries were major injuries (required medical attention).

TRAVEL EXPOSURE ESTIMATION

Procedure

The network of roads, off-road paths, and intersections for the Toronto study area was represented as a system of links and nodes in an Arc/Info GIS coverage. The routes traced on the maps by the cyclists were entered into this network coverage. The links and the nodes in the GIS coverage each have an associated attribute table. Each individual's route was then related to the coverage's attribute tables to get the exact length of travel on each type of infrastructure in the regular commute. The cyclists were asked to circle any portions of their route where they traveled on the sidewalk. These sections were identified in the GIS route systems and do not count as travel along the road but rather as travel on a sidewalk. Many cyclists indicated a different route to and from work or school or more than one route. Average round trip distances on each type of infrastructure were used in these cases. Some cyclists (10 % of those providing routes and answering the exposure questions) had origins outside the area provided on the map. The assumption was made that the individual's route off the map was in the same proportion on-road, off-road and on sidewalks as that on the map. For these individuals, their travel on the different types of infrastructure was multiplied by the ratio of their estimate of their total oneway trip length to their total oneway distance on the map.

An estimate of the total travel or exposure to events was required for two time periods: the previous 12 months (for fall, injury and major injury events) referred to subsequently as the "fall exposure"; and the previous three years (for collision events) referred to subsequently as the "collision exposure". Each cyclist was requested to provide the number of round trips made to the destination for each month in the last 12 months. For cyclists who had been travelling between their current home and work/school location for greater than or equal to 12 months, the fall exposure on each type of infrastructure was equal to the average distance traveled on each infrastructure type in the round trip multiplied by the number of trips made over the year. If the individual had been travelling between their current home and work location for less than one year the fall exposure was equal to the average distance multiplied by the number of trips made in the appropriate months during the last year. The collision exposure was calculated in a similar fashion assuming that travel in each month of the year for the previous 2 years followed the same pattern on average as the average trips indicated for the previous 12 months. Adjustment was made if the individual had been making their commute for less than 3 years. Note that individuals who had been making this trip for less than 12 months (or three years) were not necessarily new to bicycle commuting but may have changed work or home locations.

The total amount of exposure in the sample for different groups such as men and women is different. It is not possible, given the lack of knowledge of the population of all Toronto commuter cyclists, to determine if the sample exposure is representative of all the bicycle commuter travel undertaken in the region in the last 12 months or 3 years. However, for the purposes of the relative rate analysis it is important to determine if different groups of cyclists undertook different proportions of their travel on the three types of infrastructure. This is required in order to evaluate if efforts are necessary to control for the possible confounding effects of certain personal characteristics with the relative rates on different infrastructure. For dummy variables (sex, left turns from left most lane, cycling club / course, cycle on busy streets only when unavoidable) t-tests for differences in the mean proportion of the routes on each type of facility were conducted. For categorical variables with more than 2 levels (age, years commuting, peak km per week) one-way ANOVA tests were used to test for differences between the means.

Travel Results

The average length of the one-way commute by bicycle in the Toronto sample was 5.3 km. The commutes were undertaken on average 94% on-road, 4% off-road path and 2% on sidewalks. A total of 183 cyclists reported some (averaging 0.5 km) commuter travel on a sidewalk. In aggregate over the previous 12 months the sample reported a total of $1.57 * 10^6$ km of commuter exposure: $1.43 * 10^6$ km on-road; $0.12 * 10^6$ km on off-road paths or trails; and 20,000 km on sidewalks. Over the previous three years the sample traveled a total of $3.65 * 10^6$ km: $3.30 * 10^6$ km on-road; $0.30 * 10^6$ km on off-road paths or trails; and 44,200 km on sidewalks. Slight differences between the sum of the travel on the three types of infrastructure and the total travel are due to rounding error; one-way trip distances were output from the GIS in kilometres to two decimal places.

