CITY OF VANCOUVER

cycling safety study

Final Report

URBAN systems

CITY OF VANCOUVER
CYCLING SAFETY STUDY

FINAL REPORT
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Prepared by

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Executive Summary

The City of Vancouver is one of the most bicycle-friendly cities in North America. It has an extensive bicycle network that is well used by residents and visitors, and has one of the highest cycling mode shares among major North American cities. According to the 2011 Canadian National Household Survey, cycling accounts for approximately 4.4% of all trips to work in the City of Vancouver.

The City recognizes the critical role that cycling can play in creating green and livable communities, and is committed toward making cycling safe, convenient, and comfortable for people of all ages and abilities. The City's transportation plan, Transportation 2040, sets a target that two-thirds of all trips by 2040 will be made by walking, cycling or transit. Transportation 2040 also sets a target to work towards zero traffic-related fatalities, and places a special emphasis on safety for vulnerable road users, including pedestrians and cyclists. One of the recommended actions in Transportation 2040 was the development of a city-wide Cycling Safety Study to provide a better understanding of cycling safety hotspots and concerns.

The Cycling Safety Study provides a comprehensive and objective review of the safety of cycling in the City of Vancouver and provides an action plan to address each of the identified cycling safety issues. This study involved an in-depth analysis of all collisions reported to the Insurance Corporation of British Columbia (ICBC) involving bicycle users and motor vehicles in the City of Vancouver between 2007 and 2012[i]. In addition, this study analyzed the injury data from bicycling crashes that resulted in treatment at a hospital emergency room in Vancouver in 2008 and 2009 from the Bicyclists' Injuries and Cycling Environment (BICE) study conducted through the University of British Columbia Cycling and Cities program[ii]. Based on these datasets, the analysis examined **WHERE** reported cycling collisions and injury crashes took place, **HOW** they occurred, **WHEN** they took place, and **WHO** was involved.

The ICBC data included 2,994 reported cycling collisions between 2007 and 2012 in the City of Vancouver, equivalent to an average of approximately 500 reported cycling collisions per year, or approximately 1.0% of all reported collisions involving motor vehicles over this period. The overall number of reported cycling collisions in Vancouver has been relatively stable on an annual basis over the past fifteen years and beyond, despite a significant increase in the City's population as well as the number of bicycle trips made over this period. As a result, the rate of cycling collisions in Vancouver has been steadily declining over the past fifteen years.

[i] For the remainder of this report, the term **"reported cycling collisions"** has been used to refer to collisions reported to ICBC involving bicycle users and motor vehicles.
[ii] For the remainder of this report, the term **"cycling injury crashes"** has been used to refer to injury data from the BICE Study based on bicycling crashes that resulted in treatment at a hospital emergency room in Vancouver.

Of the 2,994 reported cycling collisions between 2007 and 2012, only four of these collisions resulted in cycling fatalities. When comparing the number of cycling fatalities among other peer cities in Canada, the United States, and internationally, Vancouver has one of the lowest cycling fatality rates in the world in terms of both the average number of annual cycling fatalities and the number of cycling fatalities per million bicycle trips. Despite having one of the highest cycling mode shares among major North American cities, and one of the lowest cycling fatality rates among comparable cities around the world, there are a number of opportunities to continue to improve cycling safety in Vancouver and to work towards the City's target of zero traffic-related fatalities.

Based on the analysis of reported cycling collision data from ICBC and supported by the cycling injury crash data from the BICE study, this study identified the following twelve key cycling safety issues:

- **Key Issue 1: Doorings.** Doorings were the most common type of reported cycling collision in the City of Vancouver, representing approximately 15.2% of all reported cycling collisions. Doorings occurred when bicycle users were struck by or strike a door of a parked motor vehicle, typically on the driver side. Approximately two-thirds (67%) of all doorings occurred on arterial streets without designated bikeways (such as Broadway, Commercial Drive and Main Street). In addition, approximately 20% of doorings occurred on local street bikeways such as 10th Avenue.
- **Key Issue 2: Conflict Zones.** Mid-block conflict zones such as driveways, parking lots and alleyways accounted for approximately 10.7% of all reported cycling collisions. This type of collision occurred between a bicycle user and a motor vehicle entering or exiting an alleyway, parking lot, or driveway. As the bicycle users were proceeding straight ahead, motor vehicles were identified as failing to yield when they were pulling in or out of these locations. The majority of reported conflict zone cycling collisions occurred on arterial streets (58%), and on streets with no designated bikeways (56%). Several locations were identified as hot spots for collisions that occurred when drivers were entering or exiting an alleyway, parking lot, or driveway, including: Burrard Street, Main Street, Broadway, Kingsway, 1st Avenue and 10th Avenue.
- **Key Issue 3: Right Hooks.** Collisions involving right turning vehicles, also known as 'right hooks', accounted for approximately 12.6% of all reported cycling collisions. Most of the right hook collisions occurred in the downtown core. The majority of the right hooks occurred on arterial streets (82%), including 41% on arterial streets with no designated bikeways. Many of these collisions occurred at signalized intersections when the bicycle user was crossing with the signal. A higher than expected number of right hooks occurred on Dunsmuir Street after the protected bicycle lanes were

installed. They involved motor vehicles making prohibited right turns and colliding with bicycle users or motor vehicles failing to yield to bicycles.

- **Key Issue 4: Left Crosses.** Collisions involving left turning vehicles at intersections, also known as 'left crosses', were the most common type of vehicle movement resulting in a reported cycling collision (14.9%). Similar to collisions involving right turning vehicles, many of these collisions occurred at signalized intersections when the bicycle user was crossing with the signal. Similar to other key issues, the majority of left cross collisions occurred on arterial streets, with 36% of left crosses occurring on arterial streets with no designated bikeways. The majority (77%) of left cross collisions occurred while the bicycle user and motorist were travelling in opposing directions on the same street.
- **Key Issue 5: Sidewalk Cycling.** Approximately 6% of reported cycling collisions occurred where bicycle users were reportedly riding on the sidewalk prior to entering an intersection or conflict zone. Sidewalk cycling can create visibility challenges with motor vehicles who may not be expecting them at intersections or conflict zones, and can also create safety concerns with pedestrians and other sidewalk users. Due to the location of the incidents of sidewalk cycling, in many cases it is likely that bicycle users may be using sidewalks because there are insufficient and/or uncomfortable bicycle routes on the adjacent street. Most sidewalk cycling incidents resulted in two types of collisions: mid-block collisions as the motor vehicle was entering or exiting a driveway or alleyway, and intersection collisions where the motor vehicle was turning right. The top collision locations where bicycle users were riding on the sidewalk included Kingsway, Hastings Street, Clark Drive, Main Street, Commercial Drive, Victoria Drive, and 10th Avenue. None of the arterial streets noted above have designated bicycle facilities, with the exception of Main Street, which has shared use lanes.
- **Key Issue 6: Two Way Stops.** Collisions at two-way stops involving all motor vehicle turning movements (right turns, left turns, and straight motor vehicle movements) accounted for approximately 13% of all reported cycling collisions. Where right-of-way could be established, most of the collisions at two-way stops occurred as a result of the motor vehicle not stopping at the stop sign while the bicycle user had the right-of-way and was on the major street that did not have the stop sign.
- **Key Issue 7: Non-Motor Vehicle Collisions.** This key issue summarizes cycling injury crash results from the BICE study. It includes non-motor vehicle injury crashes between bicycle users and pedestrians, road infrastructure, and debris. The BICE study found that a minority of injury crashes were a result of collisions with motor vehicles (37%), although another 10% involved

avoidance manoeuvres to avoid a motor vehicle collision. The most common types of non-motor vehicle injury crashes were a result of bicycle users crashing because of surface conditions (holes, bumps, roots, debris, leaves, etc.), colliding with infrastructure (curbs, bollards, posts, etc.), or colliding with a cyclist, pedestrian or animal (12%, 11%, and 8% of all injury crashes, respectively).

- **Key Issue 8: High Collision Corridors.** Several corridors throughout the City were identified that had a high density (collisions/km) of reported cycling collisions. High collision corridors included: Burrard Street (West Hastings Street to Harwood Street), Commercial Drive (Adanac Street to East 12th Avenue), Clark Drive (Adanac Street to West 10th Avenue), Pacific Street (Hornby Street to Homer Street), and Cypress Street (Cornwall Avenue to West 19th Avenue). In addition, high collision frequencies were also found on 10th Avenue (Trafalgar Street to Victoria Drive), Main Street (Powell Street to West Kent Avenue), and Broadway (Highbury Street to Commercial Drive). The highest collision corridors generally corresponded with streets with designated bikeways. This likely indicates that they have a high level of usage.
- **Key Issue 9: High Collision Locations.** It is also important to identify the specific high collision locations within the City of Vancouver. Nineteen locations had more than ten reported cycling collisions between 2007 and 2012. Most of these collisions occurred at intersections that were controlled by a full signal (72%), followed by intersections with a half signal (17%) and a two-way stop (11%).
- **Key Issue 10: Designated Bikeways.** The majority (56%) of reported cycling collisions occurred on streets without designated bikeways. Arterial streets with no designated bikeways were the most common location for collisions. 44% of collisions occurred on a designated bikeway. Local street bikeways had a lower proportion of cycling collisions than would be expected based on network coverage, whereas shared use lanes, painted bicycle lanes and protected bicycle lanes had a higher proportion of cycling collisions.
- **Key Issue 11: PM Peak.** The collision data indicated that the majority of reported cycling collisions occurred during the afternoon peak period. Reported cycling collisions were most common between 4:00 and 7:00 pm, which accounted for nearly a third (31%) of all reported cycling collisions. This is also when the highest proportion of cycling volumes occurred.
- **Key Issue 12: Adverse Weather and Low Light.** The study found that a higher than expected number of collisions occurred in adverse weather and darker lighting conditions relative to the observed cycling volumes.

The study included a comprehensive action plan to address each of these twelve cycling safety issues based on a combination of engineering, education, and enforcement measures. A range of engineering measures were recommended to address each cycling safety issue, including treatments such as protected bicycle lanes, buffered bicycle lanes, coloured conflict zone markings, and protected bicycle signal phases among others.

Based on the findings of this study, a number of corridors repeatedly presented a range of cycling safety issues. The City should prioritize conducting safety reviews on the following corridors:

- **Highest priority:** Main Street and Burrard Street
- **Moderate priority:** Commercial Drive, 10th Avenue, and Broadway.
- **Lower priority:** Clark Drive, Pacific Street and Cypress Street.

In addition to these high collision corridors, a number of specific locations were also identified as presenting cycling safety issues. Many of these specific locations corresponded with the high collision corridors noted above, including Burrard Street, Main Street, and 10th Avenue. The City should conduct detailed intersection safety reviews at each of these locations to identify cycling safety issues and mitigation measures.

In addition to engineering treatments at high collision corridors and locations, the City should prioritize developing education campaigns and increasing enforcement for cycling safety issues such as doorings, sidewalk cycling, parking lot and driveway entrances and exits, passing, afternoon commute and dark and rainy conditions, hazards at locations with high proportions of right/left turning vehicles, and vehicles violating right turn regulations. The City should also develop a joint education campaign for pedestrian and cycling safety.

The improvement of cycling safety within the City of Vancouver will require the involvement and coordination of a number of agencies involved in cycling-related infrastructure, operations, services, and enforcement, including the City of Vancouver, ICBC, Vancouver Police Department (VPD), Vancouver Coastal Health (VCH), TransLink, and the Vancouver School Board (VSB). Through a collaborative effort among these agencies focusing on a comprehensive range of strategies including engineering, education, and enforcement measures, the City can work to improve cycling safety and continue to be a leader in making cycling a safe, comfortable, and attractive mode of transportation for people of all ages and abilities in Vancouver.

1.0 Introduction

The City of Vancouver is one of the most bicycle-friendly cities in North America. It has an extensive bicycle network that is well used by residents and visitors, as well as one of the highest cycling mode shares among major North American cities. Many Vancouver residents use their bicycle for transportation, recreation, and to complete day-to-day trips.

Cycling is an important and growing form of transportation within the City. According to the 2011 Canadian National Household Survey, cycling accounts for approximately 4.4% of all trips to work in the City. Although more and more people in Vancouver are choosing to cycle each year, a number of real and perceived barriers may be preventing some residents from cycling. Cycling may not always be perceived as the most practical method of transportation due to challenges in finding direct routes, interaction with motor vehicle traffic, uncomfortable infrastructure, lack of convenient and secure bicycle parking, and the influence of weather and topography. Additionally, societal perceptions and attitudes towards cycling may discourage some people from cycling.

The City of Vancouver recognizes the critical role that cycling can play in creating green and livable communities. Developing a safe, convenient, and comfortable bicycle network can attract more residents and visitors to cycle for a range of purposes. The City aspires to become the greenest city in the world by 2020. The Greenest City Action Plan sets a target that over half of all trips in the City will be made on foot, bicycle or public transit by 2020. The City's Transportation Plan, Transportation 2040, builds upon this goal with a target that two-thirds of all trips by 2040 will be made by walking, cycling or transit. Transportation 2040 also sets a target to work towards zero traffic-related fatalities, and places a special emphasis on safety for vulnerable road users.

In order to achieve these targets as they relate to cycling, Transportation 2040 aspires to make cycling safe, convenient, comfortable, and fun for people of all ages and abilities. The City is currently striving to develop an All Ages and Abilities ("AAA") cycling network. This focus recognizes the demographic in the City that is interested in cycling more, but is largely discouraged from cycling due to concerns over safety and traffic. Planning a network for people of all ages and abilities entails providing safe and comfortable conditions for the novice and experienced, young and old alike, and ensuring that people can safely cycle all the way from A to B. In order to achieve these goals, the City is actively seeking ways to understand cycling issues and opportunities, including cycling travel characteristics, to improve conditions and attract more people to cycle for all trip purposes.

Despite the advantage of cycling as a common activity that can serve to improve personal and public health, there are many real and perceived barriers to cycling. A study by the Cycling in Cities Program at the University of British Columbia identified the top motivators and deterrents to cycling among Metro Vancouver residents. The survey asked about a suite of 73 factors that might influence cycling, including factors related to engineering, education, encouragement and enforcement. Overall, the engineering factors were the strongest reported influences on cycling. The majority of the strong deterrents reflected safety concerns, such as motor vehicle traffic and speeds, potential risk of injury from collisions, or the presence of debris or slippery road conditions. Three of the top ten motivators were also safety related, generally related to separation and distance from motor vehicle traffic, and facility design. By addressing these real and perceived barriers to cycling, the City can work to make cycling more comfortable for people of all ages and abilities, which can help to increase cycling levels and improve cycling safety.

Bicycle users are considered vulnerable road users along with pedestrians and motorcyclists. Vulnerable road users are particularly prone to injuries and fatalities when they are involved in a collision. Although these vulnerable road users only accounted for approximately 3% of reported collisions in Vancouver between 2007 and 2012, these users accounted for approximately 80% of fatalities over this period. Pedestrians account for the majority of fatalities among vulnerable road users and a pedestrian safety study was completed by the City of Vancouver in 2012. It is important to next consider the safety needs and issues of cyclists as part of a comprehensive effort to improve road safety, and work towards the City's targets of zero traffic-related fatalities. As such, one of the recommended actions in Transportation 2040 was the development of a city-wide Cycling Safety Study to provide a better understanding of cycling safety hotspots and concerns.

A wide range of engineering treatments can be used to improve cycling safety, such as protected bicycle lanes, buffered bicycle lanes, coloured conflict zone markings, and protected bicycle signal phases. In addition to engineering treatments, education and encouragement initiatives can help to raise awareness among bicycle users, pedestrians, and motorists about how to safely share the road and improve the behaviour of those driving and cycling.

The City has taken several significant steps in recent years to improve cycling safety, including the installation of a number of engineering treatments such as protected bicycle lanes, spot improvements at high collision intersections, installation of signage and pavement markings, traffic control upgrades at key intersections, and installation of coloured pavement markings in vehicle-bicycle conflict zones. The City has an Active Transportation Policy Council to advise on matters that encourage and enhance cycling as a means of transportation, recreation and health. In addition, the City is developing an Active Transportation

Promotion and Enabling Strategy which identifies strategies that can help promote active transportation for all residents.

The Cycling Safety Study builds on these initiatives and provides critical information on key safety and design concerns within the bikeway network that, if addressed, can further position cycling as a safe, comfortable, and attractive transportation choice for people of all ages and abilities in Vancouver. This report provides a comprehensive and objective review of the safety of cycling in the City of Vancouver and provides an action plan to address each of the identified cycling safety issues. The study will help to clarify possible misconceptions regarding the safety of cycling within the City, and to promote cycling as a safe and comfortable transportation option for people of all ages and abilities.

1.1 Study Purpose

In 2012, the City adopted Transportation 2040, which provides a long-term strategic vision for transportation within the City of Vancouver. Transportation 2040 includes targets to significantly increase the proportion of trips made by walking, cycling, and transit, while also working towards zero transportation-related fatalities. Another key component of the plan is making cycling safe, convenient, comfortable and fun for people of all ages and abilities. This includes building bicycle routes that are comfortable for all users, upgrading and expanding the bicycle network to efficiently connect people to key destinations, maintaining bikeways in a good state of repair, providing bicycle parking and end-of-trip facilities, integrating cycling into a multi-modal system, and promoting cycling as a fun and pleasant activity that can be done by anyone.

This study focuses on providing an evidence-based foundation to quantitatively understand cycling safety issues throughout the City. This study involved an in-depth analysis of all collisions reported to the Insurance Corporation of British Columbia (ICBC) involving bicycle users and motor vehicles in the City of Vancouver between 2007 and 2012.[iii] In addition, the study analyzed the injury data from bicycling crashes that resulted in treatment at a hospital emergency room in Vancouver in 2008 and 2009 from the Bicyclists' Injuries and Cycling Environment (BICE) study conducted through the University of British Columbia Cycling and Cities program.[iv] Based on these datasets, the analysis examined

[iii] For the remainder of this report, the term **"reported cycling collisions"** has been used to refer to collisions reported to ICBC involving bicycle users and motor vehicles.

