THE CLASSIFICATION AND ANALYSIS OF 300 CYCLING CRASHES THAT RESULTED IN VISITS TO HOSPITAL EMERGENCY DEPARTMENTS IN TORONTO AND VANCOUVER.

By

THERESA FRENDO

B.Sc with Honours, University of British Columbia, 2010

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
BACHELOR OF SCIENCE (HONOURS)

in

THE FACULTY OF SCIENCE
(Environmental Sciences)

This thesis conforms to the required standard

………………………………………
Supervisor

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

APRIL 2010

ABSTRACT

Although many benefits of cycling exist, the injuries often deter people from this sustainable mode of transportation. As part of the Bicyclists' Injuries and Cycling Environment study, interviews were conducted with 300 injured cyclists who visited the emergency department of one of 5 hospitals in Toronto or Vancouver. This paper classifies the crashes based on their circumstances and analyzes selected characteristics with a particular interest in city and demographic comparisons. Crashes were broadly classified as collisions (72%) or falls (28%) and as involving motor-vehicles (48.3%) or not. Injured cyclists in Toronto more frequently collided with streetcar tracks (Odds Ratio: 21.0) or vehicle doors (OR: 3.96), and less frequently collided with pedestrians or animals (OR: 0.29) than those in Vancouver. In a multiple logistic regression model comparing the odds of a crash being a collision versus a fall, collisions were more common in Toronto (OR: 3.50) than Vancouver, on trips to work or school (OR: 4.66) than trips for other purposes, and for injured females (OR: 1.69) than injured males. In a second model, motor-vehicle involvement was found to be more common among injured cyclists less than 30 years old (OR: 2.00) than those who were older, and on trips to work or school (OR: 2.89) than for other purposes. The use of drugs or alcohol was not significantly related to the crash circumstances. Variations in crash circumstances between cities suggest that modification of infrastructure could improve safety and increase the number of cyclists.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGEMENTS

This research was supported in part by the Canadian Institute of Health Research (CIHR) and the Heart and Stroke Foundation of Canada. I would like to thank the Bicyclists' Injuries and Cycling Environment (BICE) project staff, investigators, and participants, for their contributions to this study, and extend a special thanks to my thesis supervisor, Kay Teschke, and Meghan Winters in the School of Population and Public Health at the University of British Columbia, for their guidance and feedback throughout the project.

INTRODUCTION

I was riding westbound on College at Bathurst. I stopped at the intersection for the red light. The light turned green. There was an SUV with a trailer turning right at the same time that I was proceeding through the light. I didn't see the trailer until I was underneath it being dragged. (Sequential# 1004)

The risks associated with cycling in cities often become apparent by more painful means than necessary. By reducing the rate of bicycle crashes like the one described above, it is anticipated that a concurrent decrease in the risks associated with cycling in cities will result in an increase in the number of people that cycle, both as a means of transportation as well as for recreation.

Active Transport

Bicycling, in all its forms, is an important factor in maintaining a healthy society. Not only does it provide health benefits on the individual level, but cycling also contributes to the health of the greater public. On the individual level, both physical and mental health benefits are associated with cycling (Cavill & Davis, 2007), including a decreased rate of obesity (Lindstrom, 2008; Wen & Rissel, 2008; Gordon-Larsen *et al.*, 2005) and a reduced risk of diseases, such as cardiovascular disease (Gordon-Larsen *et al.*, 2009; Hammer & Chida, 2008). The greater health of the public is also enhanced by bicycling; these improvements include a decrease in the economic costs associated with physical inactivity (Katzmaryzyk & Janssen, 2004), as well as many environmental benefits, typically associated with bicycling as a form of active transportation, which include decreased noise, traffic congestion, and air pollution, including reduced greenhouse gas emissions (Pucher & Dijkstra, 2003; Boogaard *et al.*, 2009).

Ridership and the Need for Safety Assessment

The benefits of cycling support the argument that ridership should be encouraged as an urban mode of transportation alternative to the automobile. Although cycling-injury rates have decreased in recent years, the risks of cycling continue to deter people from cycling as a mode of transport (Winters *et al.*, 2010). It is estimated that 7,500 cyclists are seriously injured in Canada each year, with fatalities ranging from 40 to 70 (Transport Canada, 2005). Such statistics suggest that an investment in bicycle-specific infrastructure might be valuable in decreasing injury-crashes. However, the current literature on injuries and cycling infrastructure does not include assessment of all types of bicycling facilities; for example some studies focusing on straightaways will categorize many types into a few categories, which fail to distinguish the possible variations in risk associated with each type (Reynolds *et al.*, 2009). It is important that research continues with more specific classifications in order to establish which factors increase the rate and severity of injury crashes. This information will then be available for application when determining the type and style of infrastructure that should be built.

Previous Cycling Injury Studies and Classifications

Many studies have been conducted that examine bicycle crashes and the injuries that result. These include studies of the types of injury that can result (Finch *et al.*, 1998), as well as the patterns and repetitions within these cycling injuries. To take it a step further, such injury research is often cross-tabulated with data on helmet use (Miamaris *et al.*, 1994; Robinson, 2004). Other studies include analysis of more variables, such as injury severity, common pre-crash scenarios, and physical setting (USDOT, 2002), but not a categorical classification of the crashes studied.

Some previous research has broadened their reports from merely summarizing factors that lead to cycling crashes to the development of classification systems for bicycle crashes or injuries. Examples of crash classification systems include the classification of bicycle-motor vehicle accidents into ten categories that describe the orientation of both vehicles (Lott & Lott, 1976). A more specific classification of bicycle-motor vehicle crashes defines each as one of 34 “crash-types”, each of which is accompanied by a sketch for proper classification (Tan, 1995). However, few studies have been done that classify a comprehensive sampling of bicycle crashes; one that is not specific to those that involve motor-vehicles and includes the presence of other factors that may contribute to a crash. A study incorporating all of these variables could provide useful information to many, including municipalities attempting to improve their cycling infrastructure.

Purpose

The purpose of this study was to develop a classification system for bicycle crashes that is applicable to a wide variety of bicycle crashes. The classifications include multiple influencing factors that contributed to the occurrence of crashes, so as to present areas that need to be addressed to increase safety. This classification system was developed through the study of 300 cycling crashes that resulted in visits to hospital emergency rooms in Toronto and Vancouver. The primary circumstances behind these crashes were determined and cross-tabulated with multiple independent variables, such as trip purpose, age, and location. By categorizing the injury crash data, results regarding the situations with the highest numbers of cyclist injury crashes were established. This information could be used for determining areas that require further assessment and application of injury prevention tactics with the overall intention of improving bicycle safety and increasing ridership.

METHODS

The study of Bicyclists' Injuries and the Cycling Environment ("the BICE study") is an ongoing study in the School of Population and Public Health at the University of British Columbia, which has set out to examine cycling routes and determine the characteristics that are associated with variations in injury rates. Interviews were conducted of over 600 adult cyclists (≥19 years old) who had attended emergency departments for treatment of an injury sustained while cycling. It was required that the bicycle crashes occurred in the city in which they were treated and that the cyclists also resided in that city. The interview included information regarding a description of the injury crash, identification of route and crash site, cycling experience, demographics, and other characteristics of the trip, such as the use of personal safety devices.

The information collected from the first 300 injured cyclists was data-entered in time for this sub-study. The resulting dataset included 150 cyclists from Toronto who attended the emergency department at St. Michael's Hospital, Toronto General Hospital, or Toronto Western, as well as 150 cyclists from Vancouver who attended the emergency department at St. Paul's Hospital or Vancouver General Hospital. This dataset was used to develop a classification scheme for the bicycle crashes and to conduct an initial analysis of some of the information collected. (For a copy of the portion of the interview used see *Appendix A*).

Classification

The classification of the 300 cycling crashes was informed by a literature review. Other systems and their categories of classification were reviewed with a particular interest in those that classified crash circumstances or injury mechanisms. *Table 1* was constructed to compare these classification systems, which allows for a simple comparison of their structures and the variables they classify. *Table 2* links the variables used in other classification schemes to our data by showing the interview questions that reflect similar information. In addition, this link of classifiable variables to interview questions established the location of the information in our data.

Table 2 was used to produce *Figure 1,* which summarizes the frequency of our information used in the other classification systems, by systematically linking the categories

Table 1: **Classification systems reviewed** in order to determine which variables should be included in our classification of cycling injury-crashes.

System	Source	Variables Classified	Structure of Classification	Additional Information
Occupational Injury and Illness Classification Manual (OIICM)	U.S. Department of Labor, Bureau of Labor Statistics (1992).	- Nature of Injury or Illness - Part of Body Affected - Source of Injury or Illness - Event or Exposure, e.g.: - contact with other objects - falls - Secondary Source of Injury or Illness	- Category (symbol) - Divisions (0) - Major group (00*) - Minor group (000*)	Source of injury: 8 Vehicles 83* highway vehicle, non-motorized 831* Animal or human powered vehicle 8312 Bicycle
International Classification of External Causes of Injuries (ICECI)	(Version 1.2) ICECI Coordination and Maintenance Group (2004). Consumer Safety Institute, Amsterdam and AIHW National Injury Surveillance Unit, Adelaide.	Core Module: - Intent - Mechanism of injury - Object/substance producing injury - Place of occurrence - Activity when injured - Alcohol, psychoactive drug, or substance use	Module (character) -- Core: overview, applicable to all injuries *Additional modules: specific to injury Each module includes: - elements (numerical) - code: categories (numerical) - inclusions/exclusions (decimal)	Sport Module (S) of particular interest: Elements: S1: Type of sport/ exercise activity S2: Phase of activity S3: Personal counter measures S4: Environmental counter measures
Ten classes of Bicycle-automobile accidents in Davis, CA	Lott, D.F. and D.Y. Lott (1976). Effect of Bike Lanes on Ten Classes of… *J Safe Res* vol. 8 (4), pg 171 – 179.	Accident type: proximal causes	Simply ten categories (single variable system)	Examples: 1. Cyclist failed to stop/yield at controlled intersection 2. Motorist collided with rear of vehicle
Crash-Type Manual	Tan, S. 1995 University of North Carolina Highway Safety Research Center. For the U.S. Department of Transport.	- precipitating actions - predisposing factors - characteristic populations and/or location	Describing title Accommodated by an illustration showing the crash situation	Examples: - Ride out at driveway, stop sign, etc. - Trapped - Overtaking - Multiple threat
Analysis of pedacyclist crashes	USDOT analysis of pedacyclist crashes, 2002.	- pre-crash scenario - severity - age involvement (driver & cyclist) - physical setting - contributing factors	each variable includes descriptive analysis, pie charts. (No systematic classification)	some statistics on fatalities
Factors in the Initiation of Bicycle-vehicle Collisions	Williams, A.F. (1976). *Am J Dis Child*, vol. 130, pg 370 – 377.	- motion of bicycle - motion of vehicle	categorized probable responsibility based on movement of bicycle and vehicle	Examples: - vehicle driving wrong may in lane or road - ran stop sign - emerged from driveway, ally, parking lot, etc.

Table 2: **Variables within each classification system and their location in our dataset.** Not applicable (n/a) means that the information was not found anywhere in our dataset.

System	**Variables**	**Categories**	**Source in our dataset** Question#(response)
ICECI—Sport Module	Type (17 : wheeled, non-motor sports)	.01 BMX	25 (9)
		.02 mountain	25 (3)
		.03 road	25 (2)
		.04 track/ velodrome	25 (4)
		.05 other specified	25
		.06 unspecified	25
	Phase	1. Training	23 (6)
		2. pre-event	no
		3.Warm-up	no
		4.Competition	23 (6)
		5. cool down	no
		6. post-event	no
		7. recreational participation	23 (6)
		98. other specified	23 (1-5, 7)
		99. unspecified	
	Personal Counter equipment	1. none	32 (7) no helmet
		2. braces, orthotics, guards	n/a
		3. taping	n/a
		4.padding	n/a
		5. thermal devices	n/a
		6. splints	n/a
		7. jock	n/a
		8. gloves	n/a
		9. mouth guard	n/a
		10. goggles	n/a
		11. helmet	32
		12. facemask	n/a
		13. footwear	n/a
		14. PFD	n/a
		98. other specified	29 and 30 (lights)
		99. other unspecified	n/a
	Environmental Counter measures	1. none	assumed response
		2. padded surfaces	no
		3. corner padding	no
		4. barrier	B21
		5. safety restraints	n/a
		8. other specified	B18
		9. unspecified	typical response
ICECI—Core Module	Intent	1. Unintentional	typical assumed response
		2. Intentional Self-harm	n/a
		3. Assault	n/a
		4. Other Violence	n/a

Table 2 continued.