Results of the investigation of possible confounding patterns affecting the proportion of exposure on different infrastructure are reported here for the exposure during the previous 12 months. Table 1 shows the t-test results for the binary variables. The busy street variable indicates whether a person indicated they cycled only on busy streets unavoidable. The club/course variable indicates whether a cyclist belong to a bicycle club or had taken a bicycle training course. The left turn variable indicates whether a cyclist indicated that at major intersections they made left turns from the left most lane. The total travel exposures for the two categories of three of the four variables are statistically different. For example, men had traveled more total distance commuting in the last year than women. However, these differences are not necessarily critical for comparing the relative event rates on different infrastructure. It is simply a characteristic of the sample; some groups travel more than others. However, any differences in the proportion of travel on different infrastructure for certain groups are critical. If these groups have different event rates (ie. they have overall more or less events per kilometre relative to other groups), this will result in incorrect estimates of the relative rates for travel on the different types of infrastructure. To deal with this possibility, the exposure and event counts for the different infrastructure will be weighted so that the same proportion of any groups with statistically different travel proportions is contained in the final weighted sample for each type of infrastructure. For the groups in Table 1, all those shown in bold have significantly different proportions of travel on different infrastructure (using 0.05 significance level for testing). Because subgroups with zero exposure interfere with weighting it is desirable to have as few subgroups for weighting as possible. Therefore, the exposure and events will be weighted to include equal proportions of busy street categories and sex. The difference in sidewalk proportion for the club/course and left turn variables is considered rather small.

Tables 2 through 4 illustrate the ANOVA results for the three multi-category variables: age; peak-season weekly total travel for all purposes including recreation; and years commuting. Categories were chosen based on the distribution of the variables within the sample. Approximately equal sub-sample size was desired while providing meaningful divisions between groups. The age variable resulted in a significant difference only for the proportion of travel on the road and paths. Older cyclists travel relatively more on paths. The weekly distance variable resulted in statistically different proportions on different types of infrastructure. Higher distance cyclists travel relatively more on paths but less on sidewalks during their commute. No statistically significant difference was found for years commuting by bicycle in the overall proportion of travel on different infrastructure. The exposure and event information was weighted for the first two variables. However, to minimize the total number of subgroups, peak weekly kilometres was weighted using only two groups (above and below 60 km).

ON-ROAD, OFF-ROAD AND SIDEWALK EVENT RATES

Analysis Procedure

The event rate analysis procedure consisted of two parts: calculation of exposure and event totals adjusted for confounding personal variables; and statistical tests for relative event rates.

There are four types of events of interest in this study: collisions, falls, injuries and major injuries (this final category is a subset of the previous one). Due to the rare nature of all events, this initial analysis considers aggregate event rates. This has implications not just for how event rates are calculated but also for the statistical tests described below. The exposure to an event is considered the total distance of travel undertaken summed over the given sample or sub-sample during the time period that the event counts were collected (3 years for collisions and 12 months for the other events). The event rate in events per kilometre can be calculated by dividing the number of events on a particular facility type reported by a particular group by the total cycle-kilometres traveled on that facility type by that group.

In order to investigate differences in observed event rates that are inherent to travel on particular infrastructure, it is necessary to weight the exposure and events observed. This adjustment ensures that each set of exposure and event counts contains the same proportion of different categories of cyclists that were determined to have confounding exposure patterns in the previous section. Four confounding variables were found: busy streets (2 levels); sex (2 levels);

age category (3 levels) and total bicycle kilometres for all trip purposes per week (2 levels). Combined and allowing for a category to include any combination of missing personal data, these variable categories form 25 sub-groups of cyclists. It was felt that this lumping of individuals with some missing data into a group 25 was preferable to excluding them from the analysis. In some survey research it is common for the sub-groups to be weighted for the final analysis relative to their known proportion in the population of interest. However, in this case the distribution of these 25 categories in the full population of cyclists is unknown. It is not reasonable to weight the groups equally. Therefore, the group proportions for the infrastructure-specific event rate calculations are set equal to each group's proportion of the total exposure in either the 12 month or three year period.