[iv] For the remainder of this report, the term **"cycling injury crashes"** has been used to refer to injury data from the BICE Study based on bicycling crashes that resulted in treatment at a hospital emergency room in Vancouver.

WHERE reported cycling collisions and injury crashes took place, **HOW** they occurred, **WHEN** they took place, and **WHO** was involved.

This study will help inform and guide facility development and policy planning regarding bicycle facilities, infrastructure, and treatments already established in Transportation 2040. This study will help the City gain a better understanding of the effectiveness of existing cycling safety treatments, and identify opportunities to improve cycling safety through engineering, enforcement, and education measures.

1.2 Report Structure

This report includes eight chapters, as follows:

- **Chapter 1 – Introduction** provides an overview of the Cycling Safety Study, including the purpose and scope of the Study.
- **Chapter 2 – Vancouver in Context** summarizes the overall collision patterns in the City of Vancouver and describes how these patterns compare with other peer cities across North America and internationally.
- **Chapter 3 – Methods** summarizes the data sources and methods that were used for the collision analysis as well as limitations of the analysis.
- **Chapter 4 – Where Analysis** summarizes where reported cycling collisions and cycling injury crashes occurred.
- **Chapter 5 – What Analysis** summarizes the types of reported cycling collisions, as well as the types of other cycling injury crashes that led to injuries which required treatment at a hospital emergency room.
- **Chapter 6 – When Analysis** summarizes when reported cycling collisions occurred, including a summary of collision patterns on annual, monthly, seasonal, day of week, and time of day bases, as well as an assessment of cycling collision trends based on weather and lighting conditions.
- **Chapter 7 – Who Analysis** summarizes the demographics of people who were either involved in reported cycling collisions or cycling injury crashes, including the age and gender of bicycle users.
- **Chapter 8 – Action Plan** includes a comprehensive set of actions to address the identified cycling safety issues based on the results of the analyses in the previous chapters.

2.0

Vancouver in Context

2.1 Existing Cycling Initiatives

The City of Vancouver is committed to making cycling a safe, accessible and enjoyable experience for residents and visitors of all ages and abilities. The City has taken several significant steps to improve cycling safety in recent years, including a variety of engineering treatments, education campaigns, and communications initiatives, as summarized below:

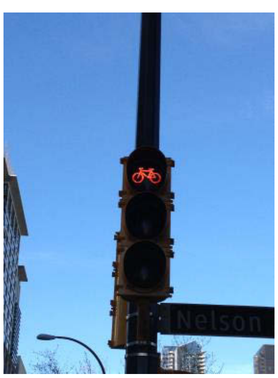
ENGINEERING

Expansion of the network of **protected bicycles lanes** throughout the City including those on Hornby Street and Dunsmuir Street.

The expansion of **local street bikeways** and **painted bicycle lanes**, including buffered and parking protected bicycle lanes.

Corridor improvements including improving the Seaside Greenway and Point Grey Road for bicycle users and pedestrians.

Installation of **coloured conflict zone markings** at motor vehicle-bicycle conflict zones throughout the City.



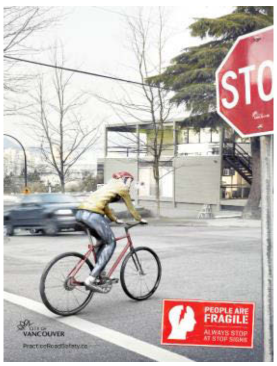
Upgrading **traffic controls** at several key locations in the City.

Installation of **signage and pavement markings** along numerous streets in the City.

Diversion and **separation** measures at key collision locations.

Spot improvements at numerous high collision and conflict intersections and corridors throughout the city.

EDUCATION



Led the *People Are Fragile* **road safety awareness program** in February 2012 in partnership with ICBC, VPD, Vancouver Coastal Health and others.

Leads the **Safe Routes to School** Programs and initiatives in conjunction with ICBC, VPD, Vancouver Coastal Health, and Vancouver School Board.

The Vancouver Community Policing Centres, through support from the City of Vancouver, **promote cycling safety at various events and festivals** occurring within the City.

COMMUNICATION

Formation of an **Active Transportation Policy Council** to advise the City on matters that encourage and enhance cycling and other forms of active transportation as a means of transportation, recreation, health, and environmental design.

Development of a **Promotion and Enabling Strategy** which outlines opportunities and actions to encourage people to choose walking or cycling for more trips.

Holding monthly **meetings with ICBC and VPD** to discuss road safety.

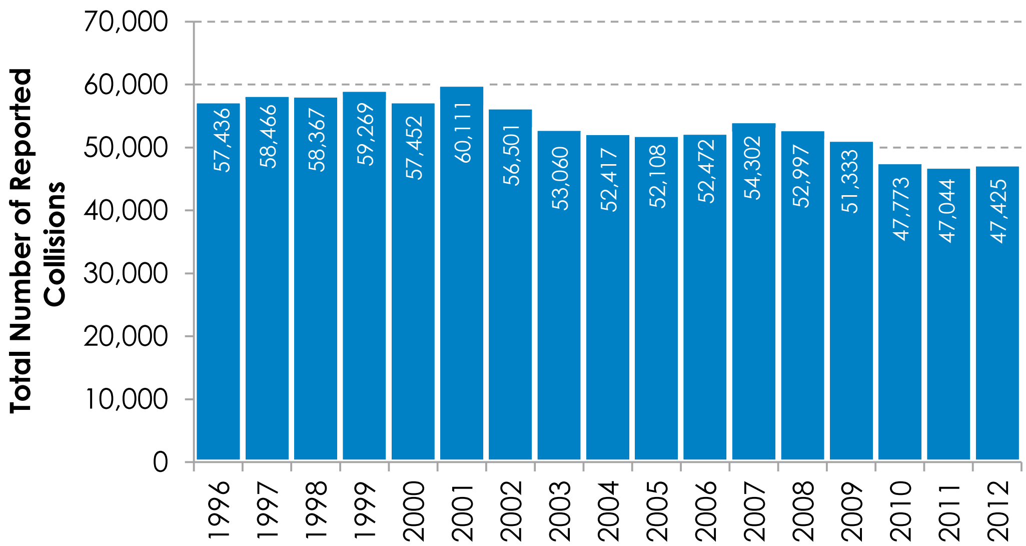
2.2 Current Collision Trends

The overall number of reported cycling collisions in Vancouver has been relatively stable on an annual basis over the past fifteen years and beyond. This has occurred despite an increase in the number of residents and employees in Vancouver, and despite a significant increase in the number of bicycle trips made in the City over the past several years. As a result, the cycling collision rate has been declining. This section summarizes recent and historic trends regarding the number of reported cycling collisions in the City of Vancouver.

The Insurance Corporation of British Columbia (ICBC) collects and maintains data regarding reported collisions involving motor vehicles across British Columbia. Based on this data, there were **2,994** reported collisions involving bicycle users and motor vehicles between 2007 and 2012 in the City of Vancouver (including collisions that occurred in parking lots or involved parked motor vehicles), equivalent to an average of about 500 reported cycling collisions per year. In comparison, there was an average of 50,145 total reported collisions in Vancouver per year over this period. As such, approximately 1.0% of all reported motor vehicle collisions involved a bicycle user over this period.

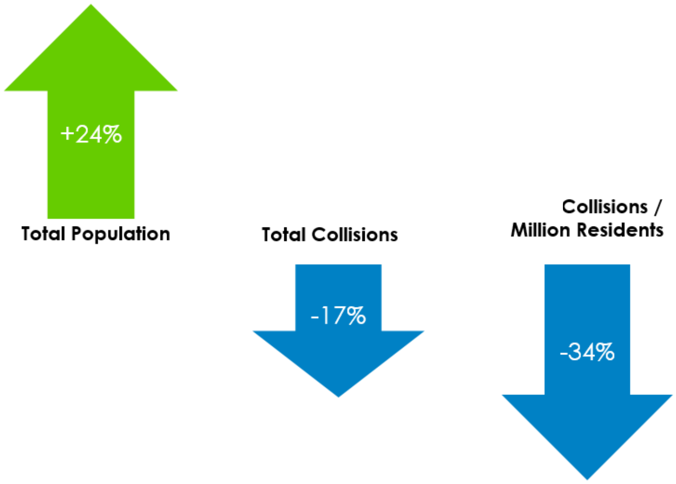
Prior to 2007 the number of total reported motor vehicle collisions among all road users has been steadily declining in the City of Vancouver. As shown in **Figure 2.1,** the total number of reported motor vehicle collisions declined by approximately 17%, or 10,000 collisions, between 1996 and 2012 – from 57,000 reported collisions in 1996 to 47,000 in 2012.

Figure 2.1
Annual Number of Overall Reported Motor Vehicle Collisions (1996-2012)
Source: ICBC Collision Data (1996-2012)



This decline in the total number of reported collisions in the City has taken place despite an increase in the City's population of 24% between 1996 and 2012. This has resulted in a significant reduction in the overall collision rate for all modes, as the number of reported collisions per one million residents decreased by approximately 34% over this period, as seen in **Figure 2.2.**

Figure 2.2
Representation of Population Growth and Reported Collisions
Source: ICBC Collision Data (1996-2012), Statistics Canada (2011)



Between 2007 and 2012, collisions involving bicycle users made up 1% of all reported collisions involving motor vehicles in Vancouver (as shown in **Figure 2.3)**. However, as shown in **Figure 2.4**, this 1% of all collisions translates to 4% of all traffic-related fatalities. In total, vulnerable road users, which include pedestrians, bicycle users, and motorcyclists, accounted for 80% of traffic-related fatalities in the City.

The majority of traffic related fatalities in Vancouver have involved pedestrians, and a pedestrian safety study was completed in 2012. The important next step is to focus on cycling safety improvements to eliminate cycling fatalities and reduce the overall number of cycling collisions in the City as a way to help meet the City's goal of zero traffic-related fatalities and encouraging bicycle users of all ages and abilities.

Figure 2.3
Reported Collisions in Vancouver by Road User (2007-2012)
Source: ICBC Collision Data (2007-2012)

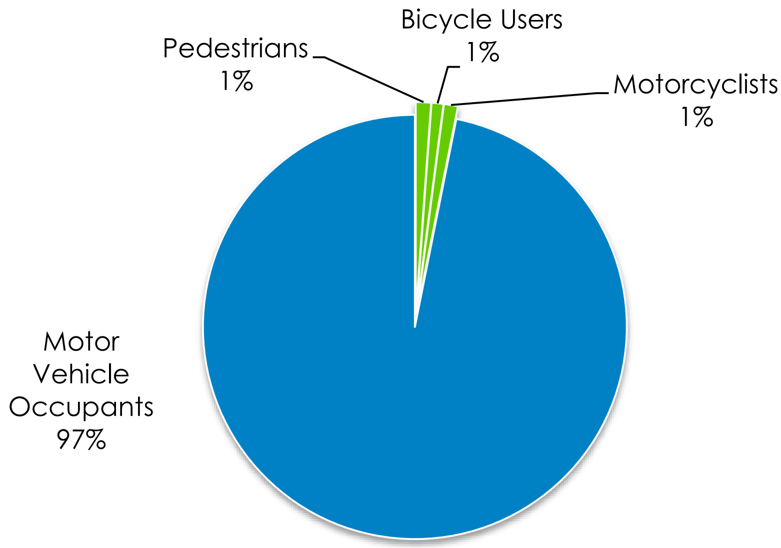
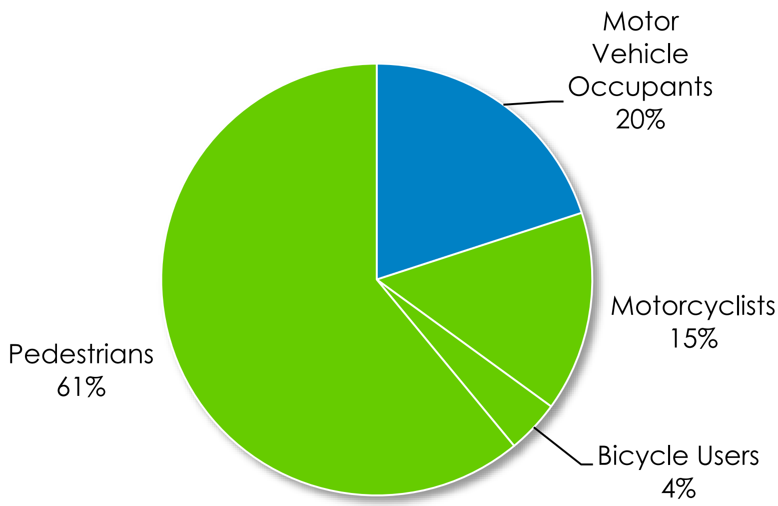


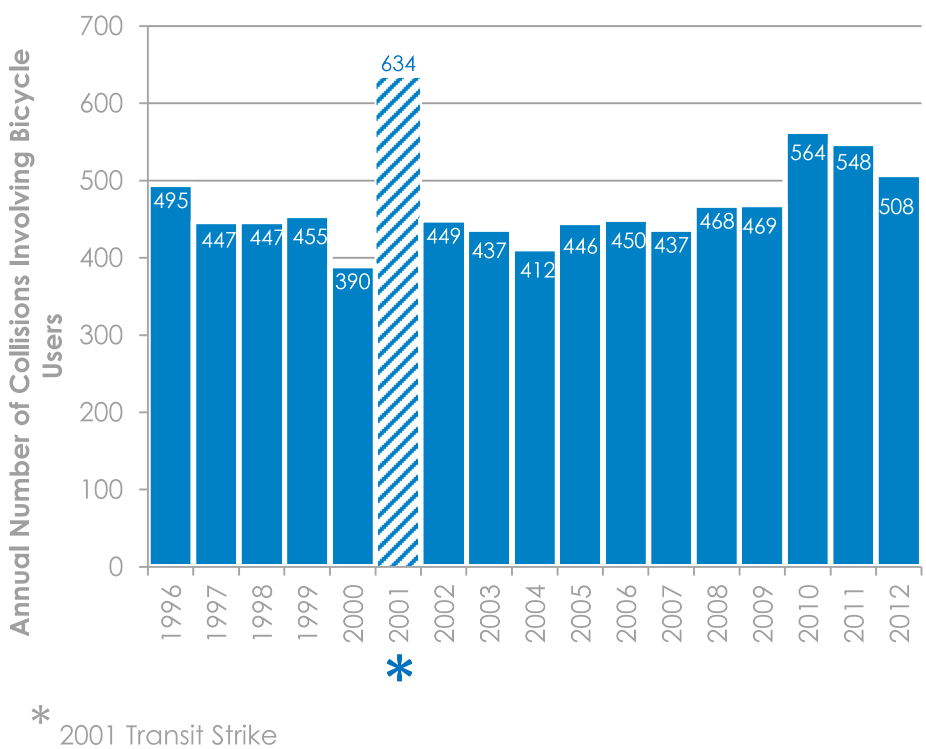
Figure 2.4
Reported Collisions Resulting in Fatality in Vancouver by Road User (2007-2012)
Source: Vancouver Police Department Traffic Fatality Data (2007-2012)



Despite the decrease noted above in the number of overall reported motor vehicle collisions since 1996, the number of reported cycling collisions has remained relatively stable since 1996. As shown in **Figure 2.5**, the total number of reported cycling collisions increased slightly between 1996 and 2010, although there has been a more recent decline in the number of reported cycling collisions since 2010.

It should be noted that there was a pronounced increase in the number of reported cycling collisions in 2001, which is likely a result of the increased number of bicycle trips made due to the transit strike in 2001. Through a detailed review of collision data for 2001, it was found that there was a significant increase in collisions during the months the transit strike occurred (April – August) as compared to the same months in the years both before and after the strike. As such, the data from 2001 should be interpreted with caution as they represent an anomalous year.

