SIDEWALK BICYCLING SAFETY ISSUES

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ABSTRACT

Bicycle route and safety datasets for 2963 commuter cyclists in Ottawa and Toronto, Canada containing cyclist characteristics, collision and fall history, and regular commute route, are used for this analysis. Previous analyses found sidewalk collisions, fall and injury rates significantly higher on sidewalks versus roads or paths. Of the 52 events reported on sidewalks none were reported to police and would therefore not be found in a police accident database. These events did result in injuries and in two cases major injuries. This analysis has found that commuter cyclists in Ottawa use sidewalks primarily on major roads (not necessarily high speed roads) and often to cross bridges or to take short cuts where no road exists. Toronto commuter cyclists use sidewalks primarily on high volume multi-lane roads. Some Toronto cyclists still use sidewalks when bicycle lanes are provided. A slightly higher proportion of women are sidewalk cyclists in Ottawa, however no age relationship was found. Sidewalk cyclists reported proportionally more near misses with bicycles in the previous month. A relatively large number of sidewalk collisions are with other bicycles. The most significant result of the analysis is that sidewalk cyclists have higher event rates on roads than non-sidewalk cyclists.

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INTRODUCTION

The use of sidewalks by bicyclists is a contentious issue. On the one hand, researchers have repeatedly found that incident rates are higher on sidewalks [1,2,3]. However, on the other hand, the subjective perception of many bicyclists and non-bicyclists is that cycling away from traffic is safer [4,5]. For this and other reasons, many cyclists choose to bicycle on the sidewalk. This decision is despite the fact that in most jurisdictions in Canada, particularly urban areas, it is illegal to bicycle on the sidewalk. In educating cyclists regarding sidewalks and planning for the bicycle as a mode of transportation, planners are often in an uncomfortable position. They seek to recommend travel behavior that maximizes the safety of cyclists and others such as pedestrians. Yet they lack significant bicycle safety data on which to base decisions. In general, two limitations constrain bicycle safety analysis: the lack of complete incident databases and the lack of information describing the travel behavior or exposure of cyclists.

In the summer of 1995, McMaster University researchers distributed approximately 6000 bicycle route and safety study questionnaires onto the crossbars of parked bicycles at employment locations and post-secondary institutions in Ottawa and Toronto, Canada. The study was funded by the Ontario Ministry of Transportation. There were two main data collection goals for the study. First, a more complete incident database comprised of self-reported bicycle safety incidents was sought to complement the more traditional sources of bicycle accident information: police databases and hospital emergency-room records. Second, a method to estimate travel exposure information disaggregated by route type (roads, off-road paths/trails or sidewalks) was used. This was possible by focusing on the commuter trip, using a map for route tracing and subsequently a Geographic Information System (GIS) for analysis. The overall objective was to obtain more defensible bicycle incident rates per distance traveled. Previous work with the data used in this paper [6,7] found the event rates shown in Table 1. These tables illustrate that the rates for sidewalk travel are very high for all four events.

Table 1: Toronto and Ottawa Bicycle Commute Event Rates

Event Type	Toronto Mean Event Rate (events / 10^5 km)	Ottawa Mean Event Rate (events / 10^5 km)
Collision – All	8.2	3.3
Collision – Road	8.2	3.2
Collision - Off-road	6.6	3.0
Collision – Sidewalk	15.8	3.0
Fall – All	12.9	9.5
Fall – Road	11.7	7.3
Fall – Off-road	13.3	13.6
Fall – Sidewalk	94.7	20.8
Injury – All	11.6	7.6
Injury – Road	11.0	6.2
Injury - Off-road	10.0	9.5
Injury – Sidewalk	59.8	17.9
Major Injury – All	1.0	1.1
Major Injury – Road	0.8	1.1
Major Injury – Off-road	1.7	1.4
Major Injury – Sidewalk	10.0	NA