An example can be used to illustrate how the weighting proceeded. Consider the group of men aged 18 through 29, who cycle less than 60 km per week in their peak cycling season, and answered "yes" to the busy streets question. In the previous 12 months, they traveled 577.7 total commute kilometres on off-road paths, 0.5% of the total path travel. Total travel for this group was 30,330 km which is 1.9% of the total 1,571,014 km of travel in the previous 12 months. Therefore, the path exposure for this sub-group is relatively under-represented and their event rate on paths could distort the overall path rate if not corrected. The 12-month path exposure and event count for this group is corrected by dividing by the ratio of the group's share of path travel to their share of the total travel. In this case, 0.5% divided by 1.9% yields 0.25. The weighted exposure is 2327.8 (577.7 / 0.025) km. The event total is corrected in the same way. All corrected values are summed over all sub-groups to obtain input for the weighted aggregate event rate calculation. These weighted event rates are the most appropriate for use in calculating relative rates on different infrastructure, but it is reasonable that for other purposes the absolute rates estimation are of more appropriate use. Therefore both the weighted and unweighted event rates are presented here.

The relative rate of an event on one infrastructure versus another is simply the ratio of the two event rates. Two statistical tests are used to evaluate this ratio. The first is that described by Hauer [6]. The paper's companion software, HYPTEST, available on the internet from the University of Toronto, was used to conduct the tests. The software tests the null hypothesis that the means of Poisson distributed event counts are equal, against the alternative hypothesis that one is less than the other (exposure is corrected for within the program). The second method, Cox's F-test, was used to develop the 95% confidence intervals for the relative event rates for travel on the different types of infrastructure. The Hauer HYPTEST is relatively conservative compared to the F-test and in cases with low event counts the HYPTEST will not reject the hypothesis that the relative event rate is one, even though the confidence interval from the F-test does not overlap unity.

Event Rate Results

Table 5 provides the unweighted and weighted total exposure and event counts. The event rates for each of the 16 event type / infrastructure type combinations are presented for both Toronto and Ottawa. The exposure on different infrastructure does not add exactly to the total in each category due to rounding error (one-way trip distances for each facility type, as well as for the total, were known in kilometres to two decimal places).

The first row of each subsection of Table 5 indicates the total number of each type of event observed for all travel on all types of infrastructure. These numbers are quite high: 300 collisions (average 0.25 per cyclist) in the previous 3 years and 203 falls (0.17 per cyclist) in the previous 12 months. Although the absolute number of reported falls is similar in Ottawa (0.16) the collisions reported were much lower (0.13). This might be simply due to the differences in the nature of the study areas. The Ottawa study area contained suburban and urban core sections while Toronto only contains the relatively congested downtown.

From inspection of the total event rates falls are the most common event experienced (12.9 falls per 10,000 kilometres). This suggests more effort should be taken to include falls in safety evaluations for cycling. All but one event rate (path falls are about the same) are higher in Toronto than Ottawa, particularly the sidewalk events. This again may be due to the relative activity levels and congestion in the two study areas. The importance of considering events per distance rather than event counts is evident from this table. If one considers the various event counts on different types of infrastructure, it might seem that roads are the problem for falls, injuries and collisions. However, inspection of the rate data indicates that events on sidewalks and off-road paths/trails are the more frequent events per kilometre traveled. Thus diverting cyclists from the road to sidewalks and paths/trails as might be suggested based on count analysis could be expected to increase overall event rates based on this analysis that accounted for travel exposure.