Figure 2.5
Annual Number of Reported Cycling Collisions (1996-2012)
Source: ICBC Collision Data (1996-2012)

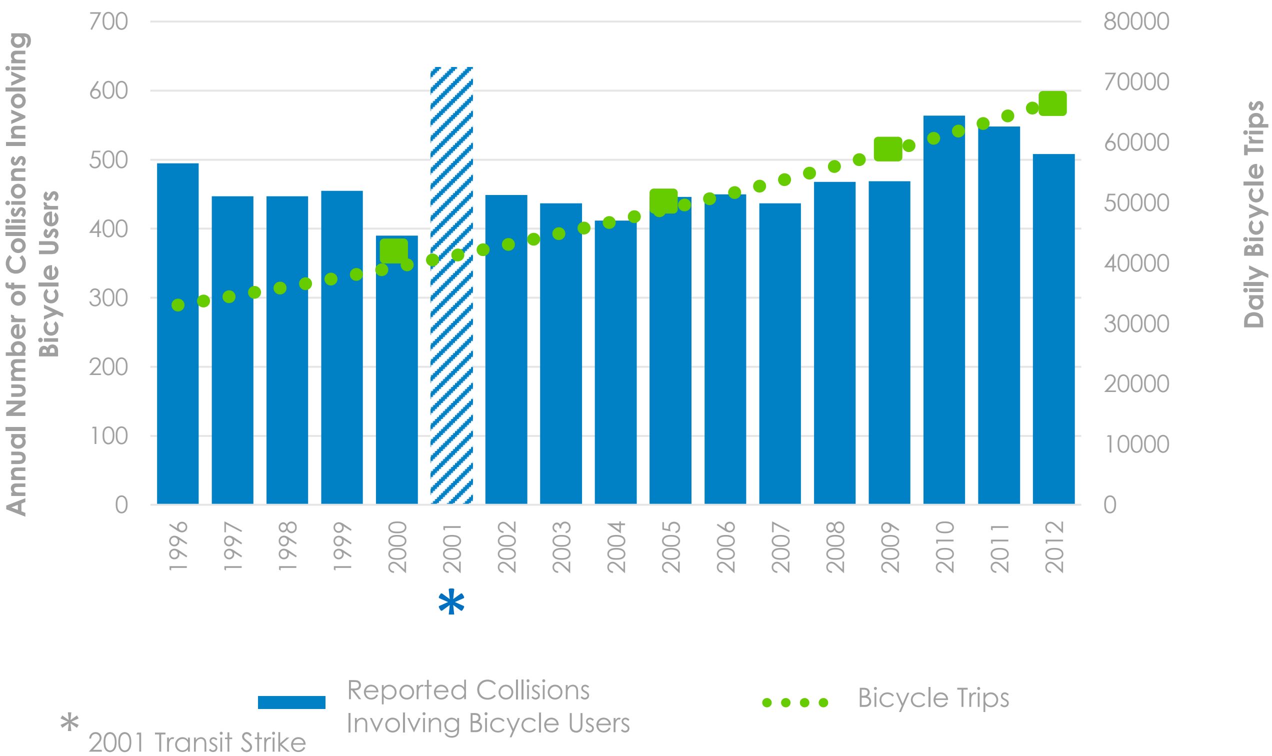


Although the absolute number of reported cycling collisions has remained relatively stable since 1996, there has been a significant increase in the City's population as well as the number of bicycle trips made over this period. The Metro Vancouver Trip Diary Survey conducted by TransLink provides a summary of travel patterns by all modes, including the number of trips made by bicycle. The Trip Diary Survey is typically conducted every four to five years to provide comparisons over time. The number of daily bicycle trips in the City of Vancouver can be determined by reviewing data from the Trip Diary Surveys conducted in 1999, 2004, 2008, and 2011. These trip diary surveys show a steady and consistent increase in the number of daily bicycle trips made in the City of Vancouver, from 41,100 daily trips made by bicycle in 1999 to 66,500 trips in 2011. The number of daily bicycle trips in intervening years was interpolated between Trip Diary Surveys. As shown in **Figure 2.6**, the number of daily cycling trips has steadily increased since 1999, but this has not translated into an increase in the number of reported cycling collisions.

Figure 2.6

Annual Number of Reported Bicycle Collisions and Daily Bicycle Trips (1996-2012)

Source: ICBC Collision Data (1996-2012); TransLink Trip Diary (1994, 1999, 2004, 2008, 2011)

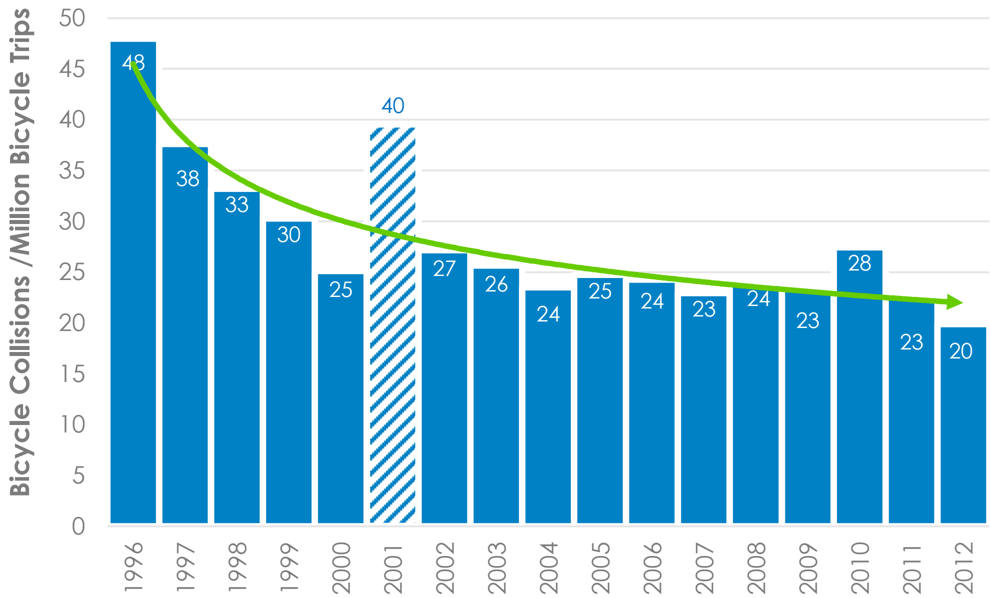


With a steady increase in the number of cycling trips in Vancouver but a relatively stable number of annual cycling collisions, the rate of cycling collisions in Vancouver has been steadily declining since 1996. The cycling collision rate is defined as the number of reported annual cycling collisions per one million annual bicycle trips. To determine the annual cycling collision rate, the number of annual cycling trips was estimated. In order to develop a cycling collision rate that was comparable with other cities, it was necessary to use comparable data sources. Mode share data from the United States Census and Canadian National Household Survey was used. This data provides a direct comparison of the proportion of commute trips to work made by bicycle on a typical day in all cities across Canada and the United States.

A number of assumptions were required to convert a daily mode share of commute trips to an estimate of the number of total annual cycling commute trips. This involved converting the data from the proportion of trips to an estimate of an absolute number of trips made by bicycle, and converting data from a daily estimate to an annual estimate. The annual cycling collision rate was first calculated by multiplying the proportion of trips to work made by bicycle by the City's total employed labour force. This provides an estimate of the total number of daily commute trips to work made by bicycle. This number was then multiplied by the number of work days in an average year, which was assumed to be 250 days, to provide an estimate of the annual number of cycling trips. It is recognized, however, that this methodology assumes consistent travel patterns on a daily basis throughout the year, and does not account for seasonal or weather variations in travel patterns. However, this methodology was used as it provides a consistent and comparable measure among all cities across North America. The annual cycling collision rate was then normalized by estimating the number of annual cycling collisions per one million annual bicycle trips. This was achieved by dividing the annual bicycle trips by one million (1,000,000) to determine the million annual bicycle trips by city.

As shown in **Figure 2.7**, the annual cycling collision rate in Vancouver decreased by approximately 59% between 1996 and 2012, from approximately 48 to 20 reported cycling collisions per one million bicycle trips.

Figure 2.7
Reported Cycling Collisions Per One Million Bicycle Trips (1996 – 2012)
Source: ICBC Collision Data (1996-2012), TransLink Trip Diary (1999, 2004, 2008, 2011)



2.3 Collisions in Context

To put Vancouver's collision trends in context, overall collision rates as well as cycling collision rates were compared with other peer cities in Canada, the United States, Australia, and Europe. Twenty-one peer cities were selected based on a range of criteria, including:

- Population of at least 500,000 residents;
- Population density of at least 2,000 people/km^2; or
- Bicycle mode share of at least 1%.

The characteristics for each of the peer cities are outlined in **Appendix A.**

Table 2.1
Peer Cities

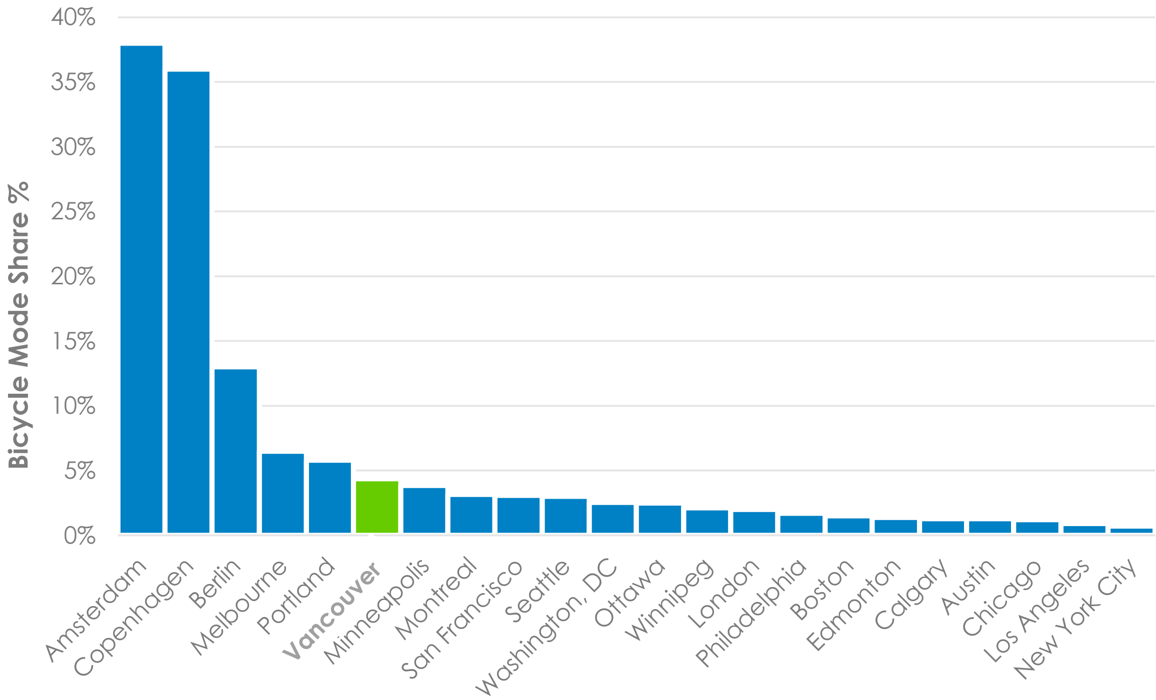
Canada	USA	International
▪ Ottawa	▪ New York	▪ Copenhagen
▪ Calgary	▪ Los Angeles	▪ Amsterdam
▪ Edmonton	▪ Chicago	▪ Berlin
▪ Winnipeg	▪ Philadelphia	▪ London
▪ Montreal	▪ San Francisco	▪ Melbourne
	▪ Boston	
	▪ Seattle	
	▪ Washington DC	
	▪ Portland	
	▪ Minneapolis	
	▪ Austin	

In comparison to the North American peer cities indicated above, Vancouver has one of the highest proportions of trips to work made by bicycle (4.4%) as shown in **Figure 2.8.** In fact, Vancouver has the highest bicycle mode share among Canadian peer cities, and the second highest bicycle mode share among North American peer cities behind Portland. However, Vancouver's bicycle mode share remains relatively low when compared to a number of European cities.

Figure 2.8

Proportion of Trips to Work Made by Cycling in Canadian and International Peer Cities (2011)

Source: Canadian National Household Survey 2011, United States Census Bureau 2011, Statistics Denmark 2011, Australian Bureau of Statistics 2011, Destatis Statistisches Bundesamt 2012, Statistics Netherlands 2011 & UK National Statistics 2013

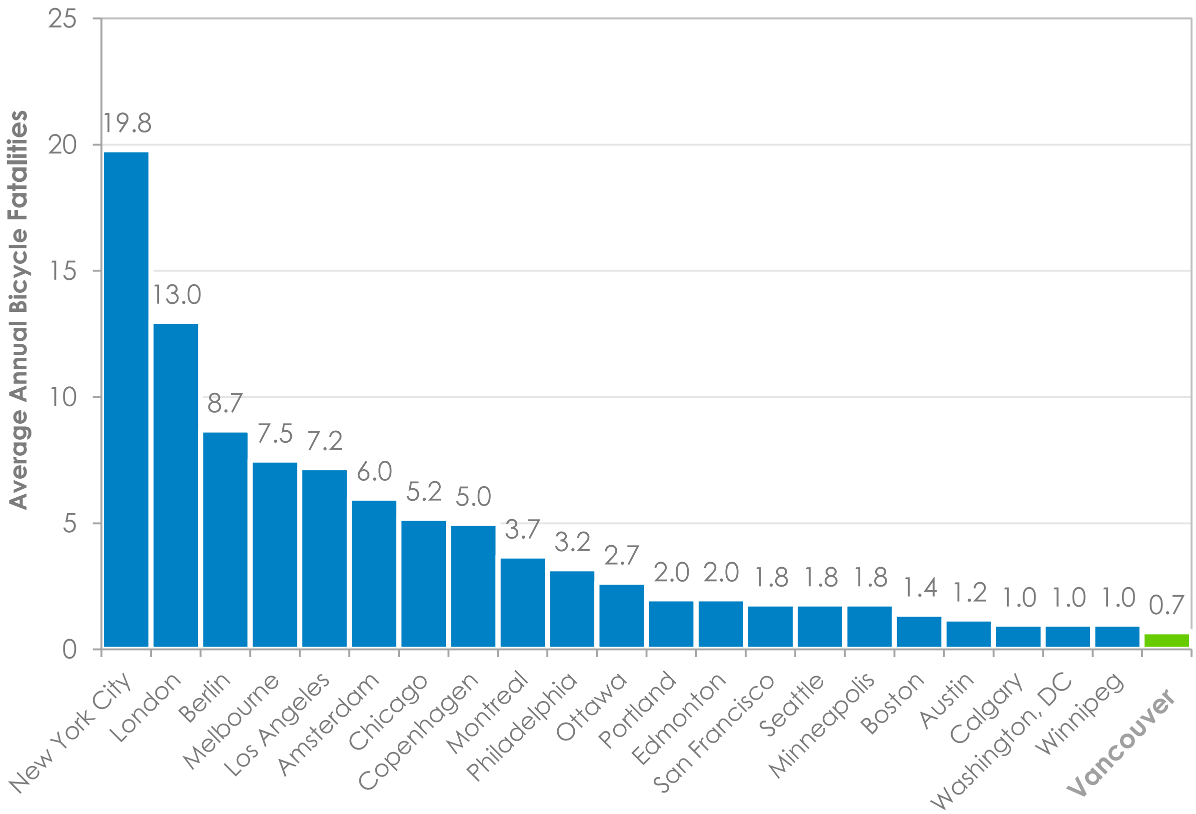


Between 2007 and 2012, there were a total of four reported cycling fatalities in the City of Vancouver, resulting in an average of 0.7 cycling fatalities per year. As seen in **Figure 2.9**, Vancouver had the lowest number of annual cycling fatalities when compared to other communities across Canada and internationally.

Figure 2.9

Average Number of Annual Cycling Fatalities in Canadian and International Peer Cities (2007-2012)

Source: Information provided directly from Canadian Cities, American Cities: National Highway Traffic Safety Administration Fatality Data (2007-2011), Copenhagen 2012 Bicycle Account (2007-2012), Transportation for London (2007-2012), VicRoads Victoria Police Department (2007-2012)

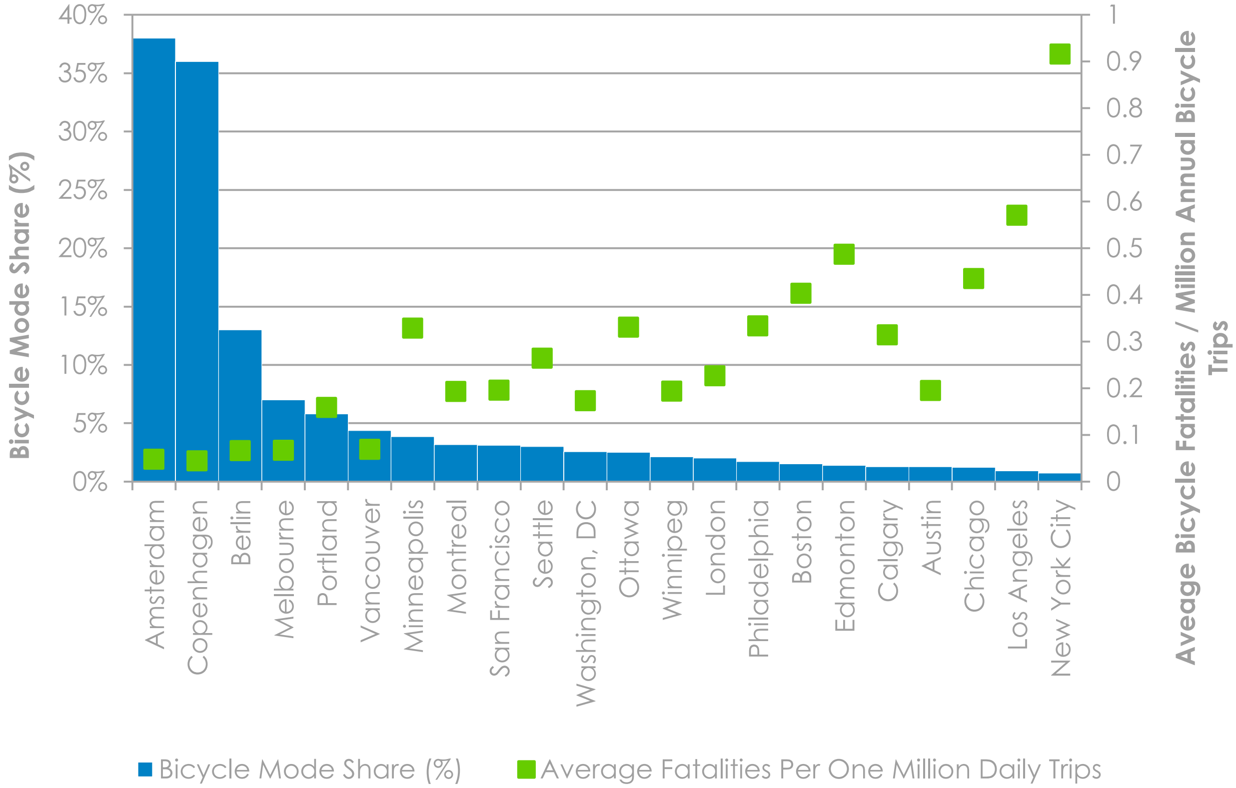


In addition to comparing the average annual number of cycling fatalities among peer cities, it is also useful to compare the cycling fatality rate per one million annual bicycle trips. As seen in **Figure 2.10,** Vancouver has the lowest cycling fatality rate among North American cities (0.07 cycling fatalities per million annual bicycle trips), with the same cycling fatality rate as Berlin and Melbourne. This cycling fatality rate is comparable, albeit slightly higher, than world-leading cycling cities, including Amsterdam (0.05) and Copenhagen (0.04). A summary of these calculations is provided in **Appendix A**.