The objective of this paper is to present the results of a more detailed analysis of the sidewalk-related data. These results for Ottawa have been reported elsewhere [8] and are repeated here with the Toronto sidewalk results for comparison. The information regarding the sidewalk events and the sidewalk cyclists is considered in order to further the understanding of issues involved in the higher sidewalk event rates and specifically to direct the development of countermeasures to improve the situation. The next two sections of this paper provide a brief overview of the data collection and the characteristics of the sample related to sidewalk travel. The next sections present the attributes of the network sections that were traveled on sidewalk and the personal characteristics of sidewalk cyclists. The second to last section of the paper presents the relative event rates for non-sidewalk commuter cyclists with respect to sidewalk cyclists on roads and paths/trails. Finally, the concluding discussion suggests possible approaches for counter-measure development with respect to safety concerns regarding and points to specific recommendations for research that stems from this work.

THE BICYCLE ROUTE AND SAFETY STUDY

The Ottawa study area covered approximately 350 square kilometres of the region (population 500,000) consisting of most of the urban and suburban areas as well as several green belts. Surveys were distributed throughout the area. In total, the study area contains 2007 km of roads and 373 km of off-road paths and trails. A total of 1603 surveys were returned and 1452 are useable for the route analysis portions of this work. Event information for these incomplete responses is still presented but not used for rate calculations. The Toronto study area consists of 130 square kilometres of metropolitan Toronto which has a total population of two 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. A total of 1360 surveys were returned of which 1196 were useable for the route analysis.

The questionnaire package consisted of a postage-paid return envelope and a four-page fold-out questionnaire including a map of the surrounding area. 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. A collision was defined as "an event in which the bicycle hits or is hit by any other object regardless of fault." The information collected on collisions experienced by the cyclists over the previous three years included the following items: time; date; object collided with; location (road, path or sidewalk); intersection (yes/no); surface condition; injuries; property damage; and whether the incident was reported to police. The approximate time and date of a collision was used to remove collisions that had occurred prior to the three year window of interest. Collisions with objects such as curbs or potholes were deemed to be falls and were transferred to the fall database described below. Information on injuries for collisions in the past 12 months was combined with injuries from falls to obtain the total number of injuries and major injuries in the previous 12 months for use in the rate analysis. Note that a major injury was defined as requiring medical attention and is a subset of the total injury events.

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 table similar to that used for collisions was used for falls but information was collected only on the time, month, location, injuries, road surface and whether the fall occurred during the commute. 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.

The indication in the collision and fall tables as to whether or not the event had occurred during the commute was key for some portions of the analysis. It was used to separate the incidents into commuter and non-commuter events. While information for all events is presented in the following section of this paper, only the commuter collisions, falls and injuries are used with the detailed exposure information obtained through analysis of the regular commuter routes to develop the rates presented later.

Cyclists were also asked to indicate if they had experienced any of the following near miss events in the previous month: almost hit the door of a parked car; lost control of your bicycle but avoided collision or fall; caused a collision for one or more vehicles; almost been hit by a motor vehicle; almost hit a pedestrian; and almost hit another bicycle. While this is a weaker measure of safety related issues it may also provide insight particularly related to perceived safety.

SIDEWALK RELATED RESULTS

The results in this section are based on all events reported by the cyclists; both those during the commute trip as well as non-commute events. Of the 1603 Ottawa respondents and the 1360 Toronto respondents, none reported a sidewalk collision to the police. Only two sidewalk collisions in each city required medical attention that might result in an entry in an emergency room database. This underscores the deficiency of recorded information concerning sidewalk bicycle accidents – little information regarding sidewalk bicycle safety is ever recorded. Among all collisions reported in both cities, fifteen (4.2% of all collisions) in Ottawa and seventeen (7.0% of all collisions) in Toronto occurred on the sidewalk. Four of the collisions in each city were reported to have occurred at intersections. In Ottawa, 37 (9.9%) of the total falls reported occurred on the sidewalk while the Toronto total stands at 45 (9.3%). The objects with which the cyclists collided are listed in Table 2. Considering the potential conflict between pedestrians and sidewalk cyclists, it is of interest to note that none of the respondents in Ottawa and only two in Toronto reported a collision with a pedestrian while riding on the sidewalk. A seemingly large number of sidewalk collisions in both cities are with other cyclists.