System	Variables	Categories	**Source in our dataset** Question#(response)
ICECI—Core Module *continued*	Intent *continued*	5. Undetermined intent	n/a
		6. Complications of medical/surgical care	n/a
		8. Other specified intent	n/a
		9. Unspecified Intent	n/a
	Mechanism	1. Blunt Force	4 (interpretation)
		2. piercing or penetrating force	4 (interpretation)
		3. other mechanical force	4 (interpretation)
		4. Thermal Mechanism	4 (interpretation)
		5. threat to breathing	4 (interpretation)
		6. Exposure to chemical or other substance	4 (interpretation)
		7. Physical over-exertion	4 (interpretation)
		8. exposure to (effect of) weather, natural disaster, or other force of nature	4 (interpretation)
		20. Complication of health care	4 (interpretation)
		98. Other specified mechanism of injury	4 (interpretation)
		99. Unspecified mechanism of injury	4 (interpretation)
	Object/ substance producing Injury	1. Land vehicle or means of land transport	5.1
		2. Mobile machinery or special purpose vehicle	4 interpretation
		3. watercraft or means of water transport	n/a
		4. aircraft or means of air transport	n/a
		5. furniture/ furnishing	n/a
		6. Infant or child product	4 interpretation
		7. appliance mainly used in household	n/a
		8. utensil or container	n/a
		9. item mainly for personal use	n/a
		10. equipment mainly used for sports/ recreational activity	typical assumed response
		11. tool, machine, apparatus mainly used for work-related activity	4 interpretation
		12. weapon	n/a
		13. animal, plant, or person	5.1
		14. building, building component or related fitting	5.1
		15. ground surface or surface conformation	5.1
		16. material NEC	n/a
		17. Fire, flame or smoke	n/a
		18. hot object/substance NEC	n/a
		19. food or drink	n/a
		20. pharmaceutical substance for human use, e.g. drug, medicine	34
		21. non pharmaceutical chemical substance	34
		40. medical/ surgical device	n/a
		98. Other specified object/substance	4 (interpretation)
		99. Unspecified	4 (interpretation)

Table 2 continued.

System	Variables	Categories	**Source in our dataset** Question#(response)
ICECI—Core Module *continued*	Place of Occurrence	1. Home	n/a
		2. Residential institution	n/a
		3. medical service area	n/a
		4. school, education area	n/a
		5. sport and athletics area	n/a
		6. transport area: public highway, street or road	6.2
		7. transportation area: other	6.2
		8. industrial or construction area	B 21
		9. farm or other place of primary production	n/a
		10. recreational area, cultural area, or public building	11
		11. commercial area (non-recreational)	n/a
		12. countryside	n/a
		98. other specified place of occurrence	11
		99. unspecified place of occurrence	n/a
	Activity when injured	1. paid work	23.3
		2. unpaid work	23
		3. education	23
		4. sports and exercise during leisure time	23.6
		5. leisure or play	23.6
		6. vital activity	n/a
		7. being taken care of	n/a
		8. travelling	23.1/ .2
		98. other specified activity	23
		99. unspecified activity	23
	Alcohol use	1. no information available	34.2 (9)
		2. no suspicion or evidence of alcohol use by any person involved in the injury event	34.2 (0)
		3. suspicion or evidence of alcohol use by the injured person	34.2 (1)
		4 suspicion or evidence of alcohol use by other persons involved in the injury event	n/a
		5. suspicion or evidence of alcohol use by both the injured person and other persons involved in the injury event	n/a
	Psychoactive drug or substance use	1. no information available	34.3/4 (9)
		2. no suspicion or evidence of psychoactive or other substance use by any person involved injury event	34.3/4 (0)
		3. suspicion or evidence of psychoactive or other substance use by the injured person	34.3/4 (1)
		4 suspicion or evidence of psychoactive or other substance use by other persons involved in the injury event	n/a

Table 2 continued

System	Variables	Categories	**Source in our dataset** Question#(response)
ICECI—Core Module *continued*	Psychoactive drug or substance use *continued*	5. suspicion or evidence of psychoactive or other substance use by both the injured person and other persons involved in the injury event	n/a
Occupational Injury and Illness Classification Manual (OIICM)	Nature of Injury or Illness	0 Traumatic Injuries and Disorders	n/a
		1 Systemic Diseases or Disorders	n/a
		2 Infectious and Parasitic Diseases	n/a
		3 Neoplasms, Tumors, and Cancer	n/a
		4 Symptoms, Signs, and Ill-defined Conditions	n/a
		5 Other Conditions or Disorders	n/a
		8 Multiple Diseases, Conditions, or Disorders	n/a
		9999 Nonclassifiable	n/a
	Part of Body Affected	0 Head	n/a
		1 Neck, Including Throat	n/a
		2 Trunk	n/a
		3 Upper Extremities	n/a
		4 Lower Extremities	n/a
		5 Body Systems	n/a
		8 Multiple Body Parts	n/a
		9 Other Body Parts	n/a
		9999 Nonclassifiable	n/a
	Source of Injury or Illness	0 Chemicals and Chemical Products	n/a
		1 Containers	n/a
		2 Furniture and Fixtures	n/a
		3 Machinery	4 (interpretation)
		4 Parts and Materials	4 (interpretation)
		5 Persons, Plants, Animals, and Minerals	4 (interpretation)
		6 Structures and Surfaces	4 (interpretation)
		7 Tools, Instruments, and Equipment	4 (interpretation)
		8 Vehicles	4 (interpretation)
		9 Other Sources	All bicycle
		9999 Nonclassifiable	n/a
	Event or Exposure (includes contact with other objects and falls as divisions)	0 Contact With Objects and Equipment	5 (1)
		1 Falls	5 (0)
		2 Bodily Reaction and Exertion	n/a
		3 Exposure to Harmful Substances or Environments	5.1
		4 Transportation Accidents	5 (all)
		5 Fires and Explosions	n/a
		6 Assaults and Violent Acts	n/a
		9 Other Events or Exposures	n/a
		9999 Nonclassifiable	n/a

Table 2 continued

System	Variables	Categories	**Source in our dataset** Question#(response)
OIICM *continued*	Secondary Source of Injury or Illness	see sources of injury	4 (interpretation)
Lott and Lott. Ten Classes of bicycle-automobile accidents in Davis, Ca.	Movement of cyclist and motorist	1. Cyclist exited driveway into motorist path	4/12 (interpretation)
		2. motorist exited driveway into cyclist path	4/12 (interpretation)
		3. cyclist failed to stop/yeild at controlled intersection	4/12 (interpretation)
		4. cyclist made improper left turn	4/12 (interpretation)
		5. cyclist rode on wrong side of street	4/12 (interpretation)
		6. motorist collided with rear of cyclist	4/12 (interpretation)
		7. motorist failed to stop/yield at controlled intersection	4/12 (interpretation)
		8. motorist made improper left turn	4/12 (interpretation)
		9. motorist made improper right turn	4/12 (interpretation)
		10. motorist opened car door into cyclist's path	4/12 (interpretation)
Factors in the initiation of bicycle-vehicle collisions.	Movement of vehicle	In motion; other vehicle not in motion	4/12 (interpretation)
		struck other vehicle from behind	4/12 (interpretation)
		intersected other vehicle travelling in same direction	11.6 (1)
		emerged from driveway, alley, parking lot, gas station, etc	4/12 (interpretation)
		Came onto road from lawn or other non-roadway location and intersected other vehicle	4/12 (interpretation)
		ran through stop or yield sign	4/12 (interpretation)
		wrong way on one-way street or in lane designated for traffic in opposite direction	11.6 (2)
		while making a left turn, collided with oncoming vehicle	4 (interpretation)
		unclassified	4 (interpretation)
	motion of bicycle	bicycle not in motion; motor vehicle in motion	4/12 (interpretation)
		both bicycle and motor vehicle in motion	4/12 (interpretation)
		bicycle in motion; motor vehicle not in motion	4/12 (interpretation)
USDOT Analysis of pedacyclist crashes	Pre-crash scenarios	vehicle going straight	4/12 (interpretation)
		vehicle turning right	4/12 (interpretation)
		vehicle turning left	4/12 (interpretation)
		vehicle parking	4/12 (interpretation)
		vehicle backing	4/12 (interpretation)
		Other	4/12 (interpretation)
		crossing paths	4/12 (interpretation)
		parallel paths	4/12 (interpretation)

Table 2 continued

System	Variables	Categories	**Source in our dataset** Question#(response)
USDOT Analysis of pedacyclist crashes *continued*	physical setting	roadway profile/ alignment	6.2.1 /12
		posted speed limit	n/a
		traffic control device	12
		relation to roadway	11
	contributing factors and circumstances	Alcohol/Drugs	34
		Impaired	34
		Driver Distracted By	n/a
		Driver Vision Obscured By	n/a
		Speeding/Reckless Driving	4 (interpretation)
		Sign/Signal Violation	4 (interpretation)
		Driver Lost Control	4 (interpretation)
		Other Violation Charged	4 (interpretation)
		Hit & Run	4 (interpretation)
	age involvement	age of cyclist	43
		age of driver	n/a
	crash severity	based on an index	n/a
Crash-Type Manual	Motion of bicycle	ride out at commercial driveway	12 (sketch analysis)
		ride out at residential driveway	12 (sketch analysis)
		ride out from sidewalk	12 (sketch analysis)
		ride out at midblock	12(sketch analysis)
		ride out at stop sign	12 (sketch analysis)
		Trapped	12 (sketch analysis)
		multiple threat	12 (sketch analysis)
		drive out at midblock	12 (sketch analysis)
		drive out at stop sign	12 (sketch analysis)
		Unknown	12 (sketch analysis)
		right on red	12 (sketch analysis)
		backing	12 (sketch analysis)
		drive through	12 (sketch analysis)
		etc. *37 categories in total; all based on the positioning of the bicycle, vehicle and traffic control devices; accompanied by a drawing	12 (sketch analysis)

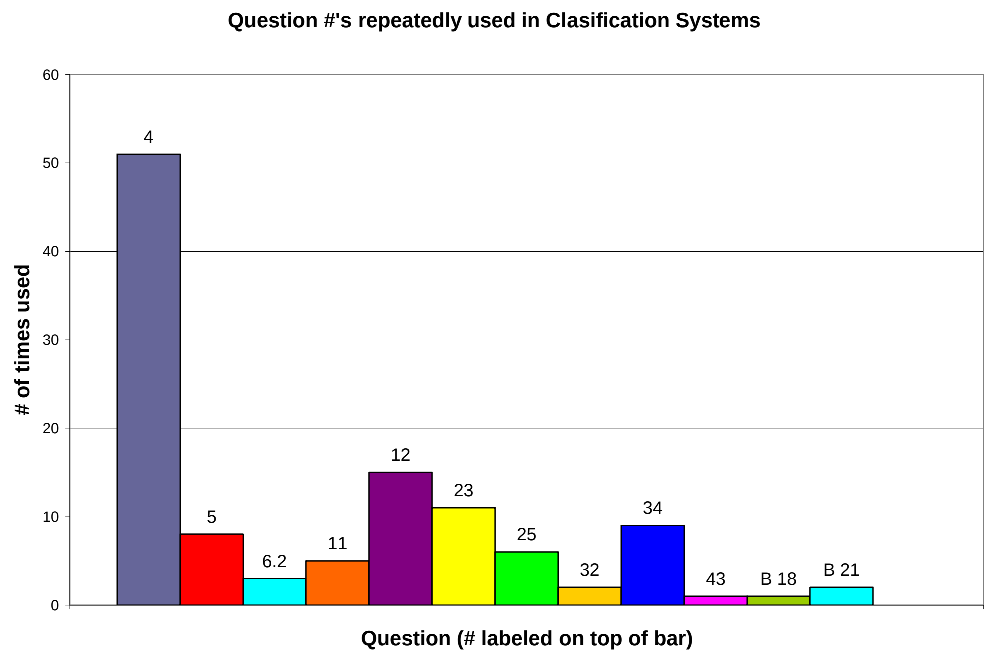


Figure 1: **Question numbers repeatedly used in classification systems** Shows the number of times the information from each interview question was used in the previous classification systems under review. A brief summary of the topics of each question are as follows (for entire question including response options see *Appendix A*): Question 4: free response question describing injury event; Question 5: object of collision; Question 6.2: street/ intersection of crash location; Question 11: specifics on injury site; Question 12: sketch of injury site; Question 23: trip purpose; Question 25: type of bicycle; Question 32: helmet specifics; Question 34: consumption of foreign substances; Question 43: age of cyclist; Question B18: illuminating street lights at crash site; Question B21:construction at crash site.

within all the reviewed systems to our dataset. It was produced to numerically show the prevalence of each variable and ease the decision about which variables to include in our classification. *Figure 1* and the interview questions represented by it were critically assessed to determine which variables to include when classifying the 300 cycling crashes in our dataset. It was established that the following information should be included in the classification of the bicycle crashes: the primary circumstance of the crash; cyclists' age, gender, and city; the purpose of the bicycle trip; and use of foreign substances prior to the trip. Wit the exception of primary circumstance, all these variables were found directly in our dataset and are summarized in *Table 3*, as well as defined in the Results (Bicycle Crash Classification) section of the paper.

Table 3: **Various descriptive variables and their sources in dataset** for use in cross-tabulations with the outcome variables.