Figure 2.10

Average Bicycle Fatalities Per Million Annual Bicycle Trips in Canadian and International Peer Cities (2007-2012)

Source: Information provided directly from Canadian Cities, American Cities: National Highway Traffic Safety Administration Fatality Data (2007-2011), Copenhagen 2012 Bicycle Account (2007-2012), Transportation for London (2007-2012), VicRoads Victoria Police Department (2007-2012)



The corresponding data for **Figure 2.10** are shown below in **Table 2.2**.

Table 2.2

Bicycle Journey To Work Mode Share and Average Bicycle Fatalities per Million Daily Bicycle Trips (2007-2012)

Source: Information provided directly from Canadian Cities, American Cities: National Highway Traffic Safety Administration Fatality Data (2007-2012), Canadian and American Census information Statistics Canada, 2011, United States Census Bureau, 2012

City / Region	Bicycle Journey To Work Mode Share (%)	Average Cycling Fatalities Per One Million Daily Bicycle Trips
Copenhagen	36.0%	0.04
Amsterdam	38.0%	0.05
Berlin	13.0%	0.07
Melbourne*	7.0%	0.07
Vancouver	**4.4%**	**0.07**
Portland	5.8%	0.16
Washington, DC	2.6%	0.17
Montreal	3.2%	0.19
Winnipeg	2.1%	0.19
San Francisco	3.1%	0.20
Calgary	1.3%	0.20
London	2.0%	0.23
Seattle	3.0%	0.26
Austin	1.3%	0.31
Philadelphia	1.7%	0.33
Ottawa	2.5%	0.33
Minneapolis	3.9%	0.33
Boston	1.5%	0.40
Chicago	1.2%	0.43
Edmonton	1.4%	0.49
Los Angeles	0.9%	0.57
New York City	0.7%	0.92

*Melbourne Bicycle fatalities and population based on the Region

Safety in numbers refers to a phenomenon that as the proportion of trips by bicycle increases, the cycling fatality rates decrease[1]. This has been observed by researchers in a number of cities with a high bicycle mode share. The evidence suggests that as levels of cycling increase, cycling injury and fatality rates per-trip and per-kilometre travelled decrease substantially. Safety in Numbers has been documented in studies from California, Australia, and Europe, with a European example shown below in **Figure 2.11.** There are several possible explanations for the "safety in numbers" phenomenon. For one, in locations with few bicycle users, drivers will be less accustomed to check for cyclists on the road at common conflict times such as turning, parking, or passing. Another consideration is that where cycling rates are high, it is more likely that drivers also use bicycles for transportation at times, and are better able to predict the movements of bicycle users. Additionally, where there are more bicycle users, there is more justification for increased resources for bicycle facilities and safer design. Regardless, the message is that if there are increases to participation in cycling, there are returns in terms of increased safety.[2 3 4]. In addition to these international peer cities, this study also examined Vancouver in relation to the fifty largest North American cities, including 44 American and six Canadian cities. As seen in **Figure 2.12**, North American cities with the highest level of bicycle mode share have some of the lowest average bicycle fatalities per million bicycle to work trips.

Figure 2.11

Safety in Numbers Represented by Bicycle Travel Distance and Fatalities per 100,000,000 km in 14 European Countries

Source: Safety in Numbers Brochure. CTS the National Cycling Charity Data from ERSO and Eurobarometer [5]

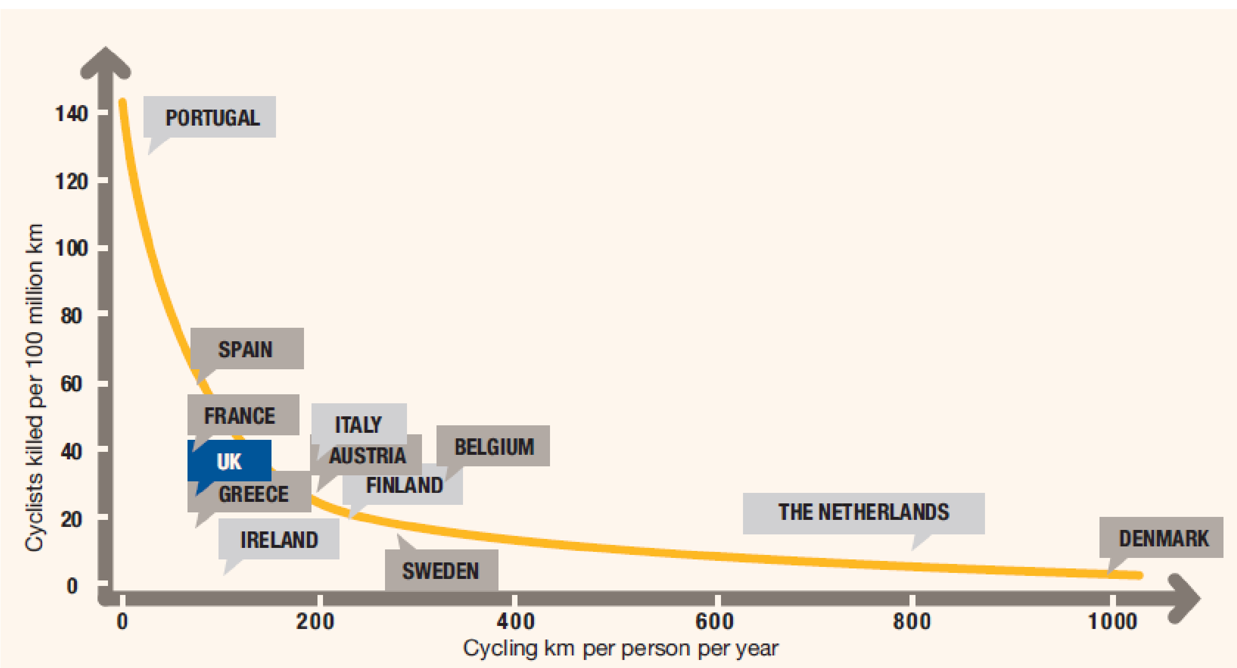


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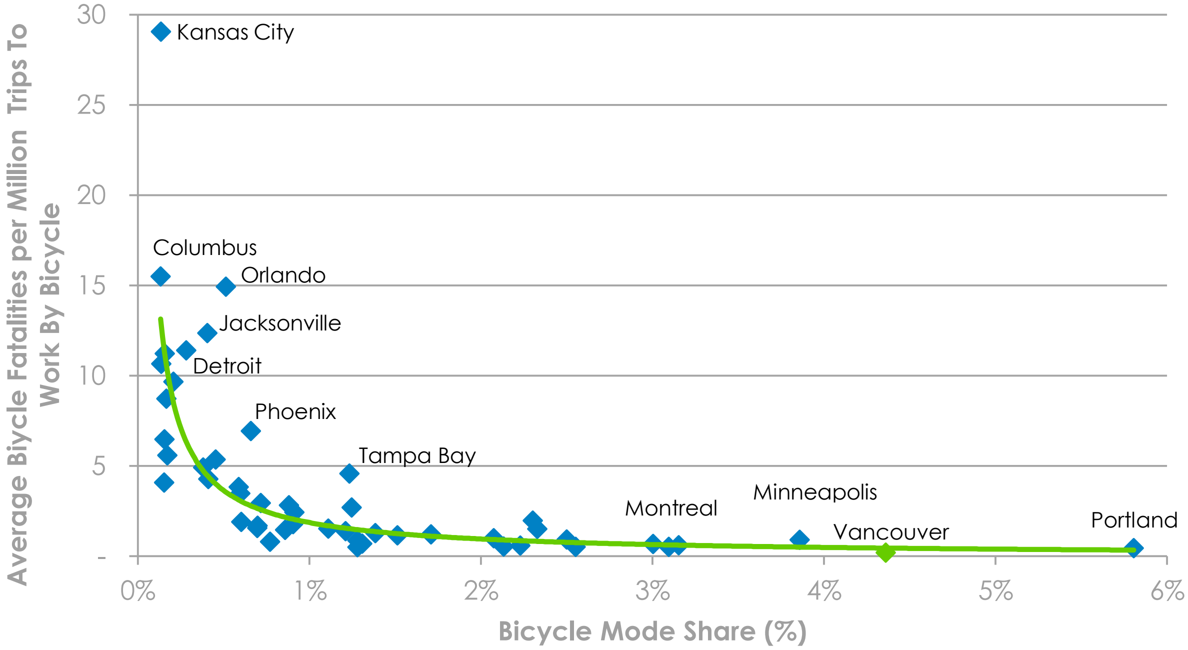
Figure 2.12

Bicycle Mode Share and Average Bicycle Fatalities per Million Bicycle to Work Trips Among Major North American Cities

Source: Information provided directly from Canadian Cities, American Cities: National Highway Traffic Safety Administration Fatality Data (2007-2012), Canadian and American Census information Statistics Canada, 2011, United States Census Bureau, 2012



3.0 Data

This chapter summarizes the data sources and methods that were used for the analysis as well as the limitations of the study.

This study involved an in-depth analysis of all collisions reported to ICBC involving bicycle users and motor vehicles in the City of Vancouver between 2007 and 2012. ICBC collects and maintains statistics for all reported collisions in British Columbia, providing Vancouver and other communities in British Columbia with unique access to motor vehicle collision data that is often not as readily available in other North American cities. The analysis included all reported collisions, including those on public streets, collisions with motor vehicles that were parked, motor vehicles entering and leaving on-street parking stalls, and motor vehicles located within alleyways and parking lots.

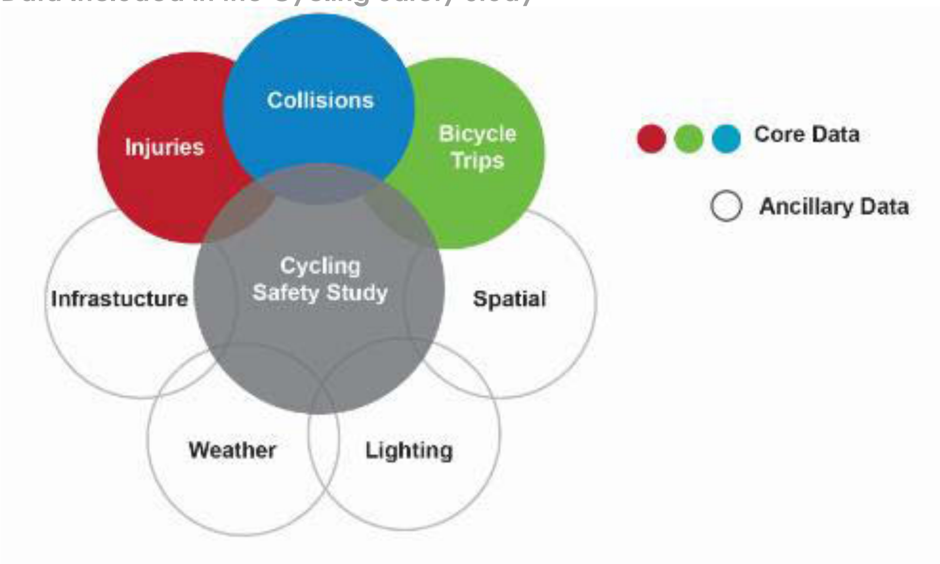
The study also included an analysis of injury crash data from bicycling injuries that resulted in treatment at a hospital emergency room in Vancouver in 2008 and 2009. This data came from the Bicyclists' Injuries and Cycling Environment (BICE) study conducted through the University of British Columbia Cycling and Cities program.

Based on these datasets, as well as a number of other data sources as described in further detail below, this study examined **WHERE** reported cycling collisions and injury crashes took place, **HOW** they occurred, **WHEN** they took place, and **WHO** was involved.

3.1 Data Types

The analysis for the Cycling Safety Study required the assembly, documentation and manipulation of data from ICBC, the Vancouver Police Department, BICE, Metro Vancouver Regional Trip Diary Survey, Statistics Canada's National Household Survey, and the City of Vancouver Open Data Catalogue. The data sets analyzed for this study are shown in **Figure 3.1** and briefly described below. Further details about the sources for each type of data are provided in **Appendix B**.

Figure 3.1
Data Included in the Cycling Safety Study



Collision Data included data provided by both the Insurance Corporation of British Columbia (ICBC) and the Vancouver Police Department (VPD). ICBC collects and maintains statistics for all reported collisions involving motor vehicles in British Columbia. The collision data classifies collisions based on the type of collision (fatality, injury, or property damage only), and also identifies when collisions involved bicycle users, motorcycles, and pedestrians. ICBC provided this dataset for all collisions reported to ICBC in the City of Vancouver between 1996 and 2012. Throughout the rest of this report, the term 'reported cycling collisions' has been used to refer to all collisions reported to ICBC involving bicycle users and motor vehicles. In addition, the VPD also collects and maintains statistics for all traffic related fatalities. The City provided this dataset for all fatalities resulting from collisions between 1992 and 2012. It should be noted that the City considers the VPD dataset as the official record of all traffic-related fatalities, and the ICBC dataset as the official record of all other collisions. The detailed collisions analysis focused on collisions between 2007 and 2012. There were 2,994 reported collisions involving bicycle users and motor vehicles between 2007 and 2012 and 4 cycling fatalities in the City of Vancouver.

Injury Data was obtained through the Bicyclists' Injuries and the Cycling Environment (BICE) study that was conducted in 2008 and 2009 through the University of British Columbia's Cycling in Cities program. This data was used to supplement the collision data noted above, particularly regarding non-motor vehicle collisions that typically are unreported to ICBC or the VPD. The objective of the BICE study was to better understand the link between bicyclists' injuries based on the type of route they took and the presence of variables that may have contributed to the injury in the Cities of Vancouver and Toronto (May 2008 – November 2009). This study included an analysis of only those participants who resided in the City of Vancouver and suffered an injury while bicycling in the City Vancouver that was serious enough to be treated at the emergency departments of either St. Paul's Hospital or Vancouver General Hospital. The study excluded children and youth 18 years and under; people who were injured outside the City of Vancouver; people who resided outside the City of Vancouver; and people who were injured while mountain biking, trick riding, racing or riding for non-commuter purposes. After these exclusions, this dataset included 414 recorded injuries between May 2008 and November 2009.

- **Bicycle Trip Data** was obtained through three sources. The 2011 Metro Vancouver Regional Trip Diary Survey provided by TransLink, provides a snapshot of travel behaviour throughout the Metro Vancouver region, including bicycle travel patterns. The 2011 National Household Survey, conducted by Statistics Canada, provides information regarding journey to work trips for the employed population 15 years and older. Finally, the City of Vancouver provided bicycle count data for four locations during 2011: Burrard Bridge, Dunsmuir Viaduct, Hornby Street at Robson Street, and Dunsmuir Street at Seymour Street. This data was used to speak to cycling volumes and trends in the City.

Other ancillary data included in this study came in the form of providing information regarding **infrastructure** including road classification, bicycle facility type, traffic signals and the location of traffic circles. **Spatial** data was also used for this project to identify neighbourhood-based trends. Other data sources included information regarding **weather**, **light conditions**, and **demographics**.

In cases where both the ICBC collision data and the BICE have been used in the analysis, the following colour coding and symbology have been used through the report to improve clarity about which dataset is being referred to:

- **Collisions (ICBC)**
- **Injuries (BICE)**
- **Combined Data: Collisions (ICBC) and Injuries (BICE)**

3.2 Data Limitations

There were a number of limitations to this study based on the data that was provided. Firstly, this study's primary data source was reported motor vehicle collision data provided by ICBC. This was a comprehensive dataset that included nearly 3,000 reports of collisions between motor vehicles and bicycle users spanning a six year period. This dataset does not include any unreported collisions, or any collisions that did not involve a motor vehicle.

To help address this limitation and incorporate additional insights about non-motor vehicle crashes, the findings of the BICE study were included. In this study, the findings provide insights into other types of bicycle-involved collisions in the City of Vancouver, not just those involving motor vehicles. However, the BICE data represents a much shorter time period and has a smaller sample size when compared to the ICBC collision data. The data was also collected before the implementation of the City of Vancouver's downtown protected bicycle lanes on Hornby Street and Dunsmuir Street. In addition, the BICE data only includes a sample of individuals whose injuries were serious enough to result in hospital emergency department treatment and does not include collisions that did not require a hospital visit, collisions where the injured party visited a medical clinic instead of an emergency room, or collisions where the injured party visited a hospital outside the City of Vancouver.

It is likely that there are a significant number of cycling collisions that are not reported to ICBC and therefore not included in the collision data, as well as a significant number of incidents that may not have been serious enough to result in treatment from a hospital emergency room. In addition, none of these data sets include 'near misses'. The ICBC collision data does not include incidents of bicycle hit and runs where, for example, a bicycle user may have collided with a parked motor vehicle resulting in damage, but did not stay on the scene or leave a note. Finally, the ICBC collision data analyzed did not include a number of attributes, such as driver information (i.e. age, gender, and place of residence), alcohol consumption, or vehicle type.

Another limitation with the data is the lack of ability to assign fault as per the ICBC source data provided for this study. Based on the incident description provided in the ICBC collision data, an objective and systematic assessment was carried out to assess right-of-way. However, this was based on limited available information and does not assign fault of any road users.

Helmet use in the prevention of injury was not addressed in this report as there was no information provided specific to helmet use in any of the data sets available or analyzed.

4.0

Where Analysis

4.1 Introduction

This section provides a summary of where reported cycling collisions occurred (as reported by ICBC collision data) and where any kind of bicycling crash occurred if it involved an injury requiring treatment at a hospital emergency department (as reported by BICE data).