Table 2:Objects Collided with in Sidewalk Collisions

Collision with …	Ottawa	Toronto
Motor Vehicle	3	6
Bicycle	6	4
Pedestrian	0	2
Animal	1	0
Object (guardrail, traffic barrier, fence, post, tree)	5	5

The effect of the surface characteristics was more significant in Toronto than in Ottawa. In Ottawa, only one collision and five falls involved snow/ice yet in Toronto ten collisions and ten falls had snow/ice reported. The physical condition of the surface, measured by the presence of potholes or cracks, contributed to only two Ottawa falls and three Toronto fall events. Only one Ottawa-Carleton sidewalk fall involved sand/gravel while five Toronto falls involved sand/gravel. While exposure information might clarify the exact relative nature of maintenance issues such as potholes, snow, ice or sand on sidewalks between Ottawa and Toronto, this result suggests better sidewalk maintenance could improve the safety experience of sidewalk cyclists. (Although it does not address whether or not the cyclists should be on the sidewalk at all.)

Two Ottawa falls and only one Toronto fall resulted in a major injury, while 22 Ottawa and ten Toronto falls resulted in a minor injury. A total of 28 minor injuries and two major injuries resulted from collisions on sidewalks in Toronto. Ottawa sidewalk collisions resulted in seven minor injuries. In Ottawa, two of the collisions resulted in an injury to another person. Both cases were collisions with other bicycles and presumably the other injured person was the second cyclist. In Toronto, only one collision on a sidewalk resulted in an injury to a second person. This collision was also with another bicycle. Given the number of total injuries cited here and the commute injury rates in Table 1, it is clear that sidewalk bicycling is not as safe as some perceive it to be. Furthermore, these numbers suggest cyclists on the sidewalk are a threat to each other.

NETWORK ATTRIBUTES OF SIDEWALK TRAVELED SECTIONS

The average one-way commute trip length was 8.4 km in Ottawa and 5.3 km in Toronto. For the 463 cyclists who reported sidewalk travel in Ottawa, on average 1.1 kilometres was on sidewalk. In Toronto, the 183 cyclists averaged 0.5 km on sidewalk. Of the Ottawa and Toronto sidewalk travel, 80% and 59%, respectively, was undertaken on the sidewalks along arterial roadways. A total of 60% and 97.5%, respectively, was undertaken along roadways with a speed limit of 50 km/h and lower, while 37% and 2.5% was along roadways with a speed limit of 60 km/h. In Toronto Average Annual Daily Traffic (AADT) estimates were available for many links. The missing AADT data are most likely links that are too minor on which to count traffic. Approximately 67% of the sidewalk travel occurred on links with AADT information. A total of 44.5% of the sidewalk travel on these links occurred on links with AADT greater that 15,000. Almost 80% of the sidewalk travel occurred on links with greater than 5,000 AADT. Also in Toronto, 64% of sidewalk travel was undertaken on roads with greater than or equal to four traffic lanes. These factors together, from both cities, suggest people are riding on the sidewalk not necessarily to avoid high-speed traffic but rather to avoid higher volume traffic.

While sidewalk travel along bridges over the rivers or canals in Ottawa attributed for only 2% of the total sidewalk travel, many of the route sections with greater than five (and up to 22) cyclists reporting sidewalk travel were along bridges. This might reasonably be due to the limited number of water crossings and a resultant concentration of cyclists using these sections. Sidewalk riding was reported on the Don Valley bridges in Toronto but to a lesser extent. This could be attributed to the bicycle lanes on several bridges. Based on the Ottawa result there is a need to note bridges as areas potentially requiring attention to improve cycling conditions for some cyclists.