Descriptive Variables	**Source**	**Categories**	**Simplified Categories**
Gender	Interview Q39	- male - female	- male - female
Age	2009 - Q43 (year of birth) = age	- 19-29 - 30-39 - 40-49 - 50-59 - 60-69 - - 70+	- young (<30) - older
Foreign substance Use	Interview Q34 34.1 on medications 34.2 on alcohol 34.3 on marijuana 34.4 on other recreational drugs	- alcohol - marijuana - other recreational drugs - medications - (2 or more) - no substance use	- non-prescription substances - medications - no substance use
Trip purpose (hierarchy order used as shown)	Dataset Q23 o to or from work o to or from school o as part of your job (e.g. courier) o for personal business (e.g. shopping) o for social reasons (e.g. visiting friends) o exercise or recreation o other	- work commute - school commute - for employment - running errands - for social reasons - exercise - other	- work/school - other
City	Hospital: 1. St. Michael's 2. University Hospital Network (TGH & Toronto Western) 3. St. Paul's 4. VGH	- Toronto (1 & 2) - Vancouver (3 & 4)	- Toronto - Vancouver

The other information found in *Figure 1* that we have obtained through the interviews was not used in this paper; however, all the information will eventually be analyze within the BICE study. For example, the presence of street lighting and personal safety devices, such as reflectors, will be part of another analysis.

The primary circumstance of each crash was established by the interpretation of the information from answers to Questions 4, 5, and 5.1 of the interview. The answer to Question 5 established the first level of classification under primary circumstance by defining the crash as either a collision or a fall. Crashes established as "collisions" were further classified into second and third levels of classification by the analysis of responses to Question 5.1 ("What did you collide with?"), combined with the interpretations of answers to Question 4 (a free response question based on the cyclist's description of the injury incident) when the specified "other" responses did not suffice. Next, those crashes that were not defined as collisions (answers of "no" to Q5) were categorized as "falls"; further levels of classification were determined based on interpretations of the free responses to Question 4. The categories of primary circumstance established are listed in *Table 4* and are individually defined, along with a description of their source in the dataset, in the Results section of this study.

Table 4: **The categories of the outcome variables** to be cross-tabulated with the descriptive variables

Outcome Variables	Categories
Primary Circumstance (levels 1 & 2)	COLLISION - Motor vehicle COLLISION - Person/animal COLLISION - Infrastructure COLLISION - Cycling surface COLLISION - Other FALL - collision avoidance FALL - bicycle malfunction FALL - wheel lodge FALL - cycling behaviour FALL - no recollection FALL – other
Primary Circumstance – Collision vs. Fall	- Collision - Fall
Primary Circumstance – streetcar or train tracks	- Streetcar or train tracks - Other
Primary Circumstance – vehicle door	- Vehicle door - Other
Primary Circumstance - person/animal	- Person/animal - Other
Motor-vehicle Involvement	- Motor-vehicle involved - No motor-vehicle involved

The motor-vehicle involvement in each crash was also developed as a separate outcome variable. This was initially established using both the primary circumstance classification, as well as the cyclists' responses to Question 4. Each crash was defined as either having a "motor-vehicle involved", which includes not only collisions or avoidance of a vehicle, but also crash descriptions that mention divergence from the cyclist's path due to a car. Crashes that did not mention a specific vehicle in the description were defined by "no motor-vehicle involvement". These categories of motor-vehicle involvement are also included in *Table 4*, and their definitions can also be found in the Results (Bicycle Crash Classification) section of the paper.

The descriptive, or independent, variables included in the classification of the crashes are also defined and described in the Results (Bicycle Crash Classification) in a systematic manner so that reference to category definitions would be simple. The categories of each variable were established by studying our dataset and making appropriate categories with careful characterization so that they could be applied to in the classification of other cycling crashes.

Data Analysis

In addition to the development of the classification system, data analysis was conducted to summarize and evaluate our data. The descriptive variables (gender, age, foreign substance use, and trip purpose) and the outcome variables (primary circumstance and motor-vehicle involvement) were compared between Toronto and Vancouver in order to determine the variations that exist between the two cities. The second outcome variable, motor-vehicle involvement, was also analyzed to determine its variation in the distribution throughout the bicycle crashes. The data analysis was conducted with the primary goal of revealing the situations that relate to a high proportion of cycling crashes, and comparing the data to see how crashes vary between the two cities.

Cross-tabulations of the descriptive variables in Toronto and Vancouver were conducted using the Statistical Package for the Social Science (SPSS) (SPSS Inc. Chicago, IL: Version 17.0) to determine the differences that exist between the two cities. A comparison of age distributions of the cyclists in Toronto and Vancouver was done by completing a T-test using SPSS. Descriptive statistics of the age distributions were also calculated including the means, standard deviations and confidence intervals. The statistical significance of variations between city and gender, foreign substance use, or trip purpose was determined via chi-squared analyses using SPSS.

After the primary circumstance of each of the 300 cycling crashes was established using the classification scheme developed, the results were displayed in frequency tables and pie charts using Microsoft Office Excel (Excel) (Microsoft. Redmond, WA: 2003). The 95% confidence interval for the proportion in each category was calculated using the following formula:

$$95\% \text{ CI} = \pm 1.96\ [(p(1-p))/\ n]^{0.5}; \qquad \text{where } p = \text{number in the category}$$
$$n = \text{sample size}$$

Simplified forms of the primary circumstance were developed for more comprehensive cross-tabulation between the two cities; these variations of primary circumstance are described in *Table 4*. Comparisons between the two cities were made by calculating the odds ratio (OR): the ratio of the odds of a collision being in Toronto versus Vancouver to the odds a fall being in Toronto versus Vancouver. Similar calculations of odds ratios were done for the comparison of motor-vehicle involvement to no motor-vehicle involvement. The significance of each OR was determined by calculating the 95% confidence interval using the following method:

$$95\% \text{ CI} = e^{\ln \hat{OR} \pm 1.96 \cdot \text{SE}_{\ln(\hat{OR})}} ; \text{ where SE}_{\ln(\hat{OR})} = \sqrt{\frac{1}{a_1} + \frac{1}{b_1} + \frac{1}{a_2} + \frac{1}{b_2}}$$

The initial analyses examined each independent variable (city, age, gender, foreign substance use, trip purpose) separately. This was followed by the creation of models that incorporated and adjusted for all important independent variables in a single analysis. This was completed via two separate multiple logistic regressions to determine the adjusted influence of each significant independent variable on each of the outcome variables: primary circumstance; and motor-vehicle involvement. In order to determine which independent variables to include in the logistic regression, each descriptive variable was first simplified to have only two categories (except for Foreign Substance Use which required 3) (refer to *Table 3* for the simplified categories developed) and then cross-tabulated with each outcome variable, in unadjusted analyses. The independent variables with statistically significant odds ratios were then used in the logistic regression models.

A binary logistic regression was run using SPSS with the dependent variable of primary circumstance: collisions (1) versus falls (0), and descriptive variables with statistically significant odds ratios as the covariates. The same type of regression was repeated with the dependent variable being motor vehicle involvement (1) (with no motor-vehicle involvement being the reference (0)) and the appropriate descriptive variables, based on significant odds ratios, as covariates. The results included the coefficient (B value), the standard error (S.E.), and the significance (*p*-value) of each descriptive variable; the adjusted odds ratios and 95% confidence intervals were then calculated using the formulas:

$$OR = e^{B} \qquad\qquad 95\%\ CI = e^{(B \pm 1.96\ S.E.)}$$

The results of each logistic regression model were displayed in a table and showed the odds of collisions or motor-vehicle involvement under the combined influence of the multiple descriptive variables.

RESULTS

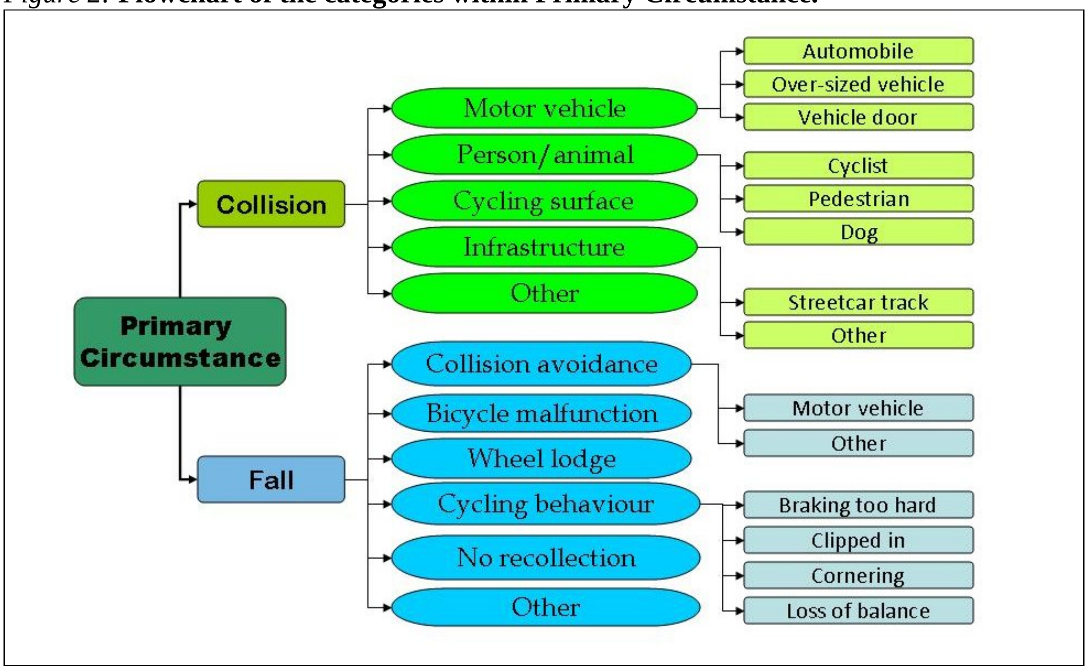
Bicycle Crash Classification

The categories of classifications used throughout this study are defined below, and the sources of the information used from the interview conducted are indicated for eash. (See *Appendix A* for the portion of the interview used). The systematic descriptions are intended to make reference to definitions efficient and to make application of this classification system to future cycling crash studies possible.

Outcome Variables (1-2): Category name: definition (source in our dataset).

1. **Primary Circumstance**: designates the simplest circumstance that led to the bicycle crash; our own method of classification based initially on responses to Question 5 of the Interview, but made more sophisticated by the interpretation of free-response, incident descriptions in Question 4. *Figure 2* gives a visual layout of the categories of primary circumstance.

Figure 2: **Flowchart of the categories within Primary Circumstance.**



1.1 **Collision**: a crash initiated by the cyclist coming in contact with another object, including motor vehicle, person, animal, or road hazard. (Question 5, response (1.) "Yes").

1.1.1 *Motorized vehicle*: collision with a motor-vehicle

1.1.1.1 *Automobile*: collision with an automobile, except collision with automobile door(Question 5.1, response of "Car, SUV, pick-up truck, van")

1.1.1.2 *Over-sized vehicle*: collision with a large vehicle, including truck, bus, trailer; except collision with over-sized vehicle door (Question 5.1, responses of "Large truck", "Bus or streetcar" or "other" specified as "trailer")

1.1.1.3 *Vehicle door*: collision with the door of a parallel-parked vehicle; often due to sudden opening (Question 5.1, specified in "Other" responses, or interpreted from free response Question 4)

1.1.2 *Person or Animal:* collision with a person or animal

1.1.2.1 *Cyclist*: collision with another person on a bicycle (Question 5.1, response "bicycle")

1.1.2.2 *Pedestrian*: collision with a person on foot (Question 5.1, response "Cyclist")

1.1.2.3 *Dog*: collision with an animal, all of which were dogs in our study (Question 5.1, response "animal")

1.1.3 *Infrastructure*: collision with an obstacle that is of permanent in nature and built by man; fence, curb, barrier, etc. (Question 5.1, response "Other" specification interpretation including responses of "curb", "fence", etc.)

1.1.4 *Cycling Surface*: collision with an obstacle that is on or in the surface the cyclist is on; often misplaced, requiring maintenance or removal; metal sheets, pot hole, etc. (Question 5.1, response "pot hole" and "Other" specification interpretation including responses of "metal plates" and "debris").

1.1.4.1 *Streetcar or train track*: collision with the track of a train or street car; often causing the bicycle wheel to slip or be lodged in the track's depression (Question 5.1, response "Street car or train track").

1.1.4.2 *Other surface*: Collisions with other unfavourable cycling surfaces, such as patches of rough road (including potholes), ice and gravel. (Question 5.1, responses "pothole" and "other" specification interpretations).

1.1.5 *Other (collision)*: collision with obstacles that do not fall into any other collision category, examples include a locked bicycle or a low tree branch, etc. (Question 5.1, response "Other" specification interpretations that did not fall into previous categories).

1.2 **Fall**: crashes that were not initiated by the collision of the bicycle with another object (Question 5, response (0.) "No". All variables were classified based on the interpretations of free responses to Question 4).

1.2.1 *Collision avoidance*: fall from attempting to avoid colliding with other object (person, car, obstacle) causing loss of control.

1.2.1.1 *Vehicle avoidance*: a fall resulting from an attempt to avoid colliding with a vehicle.

1.2.1.2 *Other avoidance*: a fall resulting from an attempt to avoid colliding with an object other than a vehicle, including pedestrians, other cyclists and curbs.

1.2.2 *Bicycle malfunction*: malfunction of a bicycle part, i.e. chain break, gear jam, brake failure.