Reported cycling collision data and injury crash data was analyzed and represented in a number of ways throughout this study. Through the analysis of where these incidents occurred, this section summarizes top collision locations and corridors both in terms of ***frequency*** of incidents and the ***likelihood*** of incidents after taking cycling volumes into account, where available. The frequency of incidents refers to the absolute number of reported cycling collisions or cycling injury crashes over a given time period, without normalizing the data. Collision likelihood provides a more accurate representation of the risk of being involved in a cycling collision or an injury crash based on cycling volumes. Although the term likelihood is used throughout this report, it should be noted that the denominator used to estimate the number of bicycle trips and to calculate the likelihood of a cycling collision varied based on the specific analysis conducted. There were several sources of bicycle volume denominator data used to calculate likelihood throughout this study:

1. **Bicycle count data** provided by the City of Vancouver at four locations during 2011: Burrard Bridge, Dunsmuir Viaduct, Hornby Street at Robson Street, and Dunsmuir Street at Seymour Street;

2. **Modelled bicycle volume data** from the Vancouver Cycling Data Model provided by the City of Vancouver. The Cycling Data Model was developed in 2011 and provides an estimate of cycling volumes on designated bikeways as well as arterial streets without bikeway facilities throughout the City based on bicycle counts.

3. **Bicycle trip data** provided by TransLink from the 2011 Metro Vancouver Trip Diary Survey; and

4. **Bicycle injury trip data** collected through the BICE study that recorded the full route taken by each of the 414 participants included in that study.

Further details about the data sources and methodology used to calculate cycling collision likelihood are provided in subsequent sections of this report.

WHERE ANALYSIS INCLUDES:

1. Top Collision Locations
2. Top Collision Corridors
3. Collision & Injury Prone Corridors
4. Neighbourhoods
5. Type of Bikeways
6. Type of Intersections

Collision ***density*** was also calculated based on the length of bikeways or number of intersections.

By including collision likelihood or density wherever possible, the analysis contextualizes the findings of the reported cycling collisions or injury crashes and provides more meaning specific to Vancouver. A definition of each of these terms is provided below:

- **Collision Frequency:** The total absolute number of reported cycling collisions with motor vehicles or cycling injury crashes over a given period of time (collisions/year or collisions/study period).
- **Collision Likelihood:** The number of reported cycling collisions with motor vehicles or cycling injury crashes divided by the bicycling trips, based on one of the four data sources described above (collisions/bicycle trip).
- **Collision Density:** The number of reported cycling collisions or cycling injury crashes divided by the length of the corridor or number of intersections (collisions/km or collisions/intersection).

This section also summarizes where incidents occurred on a neighbourhood-basis throughout the City as well as patterns based on the type of bikeway present, the type of street classification, and the type of intersection traffic control.

4.2 Detailed Findings

4.2.1 Top Collision Locations (Collision Frequency)

Collisions (ICBC)

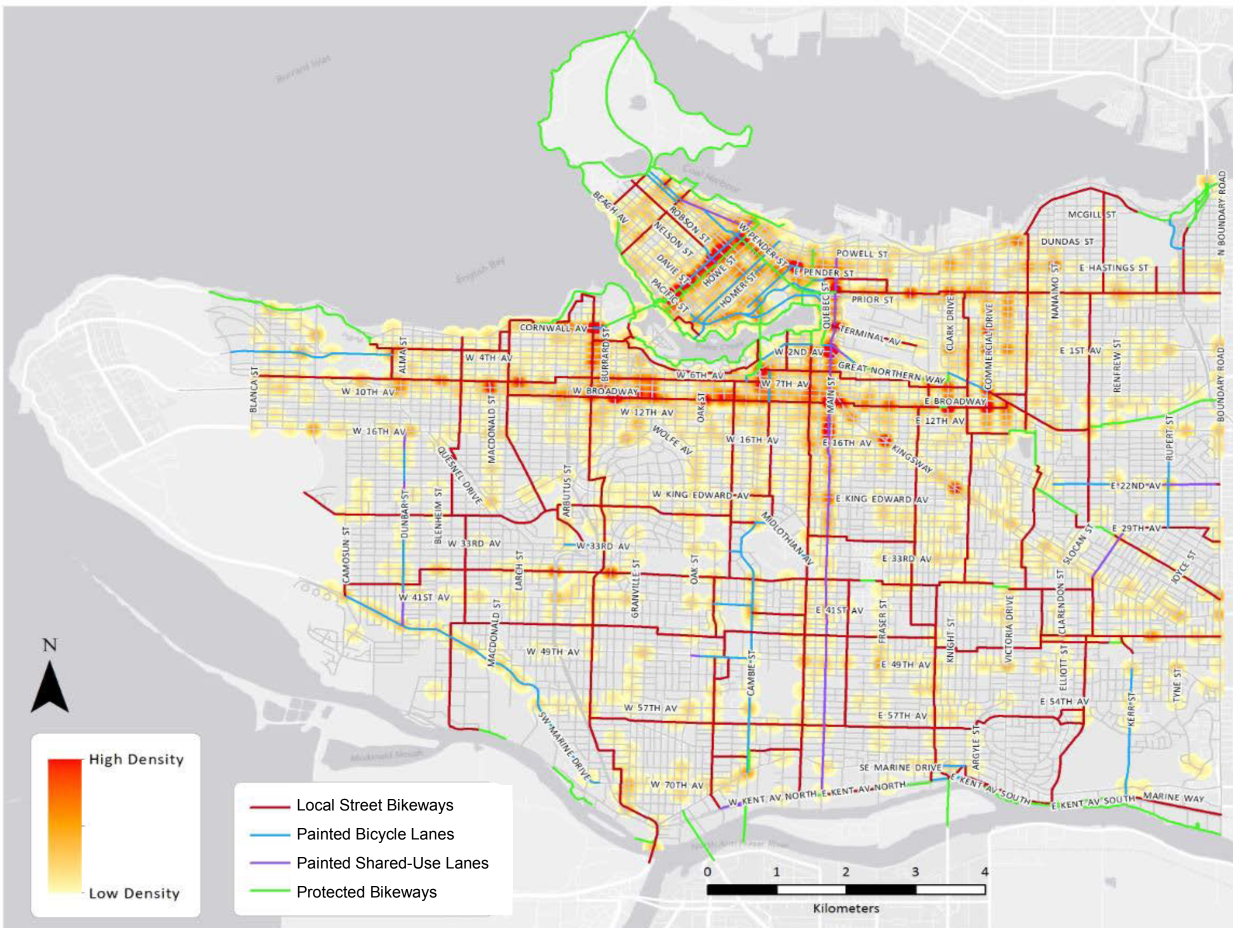
This section describes collision frequency in terms of the spatial distribution of reported cycling collisions between 2007 and 2012. Reported cycling collisions occurred throughout the City, with a high concentration of reported cycling collisions in the Downtown and Metro Core areas in particular. **Figure 4.1** uses a heat map to graphically represent concentrations of reported cycling collisions. Total reported cycling collisions within a 150 metre radius of each cycling collision record were calculated, and the figure shows the resulting range of low to high collision concentration areas. Areas with higher collision concentrations are shown in red and indicate "hot spots" of cycling collision activity. As shown in this figure, there is a high concentration of collisions in the Downtown core and the Metro Core of Vancouver including Burrard Street, Main Street, 10th Avenue, Cypress Street, and Commercial Drive in particular.

However, reported cycling collisions did occur throughout the city, on routes with and without designated bikeways, and at locations throughout Vancouver outside of the City's Downtown and Metro Core.

Figure 4.1

Concentration of Reported Cycling Collisions (2007 – 2012)

Source: ICBC Collision Data (2007-2012)



More detailed cycling collision patterns are shown in **Figure 4.2** and summarized in

Table 4.1, which identifies the locations with the highest number of reported cycling collisions throughout the City, including all locations with a total of ten or more reported cycling collisions.

The 2,994 reported cycling collisions took place at 1,421 locations within the City of Vancouver between 2007 and 2012. However, a relatively small number of locations accounted for a high proportion of reported cycling collisions. Of the 1,421 cycling collision locations throughout the City, only 61 had at least 6 cycling collisions between 2007 and 2012 (equivalent to at least one reported cycling collision per year). The remaining 1,360 collision locations had five or fewer reported cycling collisions over this period (equivalent to less than one collision per year on average). Although these 61 locations only represented 4% of all cycling collision locations, they accounted for 20% of all reported cycling collisions.

The location with the greatest number of reported cycling collisions was Burrard Street at Pacific Street, followed by Main Street at East 2nd Avenue, Clark Drive at East 10th Avenue, Pine Street at West 10th Avenue, and Burrard Street at Davie Street.

Figure 4.2
Frequency of Reported Cycling Collisions (2007 – 2012)
Source: ICBC Collision Data (2007-2012)

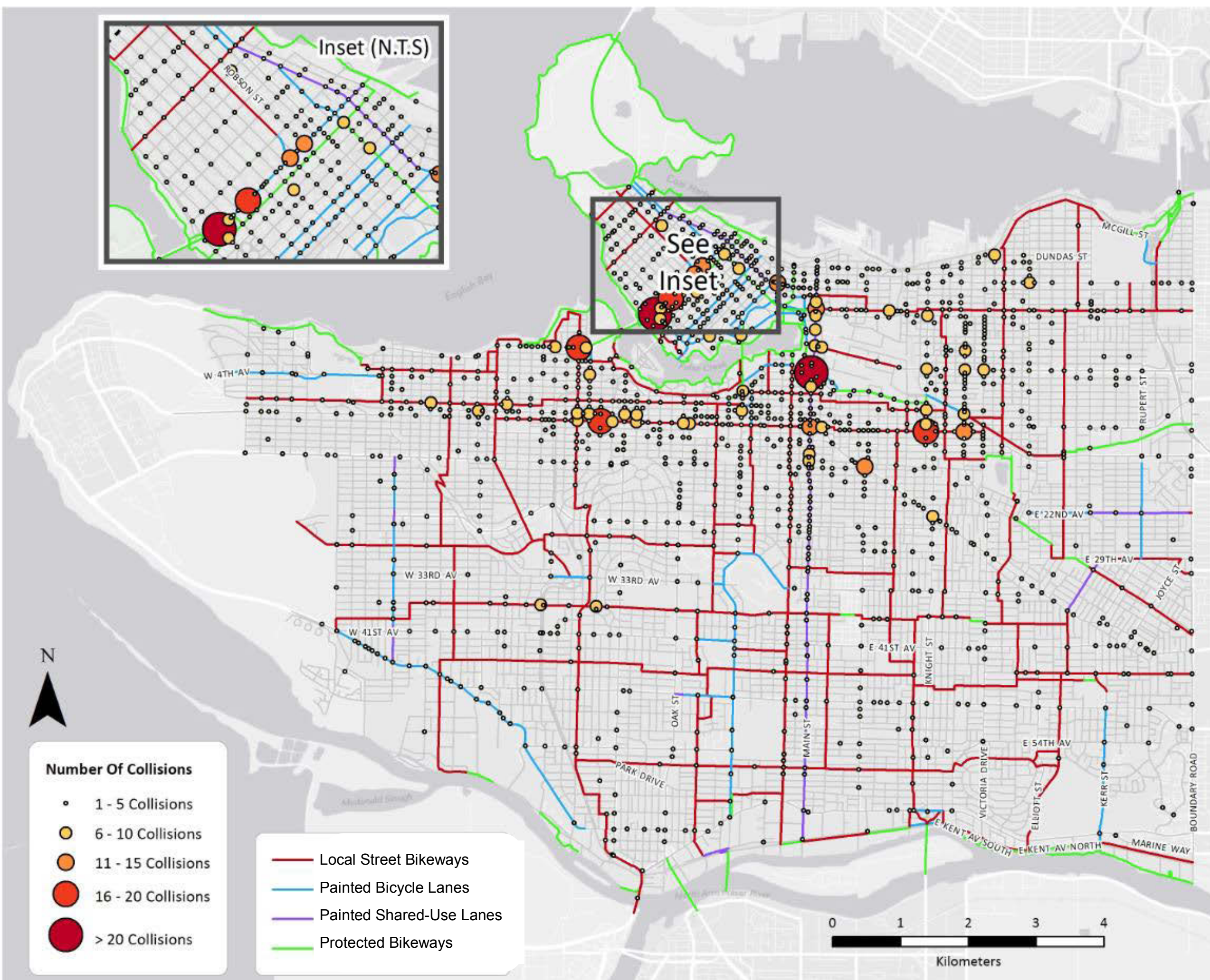


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Table 4.1

Top Reported Cycling Collision Locations (2007 – 2012)

Source: ICBC Collision Data (2007-2012)

Location	Presence of Bicycle Route (on at least one street)	Total Reported Cycling Collisions	Improvements Prior To Or During Cycling Safety Study
Burrard Street Bridge & Pacific Street	✓	37	Physical right turn prevention and green paint added with further improvements in planning stages
Main Street & East 2nd Avenue	✓	22	Green Paint Added
Clark Drive & East 10th Avenue	✓	19	Green Paint Added
Pine Street & West 10th Avenue	✓	17	Traffic Circle Removed
Burrard Street & Davie Street	✓	17	Green Paint Added at Gas Station Driveways
Cornwall Avenue & Cypress Street	✓	16	New Protected Bike Lanes
Main Street & East 10th Avenue	✓	15	Currently Planning Improvements Through Redevelopment
Robson Street & Burrard Street	✓	14	
Commercial Drive & East 10th Avenue	✓	14	
Fraser Street & Kingsway	✗	13	
Main Street & Union Street	✓	13	New Protected Bike Lanes and Intersection Changes
West Pender Street & Abbott Street	✗	13	
Smithe Street & Burrard Street	✓	12	Green Paint Added at Movie Theatre Driveway
West 10th Avenue & Laurel Street	✓	10	
Cornwall Avenue & Burrard Street Bridge	✓	10	Intersection Reconstructed with New Protected Bike Lanes
Main Street & East 14th Avenue	✓	10	
Knight Street & Kingsway	✗	10	
Dunsmuir Street & Hornby Street*	✓	10	Currently Planning Improvement
Commercial Drive & East 1st Avenue	✗	10	

*Note: protected bicycle lanes were implemented in middle of the collision data time period Dunsmuir Street in 2010 and Hornby Street, which was installed in 2010.

Key observations from the top collision locations include:

- Over half (56%) of reported cycling collisions occurred on streets with no designated bikeways.

- Less than half (44%) of reported cycling collisions occurred on streets with designated bikeways. This does not take into account bicycle volumes, and therefore does not reflect the likelihood of a cycling collision. The higher ridership on dedicated bikeways would further decrease the likelihood of a cycling collision on dedicated bikeways.
- Of the reported cycling collisions that occurred on streets with designated bikeways:
    - 53% occurred on a local street bikeway;
    - 22% occurred on a painted bicycle lane;
    - 15% occurred on a shared use lane; and
    - 11% occurred on a protected bicycle lane.

  However, when considering the extent of each type of designated bikeway within the city, cycling collisions were underrepresented on local street bikeways, and overrepresented on all other types of bikeways in the City. Further information regarding the collisions on dedicated bikeways is provided in **Section 4.2.5**.

The City has made significant steps over the past several years to implement changes at many of the top reported cycling collision locations, including intersection reconfigurations, addition of green conflict zone pavement markings, and changes in traffic control devices, as summarized above in
Table 4.1.

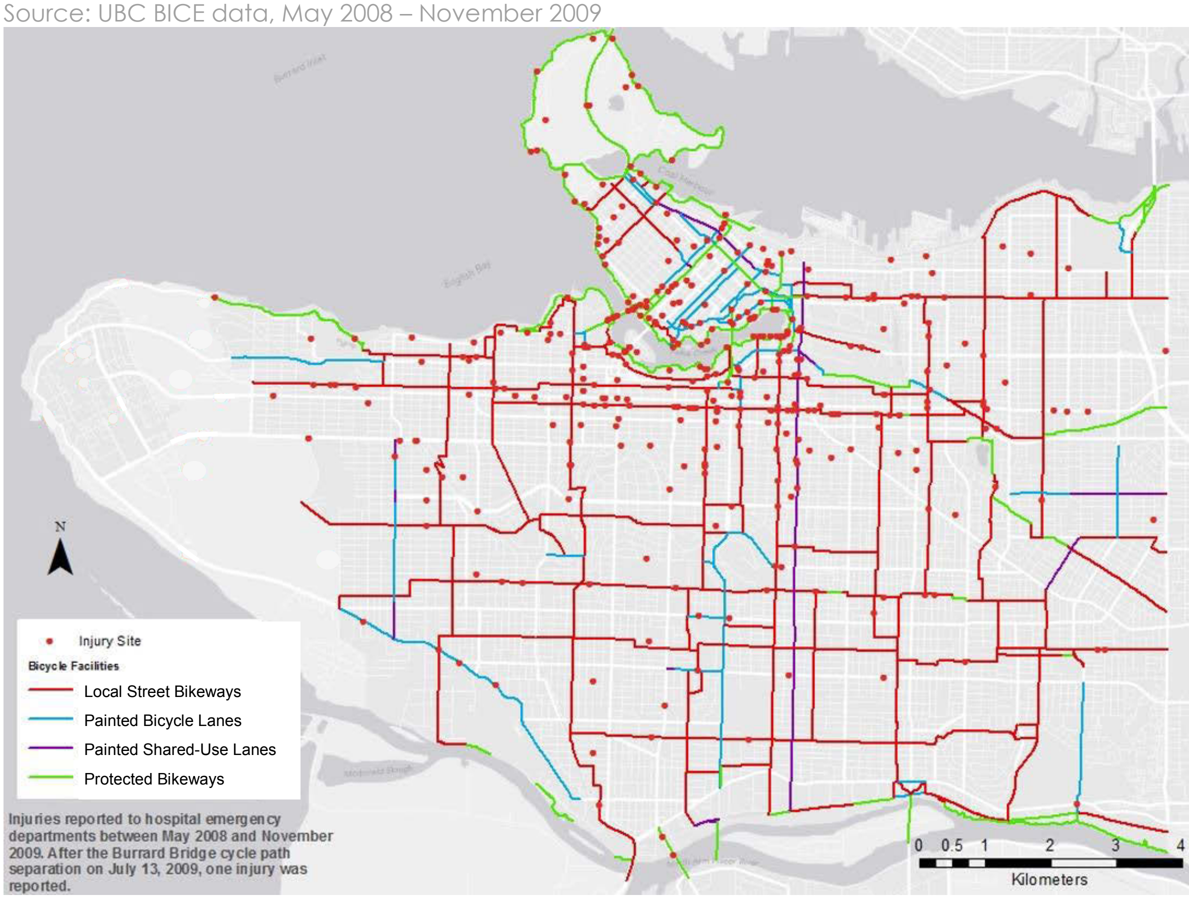
Injuries (BICE)

Data from the BICE study indicates where injuries resulting in treatment at a hospital emergency room occurred – from any type of bicycling injury crash, whether a vehicle was involved or not. Cycling injury crash locations from the BICE study are shown in **Figure 4.3**, with each point representing one cycling injury crash.