In Ottawa, a total of 1.6% of the sidewalk travel (24 reported sections) was along sidewalks that might be called “short cuts” from one neighborhood to another or out of a neighborhood. Likewise in Toronto, approximately 2.9% of the sidewalk travel (27 reported sections) was along “shortcut” links through parks. In a similar way cyclists in Toronto and Ottawa short cut through alleys and parking lots on their route. The exact safety implications of these short cuts cannot be evaluated here. Another type of short cut might be considered the use of a oneway street in the wrong direction on the sidewalk. Analysis to evaluate which way cyclists were traveling on oneway streets has not been conducted. However, 15% of the sidewalk travel did occur on oneway streets.

The Toronto GIS coverage has additional information regarding the city’s transportation network including bicycle lanes, bicycle routes, transit service and parking. Bicycle routes are roads that do not have specific special infrastructure for bicycles but are considered appropriate bicycle links that provide connectivity throughout the city. A total of 6.7% of the sidewalk travel occurred along roads with bicycle lanes. Bicycle route sections represented 6.9% of the sidewalk cycling. This suggests that for some cyclists even the bicycle lane or designation as a bicycle route is not sufficient for them to feel safe on the road with the motorized traffic. Two concerns when designating bicycle routes are often the presence of parking and public transit service along the street. Although a causal relationship cannot be established, 47% of the sidewalk travel occurred where parking was present along the streets, while 50% of sidewalk travel occurred along links with either bus, trolley or streetcar service. It is possible the presence of parking or transit vehicles is part of the motivation for some cyclists in choosing the sidewalk.

Due to the nature of the distribution pattern in each city, visual inspection of the location of sidewalk traveled network links in the GIS is more meaningful for Ottawa than for Toronto. Despite surveys being distributed throughout the Ottawa urban area, the sidewalk links are primarily in the core of the city. This suggests cyclists use the sidewalks in the busy, perhaps relatively narrow main streets, of the city core. In Toronto, the concentration of sidewalk traveled links is also in the downtown core. However, this pattern may simply be due to the concentrated survey distribution pattern that focused on the downtown.

CHARACTERISTICS OF SIDEWALK COMMUTER BICYCLISTS

Prior to devising a methodology to improve and promote bicycle safety related to sidewalks, it is helpful to understand the characteristics of people are likely to engage in sidewalk cycling. In order to analyze the difference between sidewalk cyclists and non-sidewalk cyclists, it was necessary to determine the criteria by which a person would be categorized as a sidewalk or a non-sidewalk cyclist. This was accomplished through analysis of the routes within the Geographic Information System (GIS). A new link variable was created in the coverage to keep track of the number of cyclists who reported sidewalk travel on each link in the network. In order to be labeled a sidewalk user, a cyclist had to utilize a sidewalk for any portion of their commute. Non-sidewalk users were cyclists who had not traveled on any sidewalks themselves but who rode on the road where another cyclist had used the sidewalk. People who traveled only on roads where no one had used the sidewalk were not labeled in either category because it was unclear if their commute route contained any segments that might cause a person to choose to ride on a sidewalk. Segregating the sample in this way resulted in the elimination of only 15 respondents in Toronto and 71 in Ottawa.

In Ottawa and Toronto, 32% and 15% of the cyclists were labeled sidewalk cyclists (63% and 83% non-sidewalk cyclists). This relatively large difference between the two cities may be due to differences in the character of the study areas. The Toronto study area was primarily the downtown core where sidewalks are characterized by high activity and might therefore be less desirable for cycling. Table 3 summarizes the continuous variable comparisons between sidewalk and non-sidewalk cyclists for both Ottawa and Toronto. The far right column of the table indicates whether the variables differ to a significant degree based on ANOVA tests at the 0.05 level. (These statistical tests as well as the Chi-square tests referred to below were conducted using MINITAB software. The test assumptions and procedures are outlined in the reference manual [9]). While sidewalk cyclists are slightly older, have commuted by bicycle longer, and travel slightly slower, there are no overwhelming trends among these variables that could be used to define or identify sidewalk cyclists.