The magnitudes of the overall event rates for Toronto in Table 5 should be considered with respect to similar event rates for automobile travel. The Ontario Ministry of Transportation (MTO) [7] reports 3.1 accidents per 1,000,000 km traveled. These accidents include single and multiple vehicle accidents and therefore could arguably be compared to the sum of bicycle collisions and falls. For the sample of commuters, collisions and falls have a total event rate of 211 events per million kilometres (a rate 68 times that for automobiles). Even if compared only to bicycle collisions, the collision rate of 82 per million kilometres is still 26 times that reported for automobiles. The difference in injury rates is similar. This study found the injury rate per million kilometres to be 116 for commuter cyclists. MTO reports the rate of accidents causing personal injury (to any person, not necessarily the driver or other persons in the vehicle) to be 8.1 per million kilometres, only 7% the cyclist injury rate.

Table 6 indicates the weighted relative risk for bicycle travel on different types of infrastructure as well as both the results of the Hauer statistical tests and the confidence intervals developed based on Cox's F-test. In cases where the event counts are low the results of the two tests do not agree. Overall, travel on roads has the lowest injury and fall rates, followed by off-road paths/trails and then sidewalks. Collision rates are lower on sidewalks than on paths. But collision rates are higher on paths and sidewalk compared to roads. The relative rate of injuries and major injuries on the sidewalk versus both roads and paths is very high. While the relative rate of injury between paths/trails versus roads is lower it is still significant for all injuries. Finding such significant results for injuries but not all collisions alone suggests that studies based only on the analysis of collisions could be improved by including other events.

CONCLUDING DISCUSSION

This study has found statistically significant differences between the collision, fall and injury rates for bicycle commuting on-road, off-road and on sidewalks in the Toronto study area. In general, these relative rates suggest it is safest to travel on-road followed by off-road paths and trails, and finally least safe on sidewalks. While the same analysis undertaken in Ottawa resulted in the same pattern of relative rates, the magnitudes were different. The rates per distance are all higher in Toronto suggesting that urban form, traffic levels and the attitudes of drivers and cyclists can affect bicycle safety. The Ottawa relative collision rates were approximately 1.0 while the Toronto ones were 3.5 and 2.0 for paths and sidewalk versus roads. This suggests some combination of the above factors or others is making the Toronto sidewalk and paths relatively more dangerous for cyclists. This postulation is also supported by the extremely high relative fall and injury rates for sidewalks and paths in Toronto versus roads. The methodology used in this study also allowed for defensible measures of the absolute rates. Although exact comparisons are not possible, the event rates per bicycle kilometre were found to be approximately 26-68 times higher than similar rates for automobile travel throughout Ontario.

Despite the dearth of bicycle safety information, caution should be exercised in extrapolating these results even though the overall pattern has been confirmed in two cities with quite different characters. In order to use the routes traced on maps for a precise estimate of travel exposure, it was necessary to limit the sample to commuter cyclists in limited study areas. It would be ideal to be able to conclude that these results apply more generally to the whole population of urban cyclists, at least in Ontario. However, strictly speaking, these results apply only to the specific samples of Toronto and Ottawa commuter cyclists. Further, commuters are familiar with their route and presumably therefore with the hazards it contains. Most commuters in the sample travel during the morning and evening peak traffic hours. These times represent high vehicle volume on the roadways but perhaps low recreational cyclist and pedestrian volumes on the paths/trails. These two and perhaps other factors could result in the relative incident rates for roads versus off-road facilities found here being different than for other groups or at other times.

In addition, both Toronto and Ottawa have been identified as bicycle-friendly urban areas by many sources (although in different ways). These factors could result in the on-road incident rates being lower than might be found elsewhere.

The finding that the relative risk of sidewalk travel is the most hazardous from the point of view of falls and injuries (as well as for collisions versus on-road) confirms earlier work by several others. On the surface this might seem to be an additional incentive to amend policies for those municipalities that still encourage or tolerate some form of sidewalk cycling. However, because this result seems contrary to perceived notions of safety, it is necessary that more study be conducted about the details of sidewalk incidents, the locations of sidewalk travel, and the people that choose to use a sidewalk. Some of this research has been undertaken through further analysis of this dataset.