1.2.3 *Wheel lodge*: sudden halting of bicycle (wheel) caused by an item getting lodged in the wheel, examples include grocery bag, yoga mat, chain lock; often being carried on the handle bars.

1.2.4 *Cycling behaviour*: fall resulting from the action of the cyclist; often due to misjudgement or cyclist's error.

1.2.4.1 *Clipped in*: feet remained clipped into pedals when bicycle was at/close to a complete stop.

1.2.4.2 *Braking too hard*: exceeded required leverage on brake levers causing the bike to stop too quickly; forward momentum often propelling cyclist over handle bars.

1.2.4.3 *Cornering too fast*: failing to slow down enough for a turn causing bicycle tires to slip and bicycle to fall to side.

1.2.4.4 *Loss of balance*: loss of balance while riding, with no further explanation or cause given.

1.2.5 *No recollection*: an injury incident involving a cyclist falling off of bicycle in which the cyclist has no recollection of the circumstances of the fall, typically due to impact to head.

1.2.6 *Other (fall)*: bicycle falls that do not fall into any other fall category, examples include crashes following a cyclists' seizure, or due to the cyclists walking holding their dog's leash.

2. **Motor-vehicle involvement**: designates the presence of a motor vehicle in the relating to the event of the bicycle crash.

2.1 *Motor-vehicle involved*: crashes that include the presence of a specific motor vehicle in the description of the crash; includes not only direct collision with a motor vehicle, but also the avoidance of collision with a motor vehicle resulting in a collision with some other object or resulting the cyclist to fall. As well as the presence of a motor vehicle that required the cyclists to veer from its path. (Question 5.1, responses "Car, SUV, pick-up truck, van", "Motorcycle or scooter", "Large truck", or "Bus or street car" as well as Question 4 interpretation).

2.2 *No motor-vehicle involved*: crashes that do not include the presence of a specific motor vehicle in the description of the crash. (All crashes not designated motor-vehicle related).

Descriptive variables (3-7): Variable name: definition (source in our dataset).

3. **Gender**: gender of the cyclist (determined from response to Question 39)

3.1 *Male*

3.2 *Female*

3.3 *Not specified*

4. **Age Group**: age of the cyclist at time of interview (determined by subtracting year of birth, Question 34, from 2008, which designates the year of the interview)

4.1 : *19 – 29* years of age

4.2 : *30 – 39* years of age

4.3 : *40 – 49* years of age

4.4 : *50 – 59* years of age

4.5 : *60 – 69* years of age

4.6 *70+* years of age

4.7 *Not specified*

5. **Foreign substance use**: designates the consumption of any of the following foreign substances within 6 hours prior to the bicycling trip (Question 34, specifications below).

    5.1 *Non-prescription substances*: includes alcohol, marijuana and all drugs that are not over the counter or prescription (Question 34.2, 34.3, or 34.4; responses (1.) Yes)

        5.1.1 *Alcohol*: examples include beer, wine or spirits (Question 34.2, response (1.) Yes)

        5.1.2 *Marijuana*: including cannabis or hashish (Question 34.3, response (1.) Yes)

        5.1.3 *Other recreational drugs*: examples include cocaine, heroin, and crystal meth (Question 34.4, response (1.) Yes)

    5.2 *Medications*: over the counter or prescription medications (Question 34.1, response (1.) Yes)

    5.3 *No substance use*: designates none of the above following substances were reported as consumed within 6 hours prior to the trip (Questions 34.1, 34.2, 34.3, and 34.4, responses of (0.) no, or (8.) don't know).

6. **Trip purpose**: designates the primary intention of the bicycle trip (All direct responses from Question 23; hierarchy order used as below in order to choose single purpose from responses that included multiple.)

    6.1 *Work commute*: going to or from work

    6.2 *School commute*: going to or from school

    6.3 *For employment*: as part of job; *e.g.* as a courier

    6.4 *Running errands*: completing personal business; e.g. to or from store, appointment, etc.

    6.5 *Social reasons*: riding to or from social affairs; e.g. to the movies, visiting friends, etc.

    6.6 *Exercise*: cycling for exercise or recreation

6.7 *Other*: riding a bicycling for a reason other than those described above; specifications include "trying a track bike" and "volunteering"

7. **City**: designates the city in which the bicycle crash took place (determined by hospital attended, see specifications below).

    7.1 *Toronto*: bicycle crashes that took place within the city of Toronto (Determined by designated hospital: (1) St. Michael's and (2) University Health Network (TGH and Toronto Western))

    7.2 *Vancouver*: bicycle crashes that took place within the city of Vancouver (Determined by designated hospital: (3) St. Paul's and (4) Vancouver General Hospital (VGH))

Data Analysis

Descriptive Variables

The injured cyclists' genders and ages were tallied, in order to compare the variation in these independent variables between the two cities. Frequencies of each category were compiled in *Table 5*, along with those of foreign substance use and trip purpose. It was found that 52.3% of the cyclists' interviewed from Toronto were male, while 58% of the Vancouver cyclists were male. A chi-squared analysis resulted in a *p*-value equal to 0.326, which means that there is no significant difference in the gender of cyclists between Toronto and Vancouver.

The distribution of age of the injured cyclists was also compared between the two cities. It was calculated that in Toronto the mean age was 38 years with a standard deviation of 12.8; in Vancouver, the mean age was 36 years with a standard deviation of 13.1. The t-test was completed to determine if there was a significant difference in the age distributions, produced a *p*-value equal to 0.247, meaning there in no statistically significant difference in cyclists' age between the two cities. The similarity in the age distributions of cyclists in Toronto and Vancouver is visually represented in *Figure 3*, which also shows a negative relationship between age and the number of cyclists in each category.

There were a total of 60 injured cyclists who gave positive responses to consuming foreign substances within 6 hours before the bicycle trip, with 42 consuming non-prescription foreign substances (32 alcohol, 9 marijuana, and 1 other recreational drug) and

Table 5: **Gender, age, foreign substance use, and trip purpose in Toronto and Vancouver**. This table shows the number (and percentage) of cyclists in Toronto and Vancouver in each category of the descriptive variables.

Descriptive variables	Toronto	Vancouver	Total
Gender			
Male	78 (52.3%)	87 (58.0)	165 (55.2)
Female	71 (47.7)	63 (42.0)	134 (44.8)
Age			
19-29	62 (41.3)	52 (34.9)	114 (38.1)
30-39	37 (24.7)	32 (21.5)	69 (23.1)
40-49	25 (16.7)	34 (22.8)	59 (19.7)
50-59	16 (10.7)	20 (13.4)	36 (12.0)
60-69	8 (5.3)	8 (5.4)	16 (5.4)
70+	2 (1.3)	3 (2.0)	5 (1.7)
Mean age, SD (95% CI)	36, 12.8 (34 - 38)	38, 13.1 (36 – 40)	37, 13.0 (36 - 38)
Foreign Substance Use^			
alcohol	15 (9.8)	17 (10.1)	32 (10.1)
marijuana	1 (0.7)	8 (5.0)	9 (2.9)
other recreational drugs	1 (0.7)	0 (0.0)	1 (0.3)
medications	12 (7.8)	16 (10.1)	28 (9.0)
2 or more responses (total n=300)	*3 (2.0)*	*8 (5.3)*	*11 (3.7)*
No substance use	124 (81.0)	118 (74.2)	242 (77.6)
Trip Purpose*			
work commute	69 (46.0)	45 (30.0)	114 (38.0)
school commute	5 (3.3)	3 (2.0)	8 (2.7)
for employment	9 (6.0)	3 (2.0)	12 (4.0)
running errands	29 (19.3)	20 (13.3)	49 (16.3)
social reasons	22 (14.7)	35 (23.3)	57 (19.0)
exercise	16 (10.7)	42 (28.0)	58 (19.3)
other	1 (0.7)	1 (0.7)	2 (0.7)
** p< 0.05; a statistically significant difference exists between cities*			
^total n > 300, because cyclists could give multiple responses; percentages: n(cities) = 150, n(total) = 300			

28 consuming medications including prescription and over the counter drugs. Of the 60 positive responses to the consumption of a foreign substance, 11 cyclists had consumed two or more of the categories of foreign substances. A comparison of foreign substance use between Toronto and Vancouver was completed; totals in each category can be found in *Table* 5. Chi-squared analysis confirmed that the variation in the distributions of responses between the cities was not significant (p-value = 0.101).

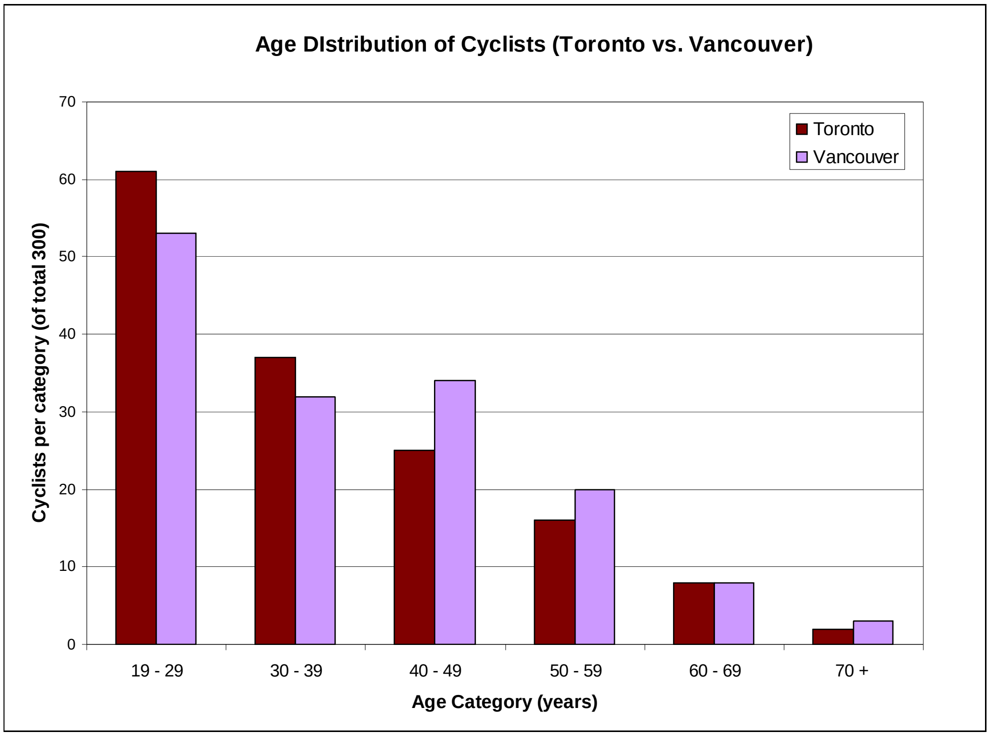


Figure 3: **Bar graph of age distribution of cyclists in Toronto and Vancouver** shows a relatively consistent pattern of age distribution in both cities. The t-test conducted yielded a *p-value* = 0.247, which indicates that there is no significant difference in the age distributions between the two cities.

A comparison of the variable of trip purpose between the two cities showed a relatively different pattern amongst the categories, as portrayed in *Figure 4*. It was found that more people in Vancouver were cycling for exercise (46 cyclists in Vancouver compared to 16 in Toronto) or social reasons (35 in Vancouver to 22 in Toronto) at the time of their crash than those is Toronto. Cyclists in Toronto were cycling to work when they crashed more frequently than those in Vancouver (69 cyclists to 45, respectively). The purpose of running errands was also more frequent in Toronto with 29 cyclists choosing this response compared to only 20 in Vancouver. Additionally, there were more people cycling for employment in Toronto than in Vancouver (9 and 3 cyclists, respectively) Chi-squared analysis showed a statistically significance difference between the trip purposes of cyclists in Toronto and Vancouver, with a *p*-value equal to 0.001.