Table 3: Comparison of Sidewalk and Non-Sidewalk Cyclists in Ottawa and Toronto

Variable	Mean for… Sidewalk Cyclists		Non-Sidewalk Cyclists		Statistical Sig. 0.05
	Ottawa	Toronto	Ottawa	Toronto	
Age	37.2	36.8	37.1	34.5	N/Y
Bicycle commute km last year	1471.0	1270.0	1842.0	1329.0	Y/N
Time as a bicycle commuter (months)	154	107	104	98.6	N/N
Bicycle km per week in peak season (all purposes)	28.0	69.0	62.0	65.0	Y/N
One-way commute length	7.6	5.3	9.0	5.3	Y/N
Commute trip speed	17.8	14.3	19.4	15.3	Y/Y

Nominal dummy variables were analyzed using Chi-squared tests conducted on the proportions of sidewalk and non-sidewalk cyclists that fell into different subcategories. In Ottawa, more women than men were sidewalk cyclists (39% versus 32%). In Toronto, no difference in the percent of sidewalk cyclists of each sex was found. Of the six categories of near misses described previously, only close calls with other bikes in Ottawa were significantly higher for sidewalk cyclists (31% for sidewalk users vs. 24% for non-sidewalk users). This corresponds to the relatively high number of collisions with other bicycles on the sidewalks in Ottawa and Toronto. In Ottawa, only 74% of non-sidewalk riders use a bicycle helmet while 81% of the sidewalk riders do. In Toronto, only 66% of non-sidewalk riders wear helmets while 71% of sidewalk riders do. This suggests a higher concern for safety among sidewalk cyclists which might correspond to an attitude of using the sidewalk because it is believed to be safer. More non-sidewalk cyclists belong to bicycle clubs in both cities, although in all cases the percentage is below ten.

Participants were asked whether they make left turns at major intersections in the left most lane and whether or not they use busy streets only when unavoidable. The sidewalk cyclists in both cities are more likely to cycle on busy streets only when unavoidable and less likely to make left turns from the left most lane. These trends seem consistent and provide support for the notion that subgroups of cyclists act consistently different with respect to road traffic. It has been suggested that a system of labeling cyclist behavior in order to plan for their transportation needs may be possible. The notion of type A and B cyclists is an example of such an attempt. These results suggest that questions such as those used in this survey or the tendency to ride on sidewalks could be used for such labeling.

EVENT RATES FOR SIDEWALK AND NON-SIDEWALK CYCLISTS

Using the classification of cyclists into sidewalk and non-sidewalk users, it was possible to calculate event rates per travel distance for the subgroups and to develop relative rates. This analysis was undertaken specifically to further consider the previous finding that the risk of fall and injury was greater for sidewalk cycling than road or path cycling. This section seeks to answer the question: Is sidewalk cycling more dangerous or are the individuals that use sidewalks more dangerous?

Table 4 illustrates the number of events reported by the cyclists to have occurred on roads and paths during their commute trip in the previous three year (for collisions) or one year (for falls, injuries or major injuries) periods. Also reported is the aggregate amount of commute trip travel in the corresponding time intervals that was undertaken on roads or paths. The route recorded in the GIS, the estimated number of trips in the previous 12 months, and the length of time making the current commute were used in deriving the estimates of travel. Any travel along roads that the individual had indicated occurred on a sidewalk was removed from the road travel exposure. The counts of events corrected by the respective exposure have been tested for significant differences at the 0.05 level using the method and program outlined by Hauer [10]. This test is particularly conservative when event count totals are low as they are for path events in this case.

Non-sidewalk cyclists in both cities have lower rates per travel distance for all four events on the road. Even on paths, sidewalk cyclists have higher rates for falls, injuries and major injuries Note that these rates take into account the fact that sidewalk cyclists might travel less on the road. Although no details on whether an event occurred on a minor or major road are available, it is reasonable from the trends described above, that the non-sidewalk cyclists interact with fewer vehicles on the road yet still have higher event rates. The event rates also suggest that the previous finding that sidewalk cycling itself is less safe. It is possible based on the results in Table 4 that sidewalk cycling is not inherently more dangerous but that those who use sidewalks are more dangerous cyclists. Further investigation is required, particularly due to the lack of statistically significant results.