The BICE study had a shorter time period (May 2008 – November 2009) than collision data available from ICBC, and also focused only on those cycling injury crashes that resulted in injuries needing hospital treatment. As a result, there are fewer cycling injury crashes in the BICE dataset when compared to reported cycling collisions from the ICBC dataset. The small sample size means there are very few locations with more than one cycling injury crash. As a result, it is more difficult to use the BICE data to discuss high injury crash locations, as was done using the ICBC data. Therefore, the BICE crashes have been discussed as corridors as opposed to specific locations.

As with the ICBC reported cycling collisions, cycling injury crashes were distributed throughout the City. **Figure 4.3** shows an additional feature when all crash types are taken into account – many of the cycling injury crashes occurred on off-street facilities, such as Seawall and in Stanley Park.

Figure 4.3
Location of Cycling Injury Crashes (2008 – 2009)
Source: UBC BICE data, May 2008 – November 2009



Combined Data: Collisions (ICBC) and Injuries (BICE)

Figure 4.4 shows the combined concentration of both reported cycling collisions based on ICBC data and cycling injury crashes based on BICE data when data is taken over the same time period (May 2008 – November 2009). Over this time period, there were 784 collisions (ICBC) and 410 injuries (BICE). This figure provides an overall perspective on where cycling incidents occurred, as it includes both collisions with motor vehicles and injuries resulting from any crash type that required treatment at a hospital emergency room. The benefit of combining reported cycling collision data and cycling injury data is that this identifies common locations of cycling incidents on on-street facilities from both datasets, but also identifies incidents on off-street facilities from the BICE data.

Figure 4.4

Combined Concentration of Reported Cycling Collisions and Injury Crashes (2008 – 2009)

Source: ICBC Collision Data and UBC BICE data (both May 2008 – November 2009)

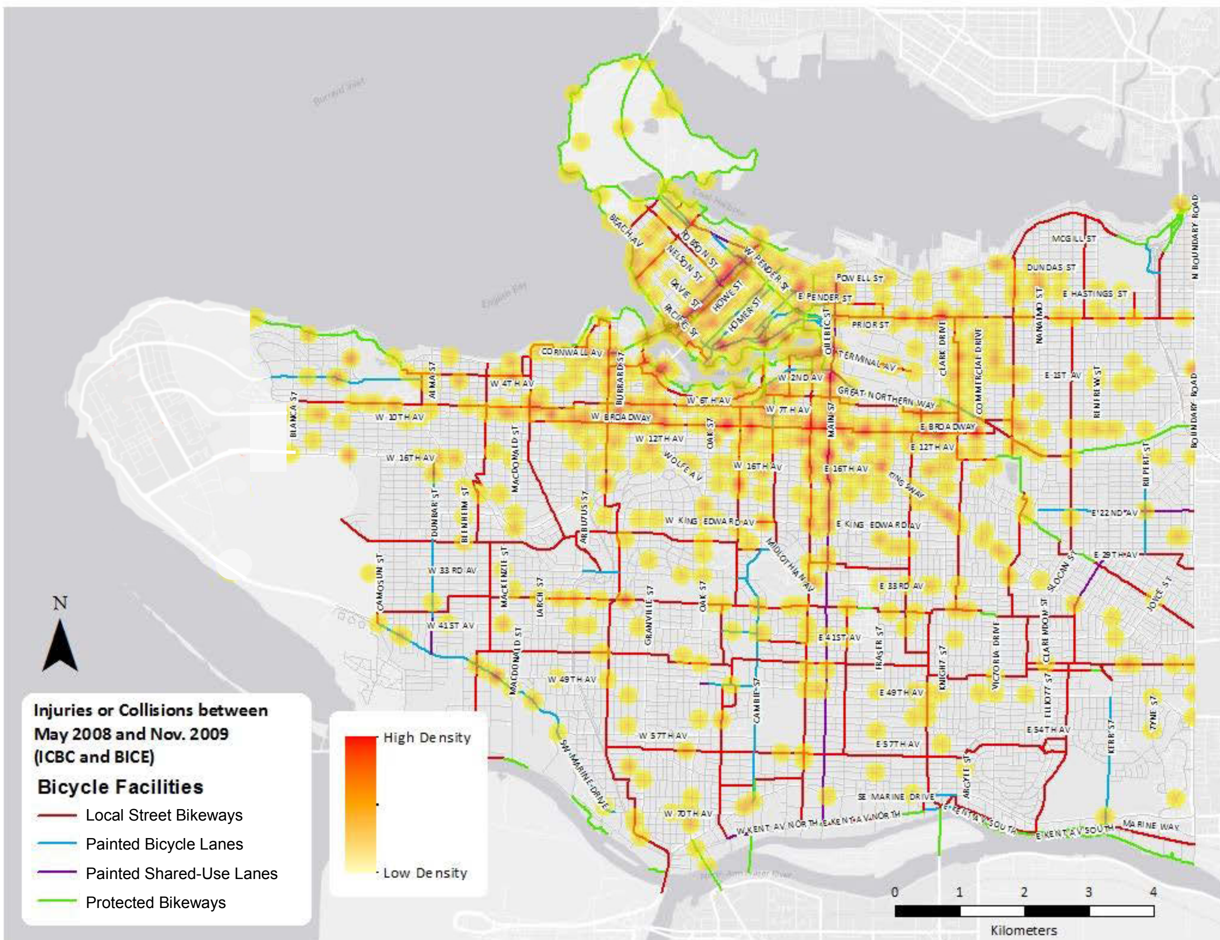
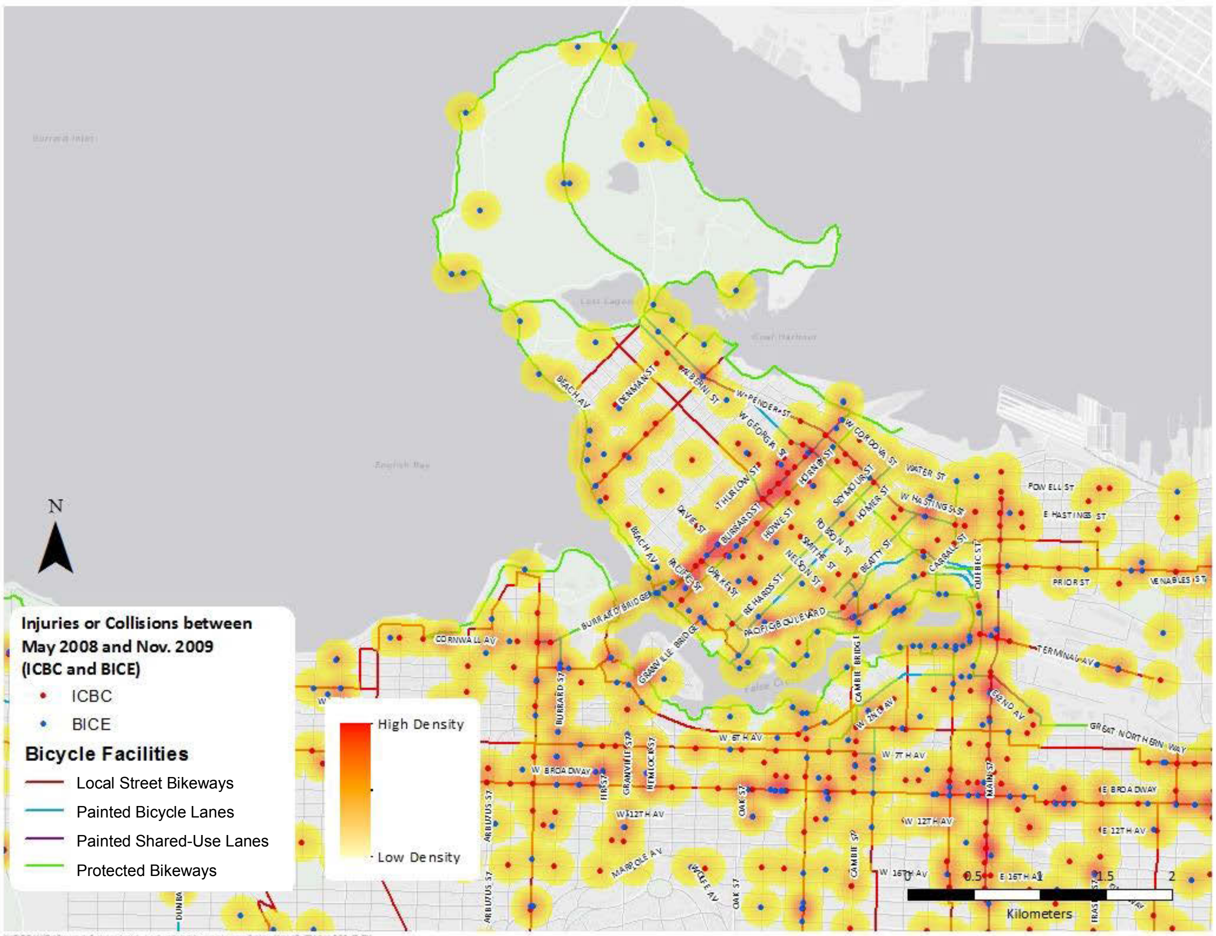


Figure 4.5 provides a more detailed map of **Figure 4.4** by focusing on the Downtown and Metro Core of the City of Vancouver. In this case, the reported cycling collision locations are shown with red points and the cycling injury crashes are shown with blue points. This figure provides additional detail on where both reported cycling collisions and cycling injury crashes occurred and highlights the complementary nature of the two datasets. This figure identifies common concentrations of cycling incidents on on-street facilities from both datasets, such as 10th Avenue and Burrard Street, as well as concentrations of cycling injury crashes along portions of the Seawall, particularly in Southeast False Creek.

Figure 4.5

Combined Concentration of Reported Cycling Collisions and Injury Crashes in Vancouver Metro Core (2008 – 2009)

Source: ICBC Collision Data and UBC BICE data (both May 2008 – November 2009)



4.2.2 Collision Corridors (Collision Frequency and Collision Density)

Collisions (ICBC)

This section summarizes the frequency and density of reported cycling collisions based on corridors within the City. Corridors were defined as streets that were at least 1 kilometre in length and had a high concentration of collisions. For corridors with designated bikeways, the start and end points were defined based on the bicycle facility type. For corridors without designated bikeways, the start and end points were defined based on the collision concentrations. It is recognized, however, that the characteristics and context of the corridors may vary significantly between the start and end points, and the frequency of reported cycling collisions may not be consistent throughout the length of the entire corridor. However, by examining corridors in addition to specific locations, it was possible to identify broader trends beyond specific locations.

The corridors with the highest number of reported cycling collisions are shown in **Table 4.2.** It should be noted that Dunsmuir Street and Hornby Street were not included in this table because protected bicycle lanes were implemented during the period in and resulted in a significant change in before and after conditions. Further details regarding collision patterns on Dunsmuir Street and Hornby Street are found in Section 4.2.5. The highest cycling collision frequencies were found on Main Street, 10th Avenue, Burrard Street, and Broadway. To normalize this data, the collision density (the number of reported cycling collisions per kilometer) was also calculated. By comparing the number of reported cycling collisions with the length of each corridor, different patterns emerged. The highest cycling collision densities were found on Burrard Street, Commercial Drive, Clark Drive, Pacific Street, and Cypress Street.

Table 4.2

Top Reported Cycling Collision Corridors (2007 – 2012)

Source: ICBC Collision Data (2007-2012)

Corridor	Total Reported Cycling Collisions	Corridor Length (km)	Reported Cycling Collisions / Km	Reported Cycling Collisions / Km / year	Improvements Prior To Or During Cycling Safety Study
Burrard Street (West Hastings Street to Harwood Street)	102	1.5	68.9	11.5	Green Paint Added
Commercial Drive (Adanac Street to East 12th Avenue)	84	2.2	38.0	6.3	
Clark Drive (Adanac Street to West 10th Avenue)	58	1.8	32.0	5.3	Green Paint Added
Pacific Street (Hornby Street to Homer Street)	17	0.5	31.5	5.2	
Cypress Street (Cornwall Avenue to West 19th Avenue)	60	2.0	29.9	5.0	Currently under improvement
10th Avenue (Trafalgar Street to Victoria Drive)	213	7.2	29.6	4.9	
Main Street (Powell Street to West Kent Avenue)	206	8.3	24.8	4.1	Green Paint Added
Broadway (Highbury Street to Commercial Drive)	145	8.6	16.9	2.8	
7th Avenue (Yew Street to Yukon Street)	45	3.1	14.6	2.4	
West 8th Avenue (Highbury Street to Yew Street)	28	2.4	11.8	2.0	

4.2.3 Collision Corridors (Collision Likelihood)

The data in the previous sections identified the locations, frequency and density of reported cycling collisions and cycling injury crashes in the City of Vancouver. Many of these incidents occurred on on-street designated bikeways and off-street pathways. This raises the question: Is this because those locations present extra cycling collision likelihood, or are they heavily used cycling routes, resulting in more collisions simply because there are more cyclists?

As noted previously, to understand the likelihood of a collision on a route, the number of collisions at a location needs to be divided by the bicycling trips through that location. Cycling volumes are not available for all locations across the city; however, two types of cycling volume estimates were used to assess collision likelihood along corridors:

- For the ICBC data, modelled bicycle volumes from the Vancouver Cycling Data Model were used. The Cycling Data Model was developed in 2011 and provides an estimate of Annual Average Daily Traffic (AADT) for cycling volumes on designated bikeways as well as arterial streets without bikeway facilities throughout the City based on bicycle counts. However, it should be noted that this data was only available for select locations along select bicycle routes and major roads. There were AADT estimates for bicycle volumes for 1,275 of the 2,814 ICBC collisions (these 1,275 collisions were at 518 unique locations).
- For the BICE data, the full routes of the 414 injured cyclists were recorded and digitally mapped. This information provided the number of injured cyclists who rode on each "segment" (typically a block) of all 414 routes. These were used as cycling volumes to map and visualize likelihood of a cycling injury crash on each specific segment (corridor) for the BICE data. Likelihood calculations were conducted only for segments travelled by at least five cyclists.

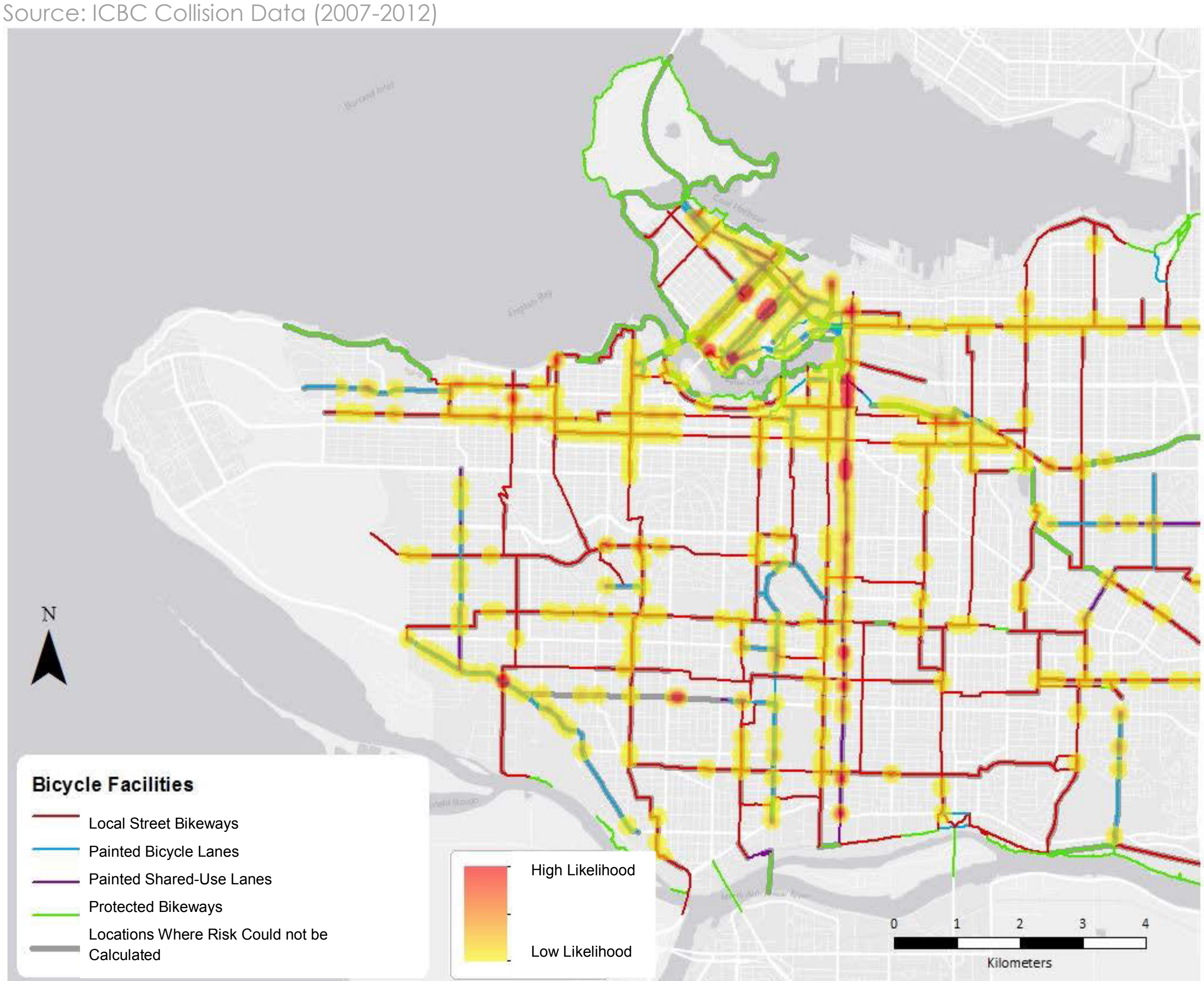
Collisions (ICBC)

The likelihood of a reported cycling collisions based on ICBC data is shown in **Figure 4.6.** The highest collision likelihoods are in red and the lowest in yellow. The areas with the highest likelihood of cycling collisions involving motor vehicles included:

- Sections of Main Street (between 2nd Avenue and 7th Avenue, and between 10th Avenue and 12th Avenue);
- Sections of Pacific Avenue (between Burrard Street and Drake Street); and
- Burrard Street near Robson Street.