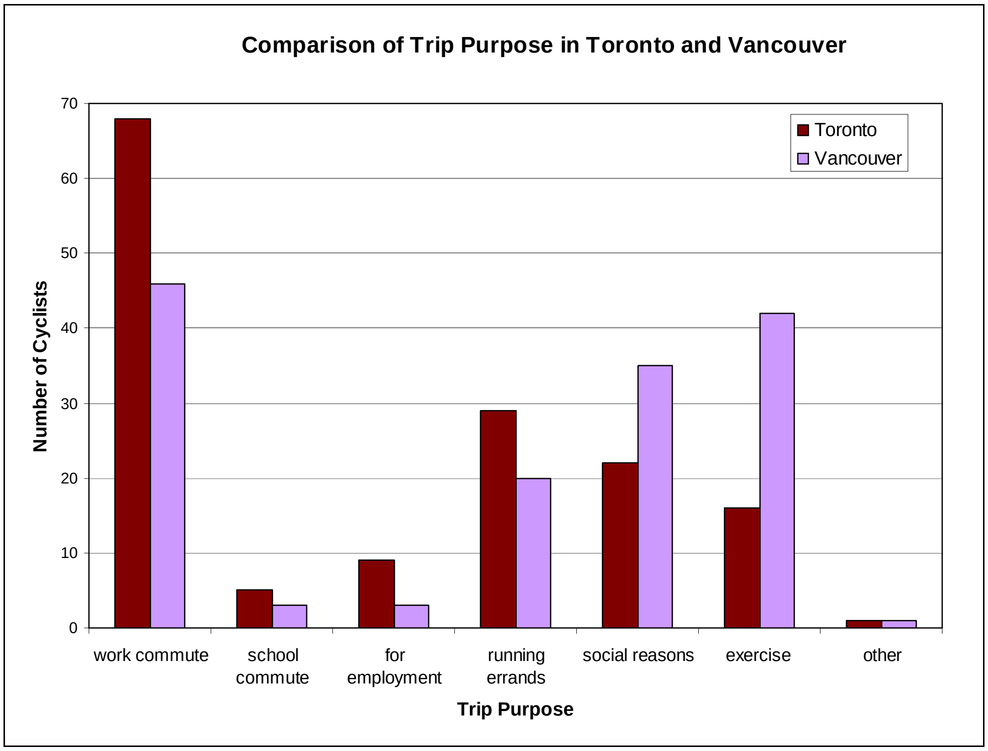


Figure 4: **Variations in the purpose of bicycle trips in Toronto and Vancouver.** This graph shows large variation in the number of cyclists that were cycling for exercise at the time of their bicycle crash, with 42 cyclist in Vancouver and only 16 in Toronto. It also shows that there were many cyclists in Toronto commuting to work at the time of their crash than in Vancouver with a difference of 24. Application of chi-squared analysis to this data resulted in a p-value equal to 0.001, which implies that the difference in trip purpose responses between Toronto and Vancouver is statistically significant.

Primary Circumstance

The primary circumstance behind each bicycle crash was established using the classification described earlier. It was found that 72% (95% CI: 66.9 - 77.1%) of all bicycle crashes were the result of a collision with another object and that the other 28% (95% CI: 22.9 - 33.1%) were falls. *Figure 5* summarizes the breakdown of the primary circumstances within the bicycle crashes. It shows that the circumstance with the highest number of crashes, 35% (95% CI: 29.3 - 40.1%), was due to collisions with motor-vehicles. The second highest frequency, 23% (95% CI: 18.2 - 27.8%), was collisions involving the

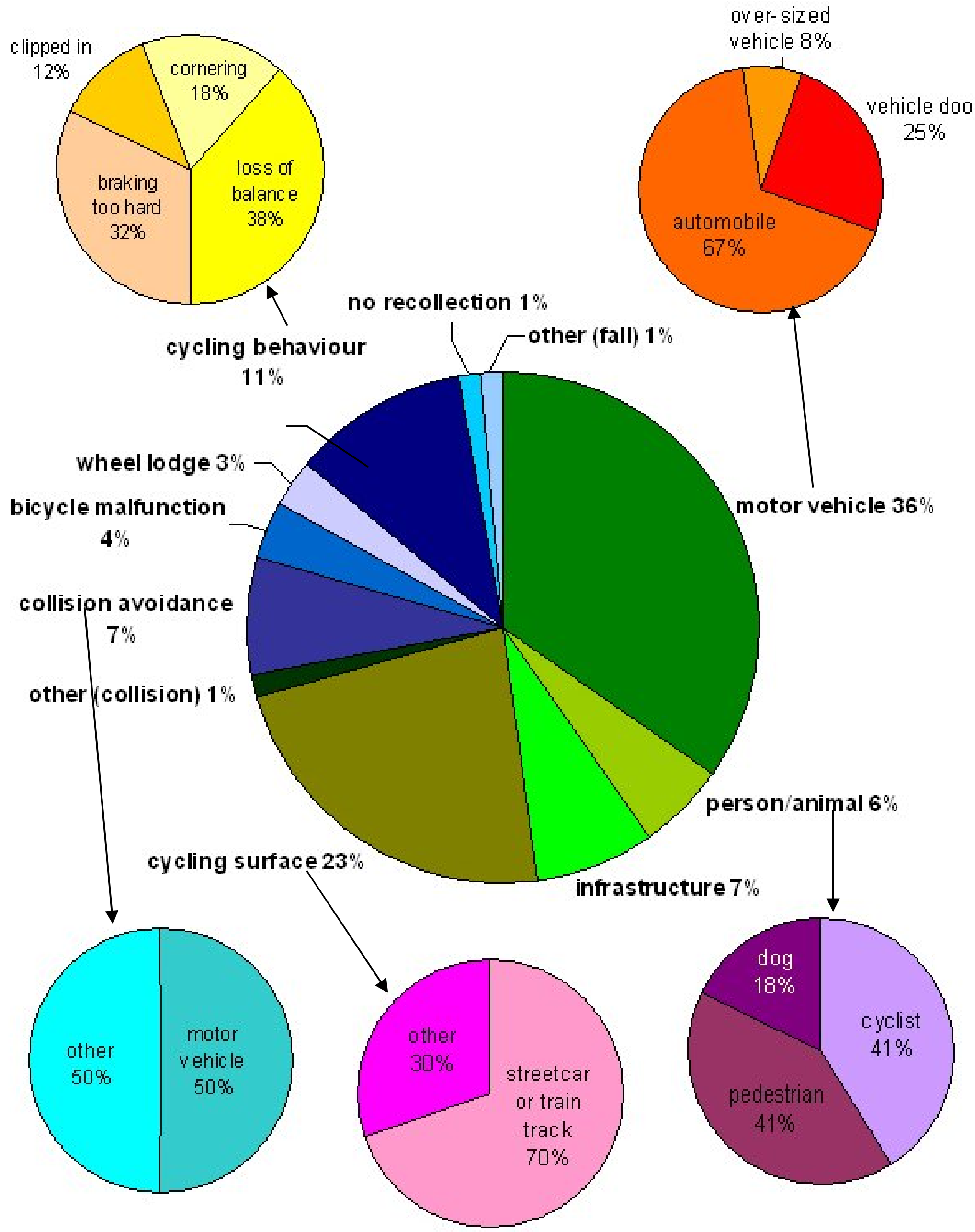


Figure 5: **Percentage of cycling crashes within each category of Primary Circumstance**. The middle chart is colour coded so that shades of green designate collisions (72%) and shades of blue designate falls (28%). The smaller charts encircling show the percentages of crashes in each category of tertiary level of classification.

cycling surface, 70% of which were with streetcar or train tracks making a total of 16% (95% CI: 11.9 - 20.2%) of all crashes related to streetcar or train tracks. Interestingly, 7.3% (95% CI: 4.4 - 10.3%) of the crashes were falls due to collision avoidance, half of which avoiding with automobiles. The results of the numbers of each primary circumstance are found in *Table 6*.

Table 6: **Number of crashes in each category of Primary Circumstance in Toronto and Vancouver** This table shows the number and percentage of cyclist crashes in each of the categories within the outcome variable of Primary Circumstance, in the Toronto crashes, in the Vancouver crashes, and in all 300 crashes combined (Grand Total).

Primary Circumstance			**City**				Grand Total	
			Toronto		Vancouver			
			#	%	#	%	#	%
COLLISION	motor vehicle	automobile	27	18.0	43	28.7	70	23.3
		over-sized vehicle	5	3.3	3	2.0	8	2.7
		vehicle door	20	13.3	6	4.0	26	8.7
		TOTAL	**52**	**34.7**	**52**	**34.7**	**104**	**34.7**
	person/animal	cyclist	2	1.3	5	3.3	7	2.3
		pedestrian	1	0.7	6	4.0	7	2.3
		dog	1	0.7	2	1.3	3	1.0
		TOTAL	**4**	**2.7**	**13**	**8.7**	**17**	**5.7**
	cycling surface	streetcar or train track	45	30.0	3	2.0	48	16.0
		other	15	10.0	6	4.0	21	7.0
		TOTAL	**60**	**40.0**	**9**	**6.0**	**69**	**23.0**
	infrastructure		6	4.0	16	10.7	22	7.3
	other (collision)		4	2.7	0	0.0	4	1.3
	TOTAL		**126**	**84.0**	**90**	**60.0**	**216**	**72.0**
FALL	collision avoidance	motor vehicle	2	1.3	9	6.0	11	3.7
		other	3	2.0	8	5.3	11	3.7
		TOTAL	**5**	**3.3**	**17**	**11.3**	**22**	**7.3**
	bicycle malfunction		3	2.0	8	5.3	11	3.7
	wheel lodge		6	4.0	3	2.0	9	3.0
	cycling behaviour	braking too hard	2	1.3	9	6.0	11	3.7
		clipped in	0	0.0	4	2.7	4	1.3
		cornering	2	1.3	4	2.7	6	2.0
		loss of balance	4	2.7	9	6.0	13	4.3
		TOTAL	**8**	**5.3**	**26**	**17.3**	**34**	**11.3**
	no recollection		0	0.0	4	2.7	4	1.3
	other (fall)		2	1.3	2	1.3	4	1.3
	TOTAL		**24**	**16.0**	**60**	**40.0**	**84**	**28.0**
Total Cyclists (Toronto/ Vancouver/Overall)			150	100.0	150	100.0	300	100.0

In addition, *Table 6* presents the variation in primary circumstance between cities. A visual representation of this comparison was also created; *Figure 6* shows circumstances that existed more prevalently in one city as opposed to the other. For example, streetcar or train track incidents were very high in Toronto at 45 crashes, while there were only 3 crashes designated with a primary circumstance of streetcar or train tracks in Vancouver. *Figure 6* also shows that there was a large difference in collisions with vehicle doors (doorings) between the cities with 20 occurring in Toronto and only 6 in Vancouver.

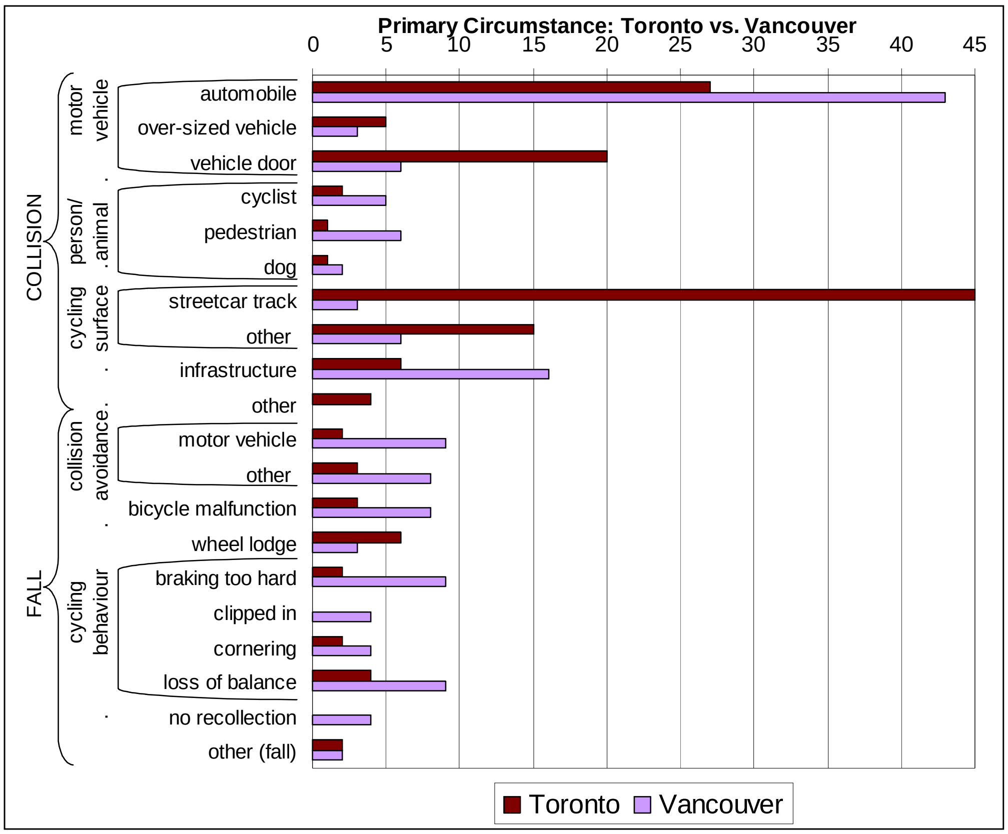


Figure 6: **Primary Circumstance: Toronto vs. Vancouver.** This graph compares the primary circumstances that resulted in 150 bicycle crashes in Toronto to that in Vancouver. It shows there were more automobile collisions in Vancouver (43 crashes) than in Toronto (27) and that there were more vehicle doorings in Toronto (20) than in Vancouver (7). The highest number of any circumstance resulting in crashes in one city comes from collisions with streetcar, or train, tracks in Toronto (45), while Vancouver only had 3 crashes primarily related to streetcar (or train) tracks.

Motor-vehicle Involvement

The motor-vehicle involvement in each bicycle crash was also determined (as defined above) and the frequencies of motor-vehicle involvement within each category of primary circumstance are present in *Table 7*. A total of 145 crashes, or 48% (95% CI: 42.4 – 54.0%) involved a specific motor-vehicle in the description of the crash. It was also revealed that there are a high number of streetcar or train track incidents (21 crashes) that involved motor-vehicles; often the cyclist had to veer off their normal route around a stopped or parking car. *Figure 7* shows the motor-vehicle involvement overlain on the primary circumstance; this diagram illustrates the fact that the aside from the direct motor-vehicle collisions or collision avoidances, the involvement of motor-vehicles is scattered throughout the primary circumstances of bicycle crashes.