Table 4: Relative Event Rates for Sidewalk versus Non-Sidewalk Users

Toronto

Event	Sidewalk Users			Non Sidewalk Users				
	Exposure (10^5 km)	Events	Rate (/ 10^5 km)	Exposure (10^5 km)	Events	Rate (/ 10^5 km)	Relative Rate	Stat. Sign. 0.05
Road Collision	4.34	41	9.4	28.4	231	8.13	0.86	No
Road Fall	1.84	23	12.5	12.4	145	11.69	0.94	No
Road Injury	1.84	25	13.6	12.4	132	10.65	0.78	No
Road Major	1.84	0	0	12.4	11	0.89	N/A	N/A
Path Collision	0.7	4	5.7	2.2	15	6.73	1.18	No
Path Fall	0.28	4	14.3	0.9	12	13.33	0.93	No
Path Injury	0.28	5	17.9	0.9	7	7.78	0.44	No
Path Major	0.28	0	0	0.9	2	2.22	N/A	N/A

Ottawa

Road Collision	9.8	36	3.7	31.8	75	2.36	0.64	Yes
Road Fall	4.2	38	9.0	12.9	78	6.05	0.67	Yes
Road Injury	4.2	36	8.6	12.9	68	5.27	0.61	Yes
Road Major	4.2	9	2.1	12.9	10	0.78	0.36	Yes
Path Collision	3.8	11	2.9	9.7	29	2.99	1.03	No
Path Fall	1.6	26	16.3	4.0	48	12.00	0.74	No
Path Injury	1.6	17	10.6	4.0	35	8.75	0.82	No
Path Major	1.6	3	1.9	4.0	4	1.00	0.53	No

CONCLUDING DISCUSSION

This analysis has found that commuter cyclists use sidewalks primarily on major roads (not necessarily high speed roads) and often to cross bridges and make short cuts. While having commuted for approximately the same time as non-sidewalk riders, sidewalk cyclists do not have the experience in terms of distance traveled by bicycle. While a slightly higher proportion of Ottawa women are sidewalk cyclists, there was no age relationship found in either city. Sidewalk cyclists reported proportionally more near misses with bicycles. Few sidewalk cyclists belong to bicycle clubs suggesting education regarding sidewalk bicycling through bicycle clubs may not be worthwhile. Most, if not almost all, collisions and falls on sidewalks normally go unreported. These events did result in injuries and even major injuries suggesting they should be of concern.

The most interesting result of the analysis was the finding that sidewalk cyclists have higher event rates on roads than non-sidewalk cyclists. While sidewalk cyclists' road event rates were greater in both cities they were only statistically significant for Ottawa. However, this result still has implications for education and counter-measure development for the high event rates found on sidewalks. While average event rates on sidewalks may be higher than similar event rates on roads or paths, simply educating cyclists to stop cycling on sidewalks may not be prudent as these cyclists have higher event rates on roads than non-sidewalk cyclists. The reasons for the higher rate of collisions, falls and injury on road by sidewalk cyclists were not measured in the data set. The cause of bicycle accidents was also not measured. For these two reasons, the following counter-measure / education statements must be viewed as suggestions. The non-sidewalk cyclists in Ottawa did have more total travel experience which may correspond to better cycling skills. This suggests education that trains cyclists to act more like experienced cyclists may be prudent. It is reasonable to suggest that more experienced cyclists are more comfortable with vehicular traffic or have learned by experience where the hazards lie. Whatever the reasons, sidewalk cyclists should not simply be educated that sidewalk cycling is dangerous and should therefore be discontinued. Attempts to train the cyclists with effective cycling skills should be considered. These types of training recommendations lead to a research recommendation. To date, no comprehensive analysis has been conducted to evaluate cycling education programs. Such an evaluation requires a large database of the bicycle safety events of educated cyclists as well as a control group over a long period of time. Given the relatively high absolute magnitude of the bicycle events per kilometre it would seem worthwhile to pursue such efforts to understand causal factors in bicycle safety.

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