The results with respect to off-road paths/trails versus roads suggest that moving cyclists away from automobile traffic onto paths is not necessarily the solution to the bicycle safety problem. Some hypotheses for future research questions can be postulated. Forester [8] suggests that roads are safer for travel because they have an established set of operating procedures that when followed provide for efficient and safe operation of the entire road system (including all types of vehicles). Future research that investigates the circumstances of path/trail accidents would be beneficial. Furthermore, the geometric and maintenance standards for paths vary from location to location. Off-road facilities, that include shared use with pedestrians, bicycles, rollerbladers and skateboarders have various operating conditions. It is possible that many paths are not necessarily built for the volume of non-motorized traffic they carry, or that their geometric standards are not sufficient for the speeds bicycles travel. The variety of path operating conditions and a possible relationship with accident levels warrants attention.

Acknowledgments: The authors wish to thank the Ontario Ministry of Transportation and the Natural Sciences and Engineering Research Council of Canada for financial support. The provision of data from the Regional Municipality of Metropolitan Toronto and the City of Toronto was essential to the undertaking this research. Fred L. Hall of McMaster University made contributions to the development of the survey and analysis methods used in this paper.

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Table 1: Mean Exposure Levels Disaggregated by Binary Variables

Exposure Type	Sex			Bike on Busy Streets			Bicycle Club or Course			Left turns from Left Lane		
	Male	Female	P stat*	Yes	No	P stat*	Yes	No	P stat*	Yes	No	P stat*
Mean Exposure last 12 months	**1444 (707)**	**1119 (479)**	**0.0005**	1236 (471)	1364 (725)	0.075	**1744 (124)**	**1264 (1072)**	**0.005**	**1415 (527)**	**1228 (661)**	**0.012**
Exposure Proportion on Road	**0.93**	**0.96**	**0.002**	**0.92**	**0.96**	**0.0005**	0.95	0.95	0.54	0.95	0.94	0.4
Exposure Proportion on Paths	**0.05**	**0.03**	**0.002**	**0.07**	**0.03**	**0.0005**	0.04	0.04	0.87	0.05	0.04	0.51
Exposure Proportion Sidewalks	0.02	0.02	0.49	0.02	0.02	0.24	**0.01**	**0.02**	**0.001**	**0.01**	**0.02**	**0.0004**

* from Student's t-test
(Number of observations)
Bold indicates proportions deemed different.
Some proportions do not add to 1.0 due to rounding.

Table 2 Travel Exposure for Different Age Groups

Exposure Type	Age Category			ANOVA p statistic
	18 - 29 (N = 376)	30 – 39 (N = 519)	> 40 (N = 299)	
Total Exposure previous 12 months (km)	1069	1366	1530	0.0005
Proportion of Exposure on-road	0.97	0.94	0.90	0.0005
Proportion of Exposure off-road	0.01	0.04	0.08	0.0005
Proportion of Exposure on Sidewalk	0.02	0.02	0.02	0.888

Table 3 Travel Exposure for Different Categories of Kilometres Cycled per Week in the Peak Season for all Purposes

Exposure Type	Weekly Kilometre Category				ANOVA p statistic
	0 - 30 (N = 389)	30 – 60 (N = 332)	60 – 90 (N = 174)	> 90 (N = 301)	
Total Exposure previous 12 months (km)	834	1066	1496	2101	0.0005
Proportion of Exposure on-road	0.96	0.96	0.93	0.90	0.0005
Proportion of Exposure off-road	0.01	0.03	0.06	0.09	0.0005
Proportion of Exposure on Sidewalk	0.03	0.02	0.01	0.01	0.013