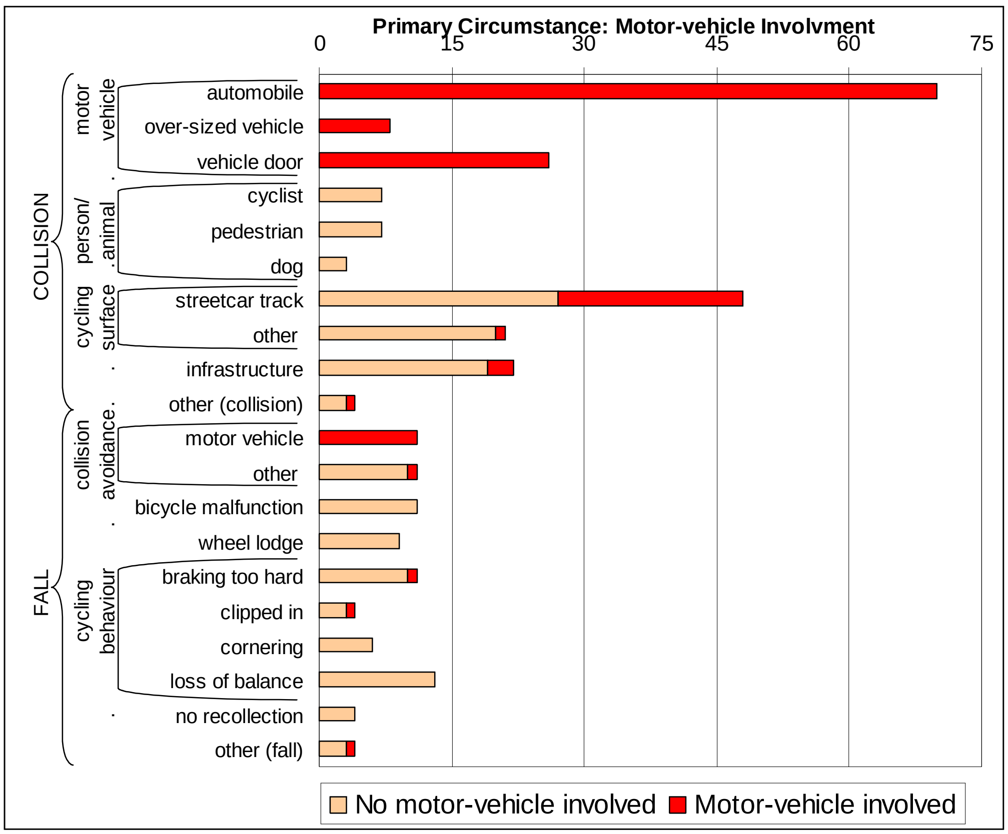


Figure 7: **Primary Circumstance: Motor-vehicle Involvement.** Graphical representation of the motor-vehicle involvement within each category of Primary Circumstance

Table 7: **Motor-vehicle involvement within each category of Primary Circumstance.** Shows the number of crashes that had/did not have motor-vehicle involvement, and the percentages of the total in all each category that those numbers represent.

Primary Circumstance			**Motor-vehicle Involvement**	
			Motor-vehicle involved	No motor vehicle involved
COLLISION	motor vehicle	automobile	70(48.3%)	0 (0.0)
		over-sized vehicle	8 (5.5)	0 (0.0)
		vehicle door	26 (17.9)	0 (0.0)
		TOTAL	**104 (71.7)**	**0 (0.0)**
	person/animal	cyclist	0 (0.0)	7 (4.5)
		pedestrian	0 (0.0)	7 (4.5)
		dog	0 (0.0)	3 (1.9)
		TOTAL	**0 (0.0)**	**17 (11.0)**
	cycling surface	streetcar or train track	21 (14.5)	27 (17.4)
		other	1 (0.7)	20 (12.9)
		TOTAL	**22 (15.2)**	**47 (30.3)**
	infrastructure		3 (2.1)	19 (12.3)
	other (collision)		1 (0.7)	3 (1.9)
	TOTAL		**130 (90.0)**	**86 (55.5)**
FALL	collision avoidance	motor vehicle	11 (7.6)	0 (0.0)
		other	1 (0.7)	10 (6.5)
		TOTAL	**12 (8.3)**	**10 (6.5)**
	bicycle malfunction		0 (0.0)	11 (7.1)
	wheel lodge		0 (0.0)	9 (5.8)
	cycling behaviour	braking too hard	1 (0.7)	10 (6.5)
		clipped in	1 (0.7)	3 (1.9)
		cornering	0 (0.0)	6 (3.9)
		loss of balance	0 (0.0)	13 (8.4)
		TOTAL	**2 (1.4)**	**32 (20.6)**
	no recollection		0 (0.0)	4 (2.6)
	other (fall)		1 (0.7)	3 (1.9)
	TOTAL		**15 (10.3)**	**69 (44.5)**
Total cyclists (% of total)			145(48.3)	155 (51.7)

Cross-tabulations

In order to compare the outcome variables between the two cities, odds ratios were calculated for Toronto versus Vancouver; these results are displayed in *Table 8*. The variable of primary circumstance was compared between cities, and it was determined that collisions were significantly more common in Toronto through the calculation of an odds ratio (OR) of 3.68 (95% CI: 2.12 – 6.39). In Toronto 84% (95% CI: 78.1 - 89.9%) of crashes were collisions and in Vancouver only 60% (95% CI: 52.0 – 67.5%) were collisions, which indicates that falls were more common in Vancouver than Toronto. It was also determined that the odds were higher in Toronto for collisions with streetcar or train tracks (OR: 21; 95% CI: 6.36 – 69.4) and collisions with vehicle doors (OR 3.69; 95% CI: 1.44 – 9.48). Furthermore, it was established that collisions with pedestrians or animals were less common in Toronto than Vancouver (OR: 0.29; 95% CI: 0.09 – 0.91). By comparing the other outcome variable, motor-vehicle involvement, in the two cities, it was determined that there was little difference in whether bicycle crashes involved motor-vehicles between cities (OR: 1.34; 95% CI: 0.85 – 2.11).

Table 8: **Cross-tabulations of the outcome variables with city.**

Outcome Variables	City		Total	OR (tor/van)	95% CI	
	Toronto	Vancouver			Lower	Upper
Primary Circumstance - collision vs. fall						
Collision	126 (84%)	90 (60.0)	216 (72.0)	3.50*	2.03	6.04
Fall	24 (16.0)	60 (40.0)	84 (28.0)	reference		
Primary Circumstance- streetcar or train tracks						
Streetcar or train tracks	45 (30.0)	3 (2.0)	48 (16.0)	21.0*	6.36	69.39
Other	105 (70.0)	147 (98.0)	252 (84.0)	reference		
Primary Circumstance – vehicle door (doorings)						
Vehicle door	20 (13.3)	6 (4.0)	26 (8.7)	3.69*	1.44	9.48
Other	130 (86.7)	144 (96.0)	274 (91.3)	reference		
Primary Circumstance - person/animal						
Person/animal	4 (2.7)	13 (8.7)	17 (5.7)	0.29*	0.092	0.907
Other	146 (97.3)	137 (91.3)	283 (94.3)	reference		
Motor-vehicle Involvement						
Motor-vehicle involved	78 (52.0)	67 (44.7)	145 (48.3)	1.34	0.852	2.113
No motor-vehicle involved	72 (48.0)	83 (55.3)	155 (51.7)	reference		
**designates statistically significant odds ratios*						

More cross-tabulations were conducted to determine if there was a significant difference in the frequency of collisions or motor-vehicle involvement depending on the simplified categories of the descriptive variables; these odds ratios can be found in *Table 9* and *Table 10* for collisions and motor-vehicle involvement, respectively.

Table 9: **Cross-tabulations of simplified-category descriptive variables with Primary Circumstance.**

Descriptive Variables	Primary Circumstance		Total	OR (collision/fall)	95% CI	
	Collision	Fall			Lower	Upper
Gender						
male	111	54	165	0.593*	0.352	0.998
female	104	30	134	reference		
Age						
young (<30)	126	59	185	0.600	0.349	1.03
older	89	25	114	reference		
Foreign substance use						
non-prescription substances	26	16	42	0.58	0.294	1.16
medications	21	7	28	1.08	0.438	2.66
no substance use	178	64	242	reference		
Trip Purpose						
work/school	117	17	134	4.66*	2.57	8.45
other	99	67	166	reference		
City						
Toronto	126	24	150	3.50*	2.03	6.04
Vancouver	90	60	150	reference		
** designates statistically significant, non-adjusted odds ratios*						

It was found that male cyclists were less frequently in crashes due to collisions than female cyclists (OR: 0.593; 95% CI: 0.352 – 0.998). It was also determined that collisions were more common than falls while commuting to or from work or school than riding for other purposes (OR: 4.66; 95% CI: 2.57 – 8.45), and they are also more common in Toronto than Vancouver (OR: 3.50; 95% CI: 2.03 – 6.04). There was no significant difference in collisions versus falls when comparing crashes of young and older cyclists or when cyclists consumed various foreign substances within 6 hours prior to their trip (see *Table 9*).

By cross-tabulating motor-vehicle involvement with the simplified descriptive variables, it was found that young cyclists, less than 30 years old, were more frequently involved in a bicycle crash involving a motor vehicle than older cyclists (OR: 2.00; 95% CI: 1.25 – 3.21). Additionally, crashes involved motor-vehicles more frequently on trips where the cyclists was commuting to or from work or school than trips that were made for other purposes (OR: 2.89; 95% CI: 1.81 – 4.63). No other simplified descriptive variable had a category that was significantly more common in a bicycle crash with motor vehicle-involvement (see *Table 10*).

Table 10: **Cross-tabulations of simplified-category descriptive variables with Motor-vehicle Involvement.**

Descriptive Variables	Motor-vehicle Involvement		Total	OR motor/no	95% CI	
	yes	no			Lower	Upper
Gender						
male	77	88	165	0.875	0.554	1.38
female	67	67	134	reference		
Age						
young (<30)	67	47	114	2.00*	1.25	3.21
older	77	108	185	reference		
Foreign substance use						
non-prescription substances	15	27	42	0.556	0.282	1.10
medications	14	14	28	1.00	0.45	2.19
no substance use	121	121	242	reference		
Trip Purpose						
work/school	84	50	134	2.89*	1.81	4.63
other	61	105	166	reference		
City						
Toronto	78	72	150	1.34	0.852	2.11
Vancouver	67	83	150	reference		
** designates statistically significant non-adjusted odds ratios*						

Logistic Regression

Two multiple logistic regression models with binary outcome variables were completed to determine the relationship of multiple factors on the odds ratios associated with 1) collisions versus falls and 2) motor-vehicle involvement versus not. The descriptive variables that had significant odds ratios in *Table 9* were used as the covariates in the logistic regression of the primary circumstance: collisions versus falls. The results of this first logistic regression model, found in *Table 11*, show the combined relationship of gender, trip purpose and city, with collisions versus falls. Collisions remained significantly more frequent that falls on bicycle trips to or from work or school than on trips with other purposes (adjusted OR: 4.42; 95% CI: 2.38 – 8.23). Collisions also remained significantly more frequent than falls in Toronto than in Vancouver (adjusted OR: 2.86; 95% CI: 1.62 – 5.07). Based on the results of the logistic regression, the adjusted odds ratio of the relationship of gender to collisions versus falls was found to no longer be statistically significant, which means that when the influence of city and trip purpose were included, the number of collisions was no longer significantly more common for females than males.

Table 11: **Logistic Regression Results for Primary Circumstance—Collision.**

Descriptive Variables	B	Standard Error	*p*-value	OR (= e^B)	95% CI	
					Lower	Upper
Gender						
male (1)	-0.340	0.284	0.232	0.712	0.408	1.24
female (0)	reference					
Trip Purpose						
work/school (1)	1.487	0.317	0.000	4.42*	2.38	8.23
other (0)	reference					
City						
Toronto (1)	1.052	0.291	0.000	2.86*	1.62	5.07
Vancouver (0)	reference					
constant	*0.158*	*0.256*	*0.538*	*1.17*	*0.709*	*1.93*
**designates statistically significant, adjusted odds ratios, based on sig.<0.05.*						

In congruence with the procedure above, the descriptive variables that had significant odds ratios in *Table 10* were used as the covariates in the logistic regression of motor-vehicle involvement. The covariates in this case were the descriptive variables of age and trip purpose. The results of this binary logistic regression can be found in *Table 12*. It was found to be more common for crashes of young cyclists (<30 years old) to have motor-vehicle involvement than crashes of older cyclists, based on the adjusted odds ratio calculated to be 2.02 (95% CI: 1.24 – 3.30). The results of the logistic regression model also showed that crashes that occurred while commuting to or from work or school more commonly involved a motor-vehicle than crashes on trips made for other purposes (adjusted OR: 2.88; 95% CI 1.79 – 4.65). Both of these descriptive variables were found to still have statistically significant odds ratios after their combined association with motor-vehicle involvement was assessed.