Several other corridors which showed higher frequency of cycling collisions in **Figure 4.2** (such as Adanac Street and Ontario Street) did not show a higher likelihood of collisions, suggesting that the higher cycling collision frequency corresponded to the higher cycling volumes on these corridors. This analysis suggests that major streets may have both a high frequency and high likelihood of collisions with motor vehicles, whereas certain local street bikeway routes may show a high number but not necessarily a high likelihood of collision with a motor vehicle for any given bicycle user along the corridor.

Figure 4.6
Cycling Collision Likelihood (2007 – 2012)
Source: ICBC Collision Data (2007-2012)



Injuries (BICE)

The relative likelihood of a cycling injury crash along streets and off-street pathways based on the BICE data is shown in **Figure 4.7**. It should be noted that this figure does not represent the overall likelihood of any bicycle user being injured on a given street or off-street pathway, but instead only indicates the relative likelihood that one of the participants in the BICE study was injured while cycling at that specific location. The highest cycling injury crash likelihoods are shown in red and the lowest in yellow. As noted previously, likelihood calculations for cycling injury crashes were conducted only for segments travelled by at least five cyclists. As a result, because of the low sample sizes of denominator data, most locations are not assigned a colour, meaning no injury likelihood could be calculated based on available data.

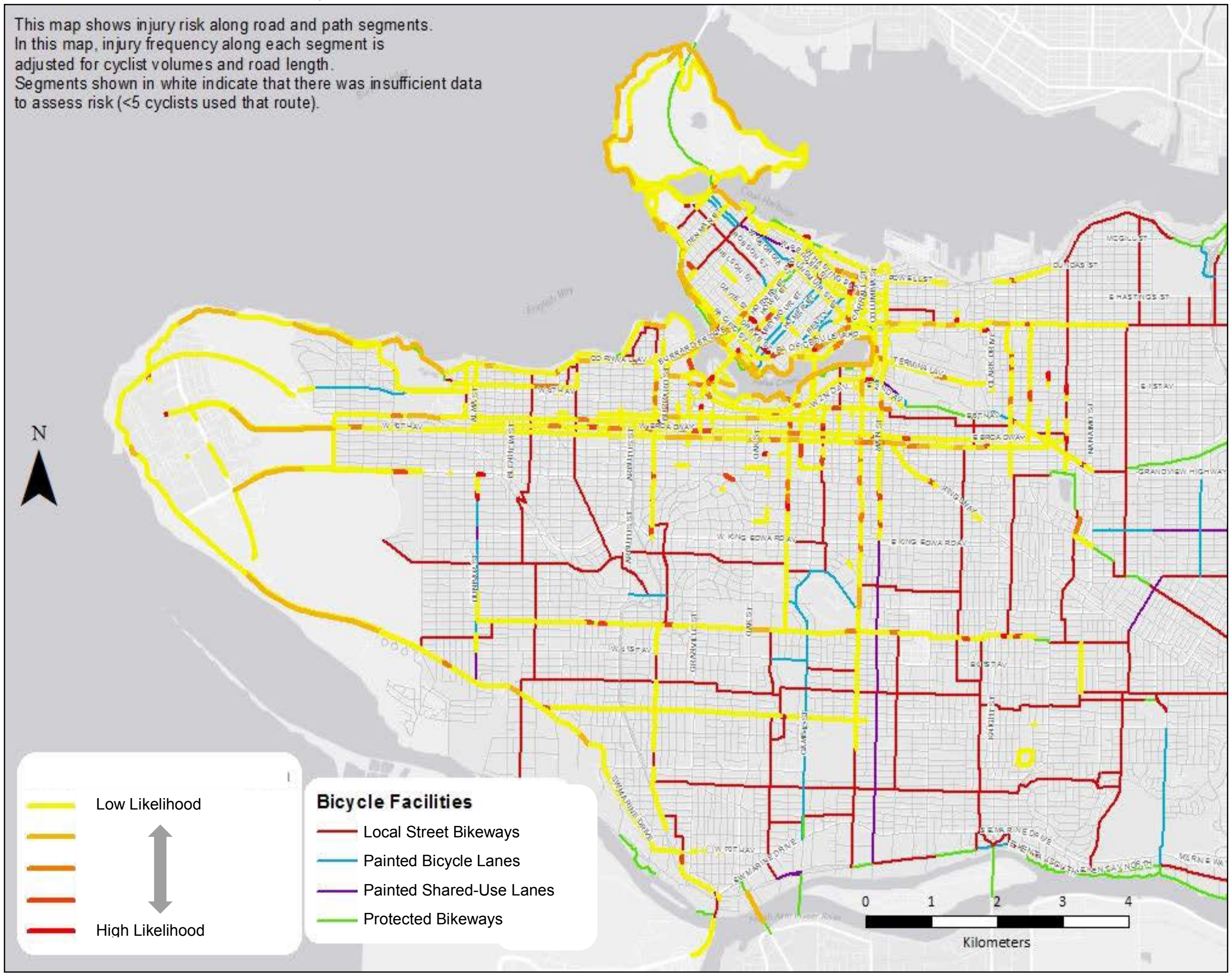
Figure 4.7 shows that some of the locations with a high number of cycling injury crashes also had a higher injury likelihood, including:

- A portion of the Seawall next to the Plaza of Nations;
- 10th Avenue between Cambie Street and Oak Street;
- 10th Avenue between Main Street and Cambie Street;
- Heather Street between 16th Avenue and 20th Avenue;
- Main Street between 16th Avenue and King Edward Avenue.

Because these locations had both high numbers of cycling injury crashes, and a high likelihood of cycling injury, they merit attention.

It is also noteworthy that there were many other segments distributed throughout the City which also had increased cycling injury crash likelihood. There are a number of potential reasons for this, which could include increased injury likelihood at those specific locations, or it could be because of increased injury likelihood on the type of bikeway or due to a lack of bikeway at a particular location. The relationship between type of bikeways and collisions will be discussed in further detail below.

Figure 4.7
Cycling Injury Crash Likelihood (2008 – 2009)
Source: UBC BICE data, May 2008 – November 2009

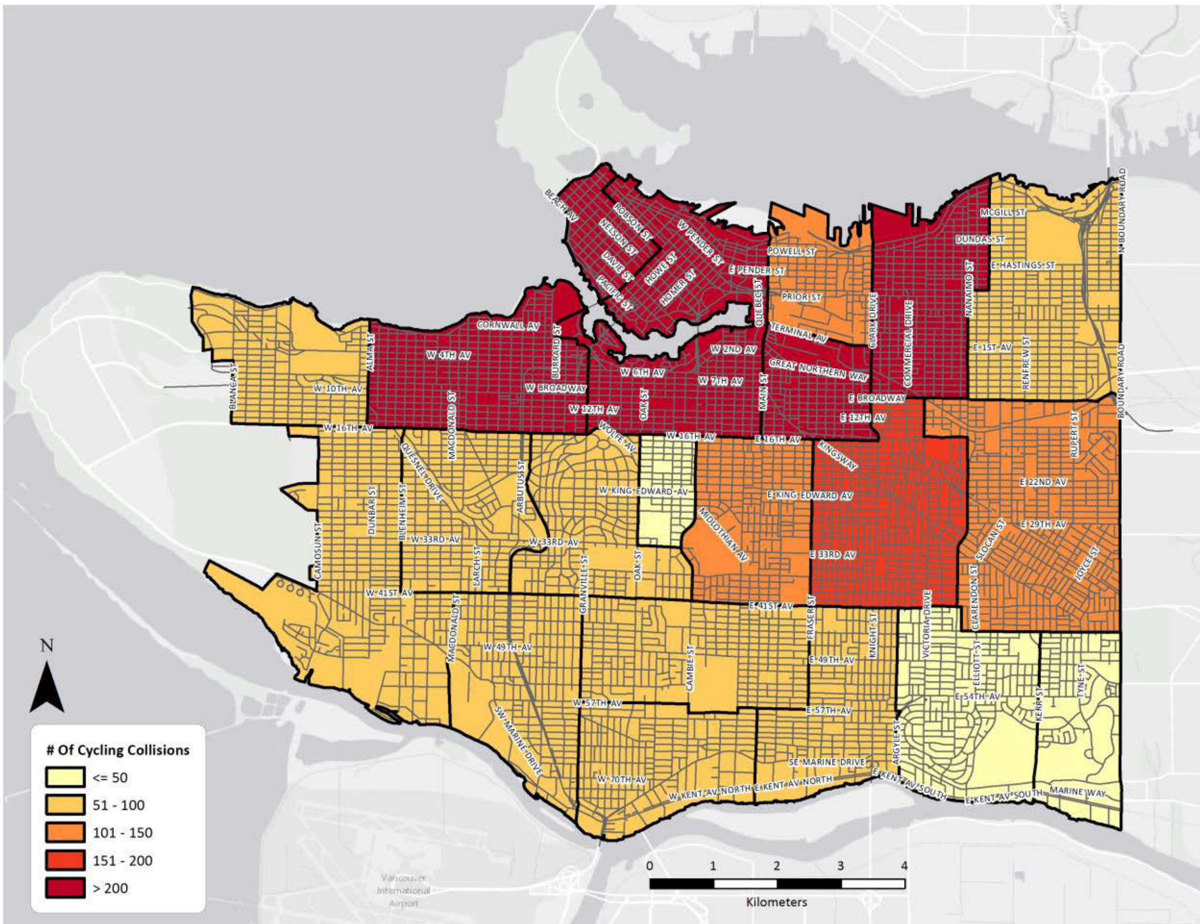


4.2.4 Neighbourhoods

Collisions (ICBC)

When looking at the frequency of reported cycling collisions by neighbourhood, the Downtown core experienced the highest total number over the past six years (as shown in **Figure 4.8**). More than 16% of reported cycling collisions occurred in the Downtown core, followed by Mount Pleasant with more than 12%.

Figure 4.8
Frequency of Reported Cycling Collisions by Neighbourhood (2007 – 2012)
Source: ICBC Collision Data (2007-2012)



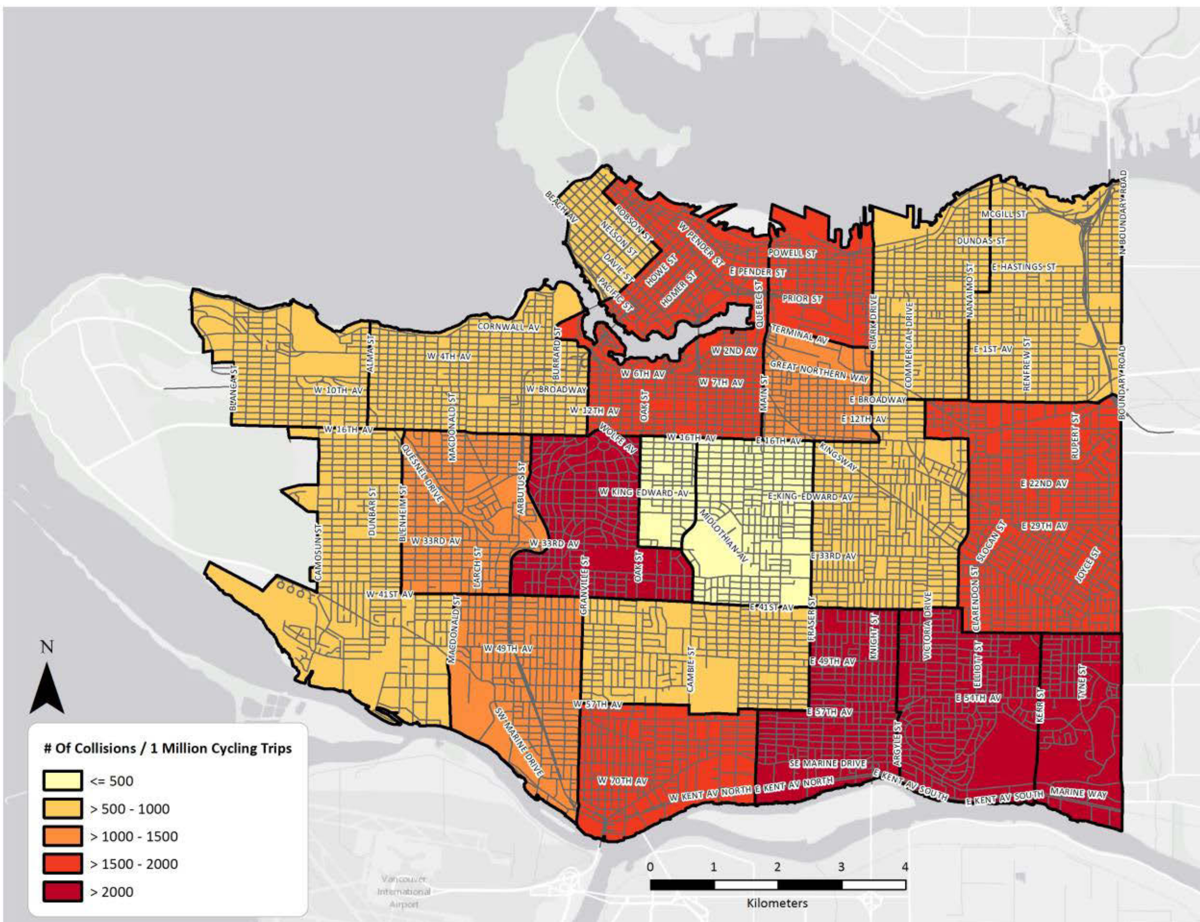
To show the likelihood of a reported cycling collision by neighbourhood, the number of bicycle trips originating from each neighbourhood was used (based on data from the 2011 National Household Survey). The cycling collision rate per million bicycle trips was also calculated for each neighbourhood based on the cycling mode share and employed labour force in each neighbourhood, as previously described in **Section 2.2**. This was the best data available to understand cycling patterns by neighbourhood.

This cycling collision rate shows a different pattern than the frequency of reported cycling collisions discussed above. The City's Downtown Core and much of the Metro Core retained moderate collision likelihoods. However, **Figure 4.9** shows that the neighbourhoods with the highest cycling collision likelihoods were Sunset, Shaughnessy, Victoria-Fraserview and Killarney. This suggests that the neighbourhoods with the lowest levels of cycling had the highest cycling collision likelihood. This is consistent with the phenomenon of "safety in numbers", which is based on research that has found that in neighbourhoods where there is less cycling there is a higher likelihood of injury. It is also worth noting that these neighbourhoods also have less bicycle infrastructure than many other neighbourhoods throughout the City, as measured by density of existing bikeways for each neighbourhood.

Figure 4.9

Total Cycling Collisions per 1,000,000 Bicycle Trips by Neighbourhood (2007 – 2012)

Source: ICBC Collision Data (2007-2012), Statistics Canada 2011 NHS



4.2.5 Type of Bikeway

There are a range of types of on-street and off-street bicycle facilities in the City of Vancouver. Streets that have bicycle infrastructure are referred to throughout this report as "designated bikeways." There are a range of types of designated bikeways defined for this study, as described below:

1. **Protected bicycle lanes**, also referred to as cycle tracks, are on-street facilities physically separated from motor vehicles and from pedestrians on the sidewalk. Protected bicycle lanes can be elevated or protected by a curb, median, and/or bollards.
2. **Painted bicycle lanes** are on-street travel lanes designated for bicycles. They are identified with a white line and a bicycle symbol. Painted bicycle lanes can be located on streets with on-street parking or without on-street parking.
3. **Shared use lanes** are on-street travel lanes denoted by the use of a "sharrow" pavement marking to indicate that this is a shared space. Bicycles and motorists have to share the lane.
4. **Local street bikeways** are on-street shared facilities, typically located on local streets with lower traffic volumes and are designated routes for cyclists, often with some form of traffic calming.
5. **Off-street bicycle-only pathways** are off-street pathways that provide separate pathways for pedestrians and cyclists.
6. **Off-street multi-use pathways** are off-street pathways where pedestrians, cyclists and other users share the same travel space.

Streets without bicycle infrastructure are referred to as "non-designated bikeways." Non-designated bikeways defined for this study include:

1. **Arterial streets** with no bicycle facility.
2. **Collector streets** with no bicycle facility.
3. **Local streets** with no bicycle facility.
4. **Sidewalks** are paved pathways that are located on the side of the road. They are designated space for pedestrians are not legal for the use of cyclists unless otherwise noted. Although not a bicycle facility, the study found that some cyclists may use sidewalks.

Collisions (ICBC)

As shown in **Table 4.3**, the majority (56%) of reported cycling collisions between 2007 and 2012 were on streets without designated bikeways. The majority of these occurred on arterial streets.

Less than half (44%) of reported cycling collisions occurred on streets with designated bikeways. Approximately half of these collisions occurred on a local street bikeway. This is not indicative of the likelihood of a collision on a designated bikeway, as the number has not been adjusted to reflect the number of cyclists on these facilities because that information was not available for each type of designated bikeway. Therefore, it is important to note that these are absolute numbers, and while it is assumed that there are more cyclists on designated bikeways than streets without designated bikeways, the numbers here could not be normalized to confirm that assumption.