Table 4 Travel Exposure for Different Categories of Years Commuting by Bicycle

Exposure Type	Years Commuting by Bicycle				ANOVA p statistic
	0 - 3 (N = 300)	3 - 6 (N = 293)	6 – 12 (N = 140)	> 12 (N = 461)	
Total Exposure previous 12 months (km)	980	1430	1272	1464	0.0005
Proportion of Exposure on-road	0.93	0.95	0.96	0.93	0.09
Proportion of Exposure off-road	0.04	0.03	0.02	0.05	0.14
Proportion of Exposure on Sidewalk	0.03	0.01	0.01	0.01	0.11

Table 5: Exposure, Events and Weighted Event Rates

Event Type	Toronto Total Exposure (x 10^5 km)	Toronto Total Events Observed	Toronto Event Rates (/ 10^5 km)	**Toronto Weighted Exposure (x 10^5 km)**	**Toronto Total Weighted Events**	**Weighted Toronto Mean Event Rate (/ 10^5 km)**	Ottawa Unweighted Event Rate (/ 10^5 km)	Ottawa Weighted Event Rate (/ 10^5 km)
Collision – All	36.5	300	8.2	**36.5**	**300**	**8.2**	3.3	3.36
Collision – Road	33.0	273	8.2	**33.0**	**270.5**	**8.2**	3.2	3.2
Collision – Off-road	3.0	20	6.6	**3.0**	**86.5**	**29.0**	3.0	3.1
Collision – Sidewalk	0.44	7	15.8	**0.44**	**7.4**	**16.7**	3.0	2.9
Fall – All	15.7	203	12.9	**15.7**	**203**	**12.9**	9.5	9.5
Fall – Road	14.3	168	11.7	**14.3**	**163.7**	**11.4**	7.3	7.2
Fall - Off-road	1.2	16	13.3	**1.2**	**20.4**	**17.1**	13.6	15.1
Fall – Sidewalk	0.2	19	94.7	**0.2**	**20.8**	**103.4**	20.8	28.9
Injury – All	15.7	182	11.6	**15.7**	**182**	**11.6**	7.6	7.6
Injury – Road	14.3	158	11.0	**14.3**	**156.4**	**10.9**	6.2	6.2
Injury – Off-road	1.2	12	10.0	**1.2**	**23.9**	**20.0**	9.5	10.0
Injury – Sidewalk	0.2	12	59.8	**0.2**	**14.1**	**70.5**	17.9	24.8
Major Injury – All	15.7	15	1.0	**15.7**	**15**	**1.0**	1.1	1.1
Major – Injury -Road	14.3	11	0.8	**14.3**	**11.4**	**0.8**	1.1	1.1
Major Injury – Off-Road	1.2	2	1.7	**1.2**	**1.1**	**0.9**	1.4	1.8
Major Injury – Sidewalk	0.2	2	10.0	**0.2**	**1.3**	**6.3**	NA	NA

Table 6: Relative Event Rates on Different Infrastructure

Relative Rate for ...	Event	Relative Risk	Hyptest Statistical Significance (level)	Lower 95% Confidence Interval	Upper 95% Confidence Interval
Travel on Off-road Path/Trail to Travel on-road	Collision	3.5	Yes (0.001)	3.4	3.7
	Fall	1.5	No (0.1)	1.4	1.6
	Injury	1.8	Yes (0.01)	1.7	1.9
	Major Injury	1.2	No (1.0)	1.2	1.2
Travel on Sidewalk to Travel on-road	Collision	2.0	No (0.1)	2.0	2.1
	Fall	9.0	Yes (0.001)	8.2	9.9
	Injury	6.4	Yes (0.001)	6.0	7.0
	Major Injury	7.9	No (0.5)	7.7	8.1
Travel on Sidewalk to Off-road Path/Trail	Collision	0.6	No (0.25)	0.5	0.6
	Fall	6.0	Yes (0.001)	5.5	6.6
	Injury	3.5	Yes (0.001)	3.2	3.8
	Major Injury	6.6	No (0.75)	6.5	6.8