Table 12: **Logistic Regression Results for Motor-vehicle Involvement.**

Descriptive Variables	B	Standard Error	*p*-value	OR (=e^B)	95% CI	
					Lower	Upper
Age						
young (1)	0.705	0.250	0.005	2.02*	1.24	3.30
older (0)	reference					
Trip Purpose						
work/school (1)	1.058	0.244	0.000	2.88*	1.79	4.65
other (0)	reference					
constant	*-0.816*	*0.192*	*0.000*	0.442*	0.304	0.644
**designates statistically significant, adjusted odds ratios, based on sig.<0.05.*						

DISCUSSION & CONCLUSIONS

Justification of the Bicycle Crash Classification Scheme

The Bicycle Crash Classification was developed on the basis of a review of multiple other systems, allowing our scheme's content and structure to be as comparable as possible to other systems. Our analysis incorporates a wide variety of variables including both descriptive and outcome variables, which is a step up from some of the systems reviewed including the "Ten classes of Bicycle-automobile accidents in Davis, CA" (Lott & Lott, 1976), and the "Factors in the Initiation of Bicycle-vehicle Collisions" (Williams, 1976), which only address the movement of the bicycle and automobile and no other variables in the bicycle crash. Other systems go into a more detailed categorization of a specific injury, for example the *Occupational Injury and Illness Classification Manual* (OIICM) (U.S. Dept. of Labor, 1992) classifies the injury or illness and detailed classification of causes, including secondary source of injury. Such a detailed classification was not used in this study, because we focused on pre-event and event circumstances rather than the injury itself.

The *International Classification of External Causes of Injury* (ICECI) (ICECI Coordination and Maintenance Group, 2004) was found to be very influential in the development of our classification system because in its "Core Module" it incorporated more descriptive variables along with the main cause, including substance use and location. The "Sport Module" was also useful, because it presented some unique variables, including the phase of activity, and many categories within each variable that could be applicable to our classification. Additionally, the systematic structure presented in the ICECI made it obvious that this adds to the efficient application of this system and inspired the structure of the classification presented here.

Discussion of the Analysis

In this study, 300 bicycle crashes were classified by two main dependent variables: the primary circumstance of the crash; and motor-vehicle involvement within the crash and/or pre-crash events. Although these two variables seem to directly overlap in some categories of the primary circumstance, *e.g.* collisions with motor-vehicles, there were quite a few categories of primary circumstance that had less obvious motor-vehicle involvement (refer to *Figure 7*). For example, there is motor-vehicle involvement in 48.3% (95% CI: 30.7 – 57.7%) of the collisions with streetcar or train tracks. With the overall involvement of motor-vehicles in the bicycle crashes equal to 48.3% (95% CI: 42.7 – 54.0%), it seems that a great reduction in the number of crashes could be possible if cycling infrastructure did not overlap that of motor vehicles. Many other studies bring support to this argument; one on fatal bicycle crashes, found that 91% of fatal crashes are due to motor-vehicle collisions (Rowe *et al*., 1995). The separation of cyclists from motor vehicles should not only decrease collisions with motor vehicles, but will also decrease the rates of injury crashes that simply involve the presence motor vehicles.

A further look at the categories of primary circumstance shows variation in the proportions of crashes associated with each category, where high crash proportions suggest areas that should be addressed in order to increase bicycling safety. The 72% of crashes classified as collisions, seem more simply preventable by alteration of the cycling environment than falls (the other 28%), due to the fact that collisions are defined by contact with another object in the cycling environment. The second-highest proportion of injury crashes (23%) occurred as a result of collisions with the cycling surface, which included streetcar or train tracks, potholes, ice, and uneven pavement. The simple repair of roadways or creation of bicycle lanes on streets without streetcar tracks could decrease the rates of these types of crashes. Falls, on the other hand, may be harder to assess by altering the environment, since many of these were associated with factors that the cyclists must alter themselves, including cycling behaviours such as mot carry things on the handle bars, which led to most of the wheel lodges and keeping up with their bicycle maintenance.

The variation in crashes between Toronto and Vancouver suggests that some aspects or areas are more important to assess in one city than the other. The fact that there was a much higher odds of a crash involving a streetcar or train track in Toronto, is almost certainly due to the fact that Toronto has over 68 kilometres of streetcar tracks (Toronto Transit Commission, 2008) running through its downtown sector; however, this clearly presents an area that needs to be assessed in Toronto to make cycling more safe. By further inquiry into the descriptions behind the pedestrian/animal collisions, which were more common in Vancouver, it becomes clear that there is a pattern of these crashes occurring on the Stanley Park Seawall. The Seawall is characterized by a 22 kilometre path with divided lanes for cyclists or pedestrians (Vancouver Park Board, 2010), and it has no comparable equivalent in Toronto. This is an area in Vancouver where a more distinct separation of the bike lane from the pedestrian lane may decrease the number of pedestrian or animal collisions. The information contained in the categories of primary circumstance may be useful to municipalities attempting to improve the safety of cycling in their city.

Strengths and Limitations

It was difficult to decide how to categorize the primary circumstance of each crash, especially within the fall category. This may contribute to an over application of the "other" categories in future use of this classification scheme. The classification of another set of bicycle crash data, after these original 300 that were used to create the scheme, would help determine whether the scheme is broadly applicable.

The use of bicycle crashes in two cities makes the results of this study stronger and also contributes to the relevance of the scheme directly; without the inclusion of crashes from Toronto, the danger associated with streetcar or train tracks as an object of collision would not have been as obvious.

Conclusions

An investigation into cycling injury crashes found that motor vehicles are involved in more crashes than just bicycle-vehicle collisions and that streetcar tracks represent a high proportion of the primary circumstance of crashes. Trip purpose was also determined to have a significant relationship with the outcome characteristics of a bicycle crash; while the use of drugs or alcohol was not significantly related to the crash circumstances. Although cycling injuries continue to deter people from cycling, the variation in crash frequencies associated with different circumstances suggests that alteration of cycling infrastructure could decrease the rates of associated injuries.

REFERENCES CITED

Boogaard, H.; Borgman, F.; Kamminga, J. and G. Hoek, 2009. Exposure to ultrafine and fine particles and noise during cycling and driving in 11 Dutch cities. *Atmospheric Environment*, vol. 43, pg. 4234-4242.

Cavill, N. and A. Davis, 2007. Cycling and health: What's the evidence? *Cycling England, UK Department of Transportation (Report).*

Cushman, R.; Down, J.; MacMillan, N. and H. Waclawik, 1990. Bicycle-related Injuries: a survey in a paediatric emergency department. *Canadian Medical Association,* vol. 143 (2), pg. 108-112.

Finch, C.; Valuri, G. and J. Ozanne-Smith, 1998. Sport and active recreation injuries in Australia: evidence from emergency department presentations. *British Journal of Sports Medicine, v*ol. 32, pg. 220 – 225.

Gordon-Larsen, P.; Boone-Heinonen, J.; Sidney, S.; Sternfeld, B., Jacobs, D.R.Jr. and C.E. Lewis, 2009. Active commuting and cardiovascular disease risk. *Archives of Internal Medicine,* vol.169, pg.1216-1223.

Gordon-Larsen, P.; Nelson, M.C. and K. Beam, 2005. Associations among active transportation, physical activity, and weight status in young adults. *Obesity Research,* vol.13, pg. 868-875.

Hamer, M. and Y. Chida, 2008. Active commuting and cardiovascular risk: a meta-analytic review. *Preventative Medicine,* vol. 46, pg. 9-13.

ICECI Coordination and Maintenance Group, 2004. *International Classification of External Causes of Injuries* (ICECI) version 1.2. Consumer Safety Institute, Amsterdam and AIHW National Injury Surveillance Unit, Adelaide.

Katzmarzyk, P.T. and I. Janssen, 2004. The economic costs associated with physical inactivity and obesity in Canada: an update. *Canadian Journal of Applied Physiology*, vol. 29, pg. 90-115.

Lindström, M. 2008. Means of transportation to work and overweight and obesity: a population-based study in southern Sweden. *Preventative Medicine,* vol. 46, pg 22-28.

Lott, D.F. and D.Y. Lott, 1976, Effect of Bike Lanes on Ten Classes of Bicycle-Automobile Accidents in Davis, California, *Journal of Safety Research* Vol. 8 (4), pg 171 – 179.

Maimaris, C.; Summer, C.L; Browning, C.; and C.R. Palmer, 1994. Injury patterns in cyclists attending an accident and emergency department: a comparison of helmet wearers and non-wearers. *BMJ* vol. 308, pg 1537-1540.

Meuleners, L.B.; Gavin, A.L.; Cercarelli, L.R.; and D. Hendrie, 2003. Bicycle Crashes and Injuries in Western Australia, 1987-2000. Injury Research Centre, The University of Western Australia.

Microsoft, 2003. Microsoft Office Excel (Excel), Microsoft, Redmond, WA.

Pucher, J. and R. Buehler. 2005. Cycling trends and policies in Canadian cities. *World Transport Policy and Practice,* vol. 11 (1), pg 43-61.

Pucher, J and L, Dijkstra. 2003. Promoting safe walking and cycling to improve public health: lessons from the Netherlands and Germany. *American Journal of Public Health,* vol. 39 (9), pg.1509-1516.

Reynolds, C.O.C.; Harris, M.A.; Teschke, K.; Cripton, P.A. and M. Winters, 2009. "The impact of transportation infrastructure on bicycling injuries and crashes: a review of the literature." UBC. Publication in process.

Robinson, D.L. 2004. Reasons for trends in cyclist injury data. *Injury Prevention.* Vol. 10, pg 126 –127.

SPSS Inc. 2008. Statistical Package for the Social Science (SPSS) Version 17.0, IBM Company Headquarters, Chicago, IL.

Tan, C. 1995. "Crash-Type Manual." University of North Carolina Highway Safety Research Center. U.S. Department of Transport Pub No. FHWA-RD-96-104. http://www.tfhrc.gov/safety/pedbike/ctanbike/ctanbike.htm (23 October 2009) .

Transport Canada. 2005. *Canadian Motor Vehicle Traffic Collision Statistics: 2004*, Ministry of Transport, Catalogue T45-3/2004.

Toronto Transit Commission. 2008. "Life-Line Script", http://www3.ttc.ca/About_the_TTC/Projects_and_initiatives/Lifeline_script.jsp (23 March 2010).

U.S. Department of Labor, Bureau of Labor Statistics, 1992. *Occupational Injury and Illness Classification Manual* (OIICM).

Vancouver Park Board. 2010. “The Seawall” http://vancouver.ca/PARKS/parks/Stanley/seawall.htm (23 March 2010)

Wen L.M. and C. Rissel, 2008. Inverse associations between cycling to work, public transport, and overweight and obesity: findings from a population based study in Australia. *Preventative Medicine*, vol. 46, pg. 29-32.

Williams, A.F. 1976. “Factors in the Initiation of Bicycle-Motor Vehicle Collisions.” *American Journal of Diseases of Children*, vol. 130, pg 370 – 377.

Winters, M.; Teschke, K.; Grant, M.; Setton, E.M. and M. Brauer. 2010. How far out of the way will we travel? Built environment influences on route selection for bicycle and car travel. To be published in *Transportation Research Record: Journal of the Transportation Research Board* March 2010.

APPENDIX A

Sequential Number: ___________________

Hospital:
1. St. Michael's
2. TGH
3. St. Paul's
4. VGH

Date Attended ED: ____ / ____ / _______
DD MM YYYY

Came by ambulance:
0. No
1. Yes

Admitted to Hospital:
0. No
1. Yes

CTAS: ______________________________

INTERVIEW FORM

Thanks so much, *[name of participant]*, for agreeing to take part in this study. The interview should take about 45 minutes.

I'll ask you about the route you cycled when you were injured, including the injury site, and two other sites, randomly selected along the route.

Did you receive a copy of the consent form with our letter of introduction to the study?

[If no, give a copy.]

[If yes:] Do you have it with you?

[If no, give a copy.]

Do you have any questions about it?

If you haven't already done so, could you please read it and sign 2 of them? I'll keep one, and you keep one.

[Proceed when the consent form has been signed.]

Are there any questions you'd like me to answer before we begin the interview?

[Give time to answer.]

Feel free to stop me and ask questions at any time during the interview. If there is a question that you feel uncomfortable answering, you are welcome to let me know that you don't want to answer it.

Interviewer: _________________________

Date of interview: ____ / ____ / _______
DD MM YYYY

Interview Start: ____:_____ am pm
hr: min

Interview Form: 6/1/08

INJURY DESCRIPTION

I will start by asking you about the trip when you sustained your injuries.

1. When did you take this trip? *[Provide calendar]* Date: ____________/ ____ / ____ / ________ Day of Week DD MM YYYY

1.1 What time did you leave your starting point? *[Best estimate]* _____ :____am pm hr: min

1.2 At what time did the trip end? *[Best estimate]* _____:____ am pm *[Stopped cycling]* hr: min

2. What day did you visit the Emergency Department? ☐ Same day

[If different day:] Date: ____ / ____ / ______ DD MM YYYY

3. Were you admitted to hospital, in other words, did you stay overnight in a ward other than the Emergency Department?
   0. No
   1. Yes

4. In your own words, please describe the circumstances of the injury incident: *[Record as verbatim as possible.]*

____

____

____

____

____

____

____

____

____

How are you feeling?

4.1 Are you willing to have this description reported to the city, without your name or identifying features, such as the street names?
   0. No
   1. Yes

Interview Form: 6/1/08

5. Was this a collision between you and a motor vehicle, person, animal or object (including holes in the road)?

0. No
1. Yes

[If yes] 5.1 What did you collide with?

[Check all that apply]

- ☐ Car, SUV, pick-up truck, van
- ☐ Motorcycle or scooter
- ☐ Large truck
- ☐ Bus or streetcar
- ☐ Pedestrian
- ☐ Cyclist
- ☐ Other non-motorized wheeled transport
- ☐ Pot hole or other hole
- ☐ Street car or train track
- ☐ Animal *[describe]*: ___________________________
- ☐ Other *[describe]*: ___________________________

6. Now I am going to ask you questions about the complete route you took on your cycling injury trip. I will ask about the starting point of the trip, the site of the injury incident, and the trip end point.

6.1 Where was your trip starting point? ______________________________________

["A", nearest intersection, description, don't indicate "home"]

6.2 Where did the injury incident occur?______________________________________

[point of impact, not where thrown to] *["B", nearest intersection, description, don't indicate "home"]*

6.2.1 Was the injury incident at an intersection?

[Intersection is meeting point of 2 roads]

B	1. Non-intersection 2. Intersection

6.3 Where was your trip end point? If the end point of the trip changed because of the injury incident, I would like to know the actual end point, not your planned destination.

Actual trip end point same as B ☐

____

[If different, "C", nearest intersection, description, don't indicate "home"]

7. Would you feel comfortable tracing your complete route on a map?

Use map to trace the route, using pencil initially. Check if correct, then mark with pen.

Mark these points in pencil	-	*"A" trip start*
with a perpendicular stroke &	-	*"B" injury site*
the letter at the end of the stroke	-	*"C" actual trip end*

Then measure route length with digital map wheel.

Could I also ask you to mark your original planned destination and the route you would have taken to that destination?

Planned destination same as C ☐

____

[If different, "F", brief description, don't indicate "home"]

Mark intended destination - *"F" intended destination*

Excuse me for a few minutes, while I select two other sites on the route.

8. *Total trip distance from starting point "A" to end point "C":* __________________*km, to 2 decimal places*

9. *Calculate distance from trip starting point "A" to additional site "D", then measure and mark on map.*

*Proportion*__________ *X total trip distance from 8. above =* __________________*km, to 2 decimal places*

9. 1 *Indicate if intersection or not. If on edge or in doubt, mark as non-intersection.*

D	1. Non-intersection 2. Intersection

10. *Calculate distance from trip starting point "A" to additional matched site "E", then measure and mark on map.*

*Proportion*__________ *X total trip distance from 8. above =* __________________*km, to 2 decimal places*

10. 1 *Measure distance. This site is matched to "B" as an intersection or not.*
If map wheel arrives at correct type of location, mark as "E" on map.
If not, check Sequential Number. If even, go forward along the route to nearest correct location, if odd, go back to nearest correct location.

E	Match to B : 1. Non-intersection 2. Intersection

SITE-SPECIFIC QUESTIONS: INJURY SITE B

Now I'd like to ask you some questions about the site where you were injured – site B on the map. *[Indicate]*

First, I'd like to check where you were cycling. At this point, you were *[choose based on info from page 4 or 5]*

11.1
1. At a non-intersection location. Were you *[read 3 categories]*
2. At an intersection. Immediately before you entered the intersection, were you *[read 2 categories]*

11.2
1. Away from roads
2. On a sidewalk or path next to a road
3. On a road

11.3

Away from roads – Were you on the
1. right side of path
2. middle of path
3. left side of path
4. no path

On a sidewalk or path next to a road – Was the sidewalk / path
1. to the right of the road
2. in centre of road (e.g., boulevard)
3. to the left of the road

On a road – Were you on the
1. right side of road
2. middle of road
3. left side of road
4. back lane/alley

11.4

Where were you <u>within</u> the sidewalk / path?
1. right side
2. middle
3. left side

8. DK

So you were on the *[indicate answer above]*. Now, <u>within</u> that side of the road, were you in a <u>marked</u> *[read categories]*:
1. right lane
2. middle lane
3. left lane
4. parking lane
5. bike lane
6. shoulder
7. or were there no marked lanes?

8. DK

11.5 Was this path / sidewalk *[read categories]*:
1. for cyclists only
2. for pedestrians only *[if DK, default for sidewalk]*
3. for pedestrians, cyclists, and other users *[if DK, default for off-road path]*

11.6 In which direction were you travelling compared to motor vehicle traffic?
1. in the same direction as motor vehicle traffic
2. facing motor vehicle traffic on your side of the street

12. Now we need a sketch of the site *[in pencil]*. Would you feel comfortable drawing it for me?

Please mark the following:
- Names of streets or other identifiable features
- Your location (*<u>with an X</u>*)
- Direction of travel (*<u>with an arrow</u>, before & after the X*)

[Check map.]

N

O Name:________

O Date:________

O Time:________

B13. What type of surface were you cycling on at this point? Would you say it was *[read categories]:*

[Check all that apply]

- ☐ Smooth pavement
- ☐ Pavement with potholes, bumps, train or streetcar tracks
- ☐ Cobblestones, bricks, or paving stones
- ☐ Packed gravel or dirt
- ☐ Loose gravel or dirt
- ☐ Grass
- ☐ Other [*specify:* ________________________]
- ☐ DK

B14. Was the surface dry, wet, icy, or snowy?

[Check all that apply]

[If wet, prompt about puddles]

- ☐ Dry
- ☐ Wet
- ☐ Puddles of waters
- ☐ Icy
- ☐ Snow covered

B15. Did the surface have debris such as leaves, glass, sand, gravel, or papers, on it?

0. No
1. Yes
8. DK

[If yes] B15.1 Was it *[read categories]:*

[Check all that apply]

[If needed, prompt that there was "enough debris that you found it bothersome".]

- ☐ Leaves
- ☐ Glass
- ☐ Sand
- ☐ Gravel
- ☐ Papers
- ☐ Other [*specify:* ________________________]

B16. Please estimate how fast you were going at this point:

1. less than 15 km/h
2. 15 to 29 km/h
3. 30 km/h or more
8. DK

B17. Was it dawn, daytime, dusk, or night-time at this point on the trip?:

1. Dawn (not fully light)
2. Day
3. Dusk (beginning to get dark)
4. Night

B18. Were there any street lights that were on and illuminating this site?

0. No
1. Yes
8. DK

B19. Were you travelling with one or more companions at this point?

0. No
1. Yes

[If yes] B19.1 How many others were with you, and how were they travelling?

[Check all that apply]

☐ On same bike as me	#	_____	Cycling,
☐ on different bike	#	_____	Jogging
☐ / walking	#	_____	In-line
☐ skating / skateboarding	#	_____	Stroller
☐	#	_____	Other
☐ *[specify: ________________]*	#	_____	

B20. How safe do you think this site was for cyclists on that trip? Would you say it was *[read categories:]*

1. Very dangerous
2. Somewhat dangerous
3. Neither safe nor dangerous
4. Somewhat safe
5. Very safe
8. DK, no opinion

[If very dangerous or somewhat dangerous]

B20.1 What dangers do you think there are at this site? *[Record in point form.]*

____

____

____

B21. Was there construction work or any other temporary features at this site?

0. No
1. Yes
8. DK

[If yes] B21.1 Please describe them: *[Record in point form.]*

____

____

____

B22. Do you have any other comments about this site you would like to add? *[Record in point form.]*

____

____

____

____

OTHER CHARACTERISTICS OF THE TRIP

Now, I would like to ask you some questions about your bike, your visibility, and some personal circumstances on this trip. These questions are not the main focus of the study. Your answers will be used for descriptive purposes only.

23. What was the purpose of this trip?

[Read list & check all that apply]

- ☐ To go to or from work
- ☐ To go to or from school
- ☐ As part of your job (e.g., courier)
- ☐ For personal business, e.g., shopping, doctor's visit
- ☐ For social reasons, e.g., visiting friends, movies
- ☐ For exercise or recreation
- ☐ Other *[specify: ________________________________]*

24. What was the weather like on this trip?

[Check all that apply]

[Probe about cloud cover, precipitation & wind.]

- ☐ Clear sky
- ☐ Partial cloud cover
- ☐ Complete cloud cover
- ☐ Fog/Mist
- ☐ Smog/Smoke
- ☐ Raining *[include light and heavy rainfall]*
- ☐ Snowing
- ☐ Hail
- ☐ Strong winds against you
- ☐ Strong winds with you
- ☐ Strong crosswind

25. What type of bike were you riding?

[Show photos]

1. City bike
2. Touring/road bike
3. Mountain bike
4. Racing bike
5. Folding bike
6. Recumbent
7. Hybrid
8. Cruiser
9. Other *[specify: ________________________________]*

26. When was the last time this bike underwent maintenance prior to the injury incident?

1. less than 1 month before
2. 1 to 6 months before
3. 7 to 11 months before
4. 1 year to 3 years before
5. more than 3 years before
6. never
8. DK
9. Refuse

27. During this trip, prior to the injury incident, did you notice anything that needed to be fixed on this bike?

0. No
1. Yes *[specify:________________________]*
8. DK
9. Refuse

28. How old is this bike?

________ years
8. DK
9. Refuse

29. Did you have a <u>front</u> light that was turned on during this trip?

0. No
1. Yes
8. DK
9. Refuse

30. Did you have a <u>back</u> light that was turned on during this trip?

0. No
1. Yes
8. DK
9. Refuse

31. What colour was the clothing on your upper body?

[specify:________________________________]

7. No clothing on upper body
8. DK
9. Refuse

32. What colour was the helmet you were wearing?

[specify:________________________________]

7. No helmet
8. DK
9. Refuse

33. In the 24 hours prior to this trip, how many hours of sleep had you had?

______________hours
8. DK
9. Refuse

34. In the 6 hours prior to this trip, had you consumed any of the following:

34.1 Over the counter or prescription medications

0. No
1. Yes
8. DK
9. Refuse

34.2 Alcohol, such as beer, wine, spirits, cider

0. No
1. Yes
8. DK
9. Refuse

34.3 Marijuana, cannabis or hashish

0. No
1. Yes
8. DK
9. Refuse

34.4 Other recreational drugs
[If examples needed: cocaine, heroin, crystal meth]

0. No
1. Yes
8. DK
9. Refuse

Cycling and Driving Experience

Now I have some questions about your cycling and driving experience. As with the last section, these questions are not the main focus of the study. Your answers will be used for descriptive purposes only.

35. Please tell me how frequently you cycled in the 12 months prior to this injury event:

35.1	in the winter *(Dec, Jan, Feb)*	0. never 1. less than once a month, but more than never 2. 1 to 3 times a month 3. 1 to 3 times a week 4. 4 or more times a week 8. DK
35.2	in the spring *(Mar, Apr, May)*	0. never 1. less than once a month, but more than never 2. 1 to 3 times a month 3. 1 to 3 times a week 4. 4 or more times a week 8. DK
35.3	in the summer *(Jun, Jul, Aug)*	0. never 1. less than once a month, but more than never 2. 1 to 3 times a month 3. 1 to 3 times a week 4. 4 or more times a week 8. DK
35.4	in the fall *(Sept, Oct, Nov)*	0. never 1. less than once a month, but more than never 2. 1 to 3 times a month 3. 1 to 3 times a week 4. 4 or more times a week 8. DK

36. Have you ever taken an urban cycling training course?

0. No
1. Yes

37. Would you consider yourself an experienced cyclist?

0. No
1. Yes
2. Somewhat

38. Have you ever had a driver's license?

0. No
1. Yes

[If yes] 38.1. At what age did you first learn to drive?

_______ years old
88. DK

DEMOGRAPHIC INFORMATION

I would like to finish by asking you a few questions that will allow us to compare the general characteristics of the people who participated in this study to other adults in the Metro area.

39. *[Record gender]*

1. Male
2. Female

40. What is the total number of people who live your household (including yourself)?

____
88. DK
99. Refuse

[If 1 or more] 40.1 How many people who live in your household are < 19 years of age?

____
88. DK
99. Refuse

41. What was your employment status at the time of the injury incident?

1. Working for pay full-time (≥ 30 hours/week)
2. Working for pay part-time (< 30 hours/week)
3. Seasonal work
4. Homemaker
5. Student
6. Retired
7. Unemployed
8. Disabled, unable to work
88. DK
99. Refuse

42. What is your highest level of education?

[Do not provide categories, use open-ended answer as basis for categorizing]

1. < high school
2. Completed high school
3. Some post-secondary education
4. Completed college or technical diploma
5. Completed university degree
6. Completed graduate university degree
8. DK
9. Refuse

43. What was your year of birth?

____
YYYY
99. Refuse