Table 4.3
Reported Cycling Collisions on Routes With and Without Bikeways (2007 – 2012)
Source: ICBC Collision Data (2007-2012)

Bikeway	Midblock		Intersection		Total	
	#	%	#	%	#	%
Local Street Bikeway	214	17%	435	27%	649	23%
Painted Bicycle Lane	132	11%	135	9%	267	10%
Shared Use Lane	84	7%	102	6%	186	7%
Protected Bicycle Lane	43	4%	90	6%	133	5%
Total Designated Bikeway	**473**	**39%**	**762**	**48%**	**1235**	**44%**
Arterial	577	47%	545	34%	1122	40%
Collector	7	1%	20	1%	27	1%
Local	171	14%	260	16%	431	15%
Total Non-Designated	**755**	**61%**	**825**	**52%**	**1580**	**56%**

As noted previously, bicycle volume data was not available for each of the different types of bicycle facilities, and as such, collision likelihood by facility type could not be calculated. However, the collision data by facility type was normalized by the length of each type of facility to compare collision frequency with the collision density between the different types of designated bikeways. As such, a comparison was done which looked at the total length of each type of bikeway in the City's bicycle network and compared this to the total reported cycling collisions on each type of bikeway. As shown in **Table 4.4**, although local street bikeways accounted for the majority of reported cycling collisions, they also make up nearly three quarters of the City's bicycle network. As such, local street bikeways have a lower proportion of collisions compared to their length. In contrast, shared use lanes, painted bicycle lanes, and protected bicycle lanes all had higher proportions of collisions compared to their length.

Table 4.4
Reported Cycling Collisions on Designated Bikeways (2007 – 2012)
Source: ICBC Collision Data (2007-2012)

Bikeway	Total Length	Total Reported Collisions	Ratio of Collision/Length
Local Street Bikeway	72%	52.5%	0.74
Painted Bicycle Lane	19%	21.6%	1.16
Shared Use Lane	6%	15.1%	2.50
Protected Bicycle Lane	3%	10.8%	3.67

To help explain the higher than expected proportion of total reported cycling collisions on protected bicycle lanes, a detailed corridor analysis was conducted for the City's downtown protected bicycle lanes on Dunsmuir Street and Hornby Street.

Between 2007 and 2012, there were a total of 30 reported cycling collisions on Dunsmuir Street. Prior to 2010, Dunsmuir Street consisted of painted bicycle lanes. These were changed to bi-directional protected bicycle lanes in 2010. Between 2010 and 2012, there were 23 reported cycling collisions on Dunsmuir Street, indicating an increase in the number of cycling collisions after the new facilities were installed, which is likely due to the increased ridership along Dunsmuir Street. There are a number of right turn restrictions and signs indicating that motor vehicles travelling west along Dunsmuir Street are prohibited from turning right or must yield to bicycle users prior to making a right turn. Despite this, 15 collisions occurred as a result of a vehicle turning right and colliding with a bicycle user in locations with right turning restrictions or signage providing bicycle users with the right of way.

There were 14 collisions on Hornby Street between Hastings Street and Beach Avenue between 2007 and 2012. Hornby Street also had protected bicycle facilities installed in 2010. Since 2010, when the protected facilities were installed, there have been four collisions on Hornby Street.

A review of the collisions along these two routes based on the turning restrictions and intersection control is shown in **Table 4.5.** As shown, the most common occurrence of collisions was on Dunsmuir Street where right turn movements are prohibited for motor vehicles. One of these also occurred on Hornby Street when a vehicle making an illegal right turn collided with the cyclist. The second most common type of collision was at intersections where there was a right turn yield to bicycles sign (8 on Dunsmuir Street and 2 on Hornby Street). Based on this analysis, collisions were occurring when motor vehicles were making prohibited right turns and failing to yield to bicycles when required. It also showed that intersections with dedicated bicycle signals appear to be the safest intersections.

Table 4.5

Cycling Collisions on Dunsmuir Street and Hornby Street Based on Turning Restrictions (2010 – 2012)

Source: ICBC Collision Data (2010-2012)

Turning Restrictions	Dunsmuir (2010 -2012)		Hornby (2010 – 2012)		Total	
	Intersection	Collision	Intersection	Collision	Intersection	Collision
Right turn prohibited for motor vehicles	5	13	2	1	7	14
Protected Bicycle Signal	-	-	6	0	6	0
Right turn yield to bicycle users (with right turn lane)	4	8	3	2	7	10
All movements permitted	1	2	-	-	1	2
No Signal	-	-	1	1	1	1
Total	**10**	**23**	**12**	**4**	**22**	**27**

Injuries (BICE)

Cycling injury crash data was also classified according to the type of bikeway (as shown in **Table 4.6**), including off-street pathways, which would be unlikely to involve collisions with motor vehicles. Similar to the ICBC collision data, nearly half (48%) of all cycling injury crashes occurred at locations without designated bikeways. Most of these were on arterial or collector streets.

The other half (53%) of cycling injury crashes occurred on a variety of designated bikeways, including painted bicycle lanes, shared use lanes, local street bikeways, multi-use pathways, and bicycle-only paths. The bikeways with the most injury crashes were local street bikeways and multi-use pathways. None of the injuries at intersections occurred on protected bicycle lanes, off-street bicycle-only pathways, or off-street multi-use pathways, although it should be noted that intersections are less common on these types of bikeways.

It is important to note that the only protected bicycle lanes that were included in the BICE study were the Carrall Street Greenway, Burrard Bridge, and small segments of protected bicycle facilities along Great Northern Way/Grandview Highway, Beach Avenue, and Stanley Park Drive. The criteria set by the BICE study for classification as a protected bicycle lane were that the facility must be: exactly parallel to the road, within 3 metres of the road, and physically separated from motor vehicle traffic and from any sidewalk.

In the five years since 2009, the City has constructed protected bicycle lanes in many other locations including the Dunsmuir Viaduct, Dunsmuir Street, Hornby Street, Hastings Street, Burrard Street, Helmcken Street, Comox Street, Ontario Street, Cornwall Avenue, York Avenue and Point Grey Road.

The National Association of City Transportation Officials (NACTO) defines a protected bicycle lane, or cycle track, as an exclusive bicycle facility that combines the user experience of a separated pathway with the on-street infrastructure of a conventional bicycle lane. A cycle track is physically separated from motor traffic and distinct from the sidewalk.

The facilities that were defined as protected bicycle lanes at the time of the BICE study, including the Burrard Bridge and Stanley Park Drive, have no or very few intersections along their length, including the Burrard Bridge which only has intersections at its start and end points, and also do not all satisfy the definition of a protected bicycle lane provided by NACTO. The types of separated bicycle lanes that the City of Vancouver has constructed since the time of the BICE study, are very different than those that were included in the BICE study, and have generally been constructed in areas with high concentrations of intersections. As such, the results of the cycling injury crash analysis on protected bicycle lanes from the BICE data should be interpreted with caution, as they do not necessarily reflect the typical characteristics of protected bicycle lanes that have been constructed in the City of Vancouver since the time of the BICE study, nor do they all necessarily reflect the City of Vancouver's definition of what constitutes a separated bicycle lane.

The numbers of injuries by bikeway type in **Table 4.6** indicate only the frequency of incidents. They do not indicate whether the numbers of injuries on certain routes were higher because there were more bicyclists or because there was an increased danger along that type of bikeway. One of the main uses of the BICE data was to understand the likelihood of injury by bikeway type and other infrastructure characteristics. This was conducted by comparing the injury sites to randomly selected control sites that were located along the trip.

Table 4.6
Cycling Injury Crash Locations on Routes With & Without Bikeways (2008 – 2009)
Source: UBC BICE data, May 2008 – November 2009

	Percent & Number of Cyclist Injuries by Location			
Bikeway	Midblock %	Intersection %*	Total #	Total %
Local Street Bikeway	12.9%	10.9%	98	23.8%
Off-Street Multi-use Pathway	12.9%	0%	53	12.9%
Painted Bicycle Lane	3.2%	2.7%	24	5.9%
Off-Street Bicycle Only Pathway	5.1%	0%	21	5.1%
Shared Use Lane	2.9%	1.5%	18	4.4%
Protected Bicycle Lane	0.5%	0%	2	0.5%
Total Designated Bikeway	**37.5%**	**15.1%**	**216**	**52.6%**
Arterial/Collector	12.6%	8.3%	86	20.9%
Local	9.5%	7.0%	68	16.5%
Sidewalk	7.5%	2.7%	42	10.2%
Total Non-Designated	**29.6%**	**18.0%**	**196**	**47.6%**

* Note: Intersections could involve more than one route type. Where this happened, they were classified according to the route type that the cyclist was arriving from. The following provides additional detail on the intersection crashes involving more than one route type:

- 45 intersection crashes (10.9% of all crashes) were attributed to local street bikeways; of these, 16 were at intersections of the local street bikeway with an arterial or collector (3.9% of all crashes).
- 29 intersection crashes were attributed to local streets (7.0% of all crashes); of these, 14 were at intersections of the local street with an arterial or collector (3.4% of all crashes).

While **Table 4.6** shows the frequency of injury collisions in terms of absolute numbers and percentages, **Figure 4.10** illustrates the relative likelihood of an injury crash by bikeway and street type, ranking them from lowest to highest likelihood. Some bikeway types with a higher frequency of injury crashes also had a high likelihood of injury crashes, and therefore merit particular attention, including arterial and collector streets, off-street multi-use pathways, and sidewalks. In contrast, some bikeway types with a high frequency of injury crashes had a low injury crash likelihood, which suggests that the high numbers of collisions simply meant these were popular bikeway types for cyclists. These included local street bikeways and local streets with no dedicated bikeways. Several other bikeway types had both low frequency and likelihood of injury crashes, including protected bicycle lanes and off-street bicycle-only paths. Painted bicycle lanes were an interesting case, as they had low injury crash likelihood where there were no parked cars, but where the bicycle lane put bicycle users between parked and moving cars, crash likelihood was much higher.

Figure 4.10

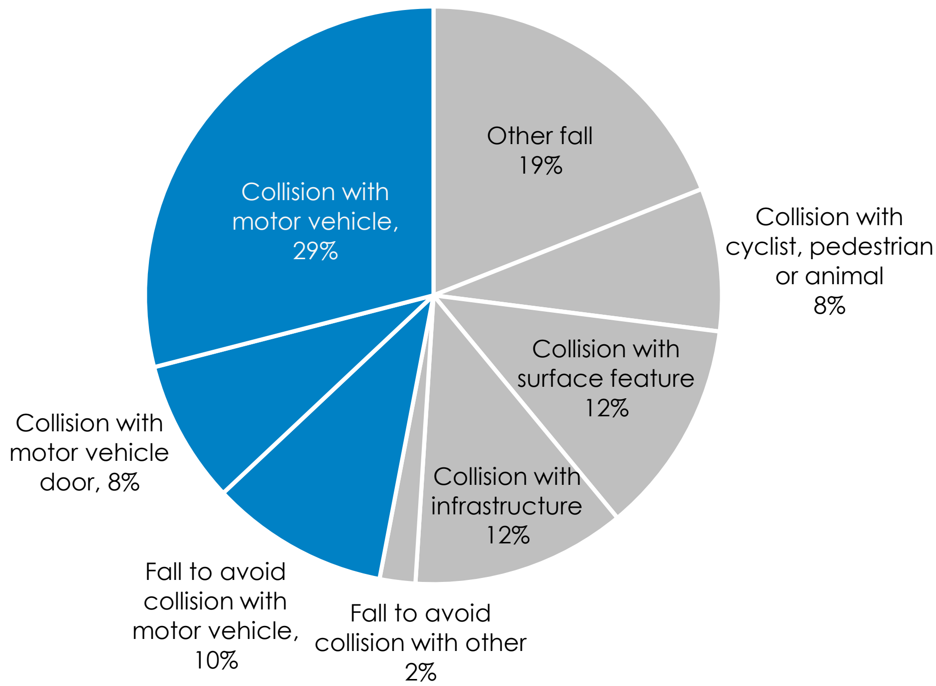
Relative Likelihood of a Cycling Injury Crash by Bikeway and Street Type (2008 – 2009)

Source: UBC BICE data, May 2008 – November 2009

Both the frequency and likelihood of injury crashes were high on downhill slopes (230 crashes, 56%). This was also the case where there was construction present (51 crashes, 12%). In addition, although there were few injury crashes at train tracks (11 crashes, 2.7%), the likelihood of injury crashes at train tracks was high, meaning that on the rare occasions that bicycle users in Vancouver encountered tracks they presented an increased likelihood of a crash, either by slipping on the rail surface or having a wheel caught in the track. Most injury crashes with train tracks occurred on private roads on Granville Island. Approximately half of the injury crashes at rail tracks were "caught in track" crashes, while the other half were "slipped on rail" crashes.

The BICE study also classified the types of injury crashes. As shown in **Figure 4.11**, 37% of injury crashes were direct collisions with motor vehicles, and another 10% resulted from manoeuvres to avoid a motor vehicle collision. Other collisions involved mainly infrastructure (e.g., bollards, furniture, curbs, fences, speed bumps, stairs) and surface features (bumps, potholes, gravel, leaves, train tracks, roots, icy or wet surfaces), although some crashes involved other cyclists, pedestrians or animals.

Figure 4.11
Types of Cycling injury Crashes (2008 – 2009)
Source: UBC BICE data, May 2008 – November 2009



The BICE data also identified which types of injury crashes were more common on the different types of streets and bikeways. As outlined in **Figure 4.12**, motor vehicle collisions and doorings were over-represented on arterials and collectors with parked cars. Collisions with infrastructure, surfaces, and other route users were more common on sidewalks, multi-use pathways, and bicycle-only pathways.

Figure 4.12
Unusually Frequent Types of Cycling Injury Crashes by Street and Bikeway Type (2008 – 2009)
Source: UBC BICE data, May 2008 – November 2009

	Collision					Fall	
	Motor vehicle (except dooring)	Motor vehicle dooring	Infra-structure	Surface	Pedestrian cyclist or animal	Fall to avoid collision	Other fall
Arterial or collector, with parked cars							
No bike infrastructure	●	●					
Shared lane	●	●				●	
Bike lane	●	●					
Arterial or collector, no parked cars							
No bike infrastructure							
Shared lane						●	
Bike lane							
Local street							
No bike infrastructure							
Bikeway							
Bikeway, with traffic calming						●	
Separated from traffic							
Sidewalk			●	●		●	
Multiuse path, paved			●		●	●	
Multiuse path, unpaved				●			
Bike path			●		●		
Separated bike lane							

● = Unusually frequent type of injury crash at this bicycle facility type

4.2.6 Type of Intersection

Collisions (ICBC)

Intersections accounted for 50.5% (1,421) of all reported cycling collisions between 2007 and 2012. Of these, signalized intersections accounted for nearly half (48%) of all reported intersection collisions, including 35% at full traffic signals and 13% at pedestrian and cyclist activated half signals (as seen in **Figure 4.13**).

Table 4.7 illustrates the collision density at intersections by comparing the total number of each type of traffic control in the City with the number of collisions at each. This emphasizes the fact that the largest proportion of collisions occur at full traffic signals.

It is also important to note the type of collisions occurring at two-way stop locations. Collisions at two-way stops involving all motor vehicle turning movements (right turns, left turns, and straight motor vehicle movements) accounted for 31% of all collisions (as seen in **Figure 4.13)**. Based on the ICBC collision reports, where the right-of-way could be established, the majority (63%) of collisions were a result of the vehicle not stopping at the stop sign while the bicycle users had the right-of-way (was on the major street that did not have the stop sign).

Figure 4.13
Reported Cycling Collisions at Intersections by Type of Traffic Control (2007 – 2012)
Source: ICBC Collision Data (2007-2012)

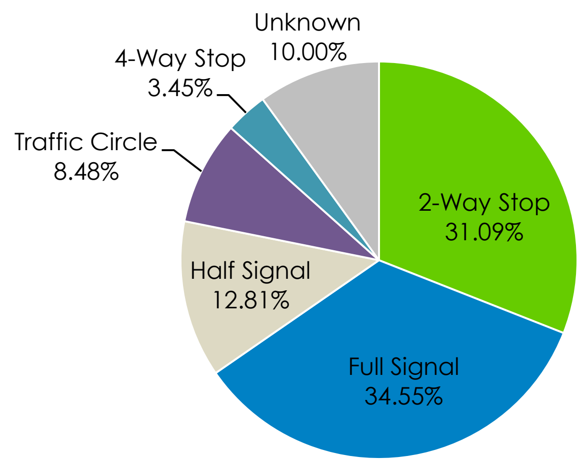


Table 4.7
Reported Cycling Collisions at Intersections by Type of Traffic Control (2007 – 2012)
Source: ICBC Collision Data (2007-2012)

Intersection Control	Total Intersections		Cycling Intersection Collisions	
	#	%	#	%
Full Traffic Signal	466	3.6%	549	35%
Half Signal	343	2.6%	197	13%
Traffic Circle	270	2.1%	136	9%
Stop Sign (2-way or 4-way)	Approx. 12,000	92.3%	565	38%
Unknown	n/a	n/a	64	5%
Total	Approx. 13,000	100%	1587	100%

Since different types of intersection traffic controls are used along different types of bikeways, it is useful to understand this relationship. **Figure 4.14** shows reported cycling collisions with motor vehicles based on intersection traffic control and bikeway type. Key observations include:

- Just over half of all collisions at intersections occur on non-designated bikeways;
- Along streets with no designated bikeways, the majority of collisions at intersections occurred at two-way stops (40%) and full signals (38%);

- Along local street bikeways, 32% of intersections collisions were at two-way stops and 25% were at traffic circles; and
- On painted bicycle lanes, shared use lanes, and protected bicycle lanes, most collisions at intersections occurred at full traffic signals.

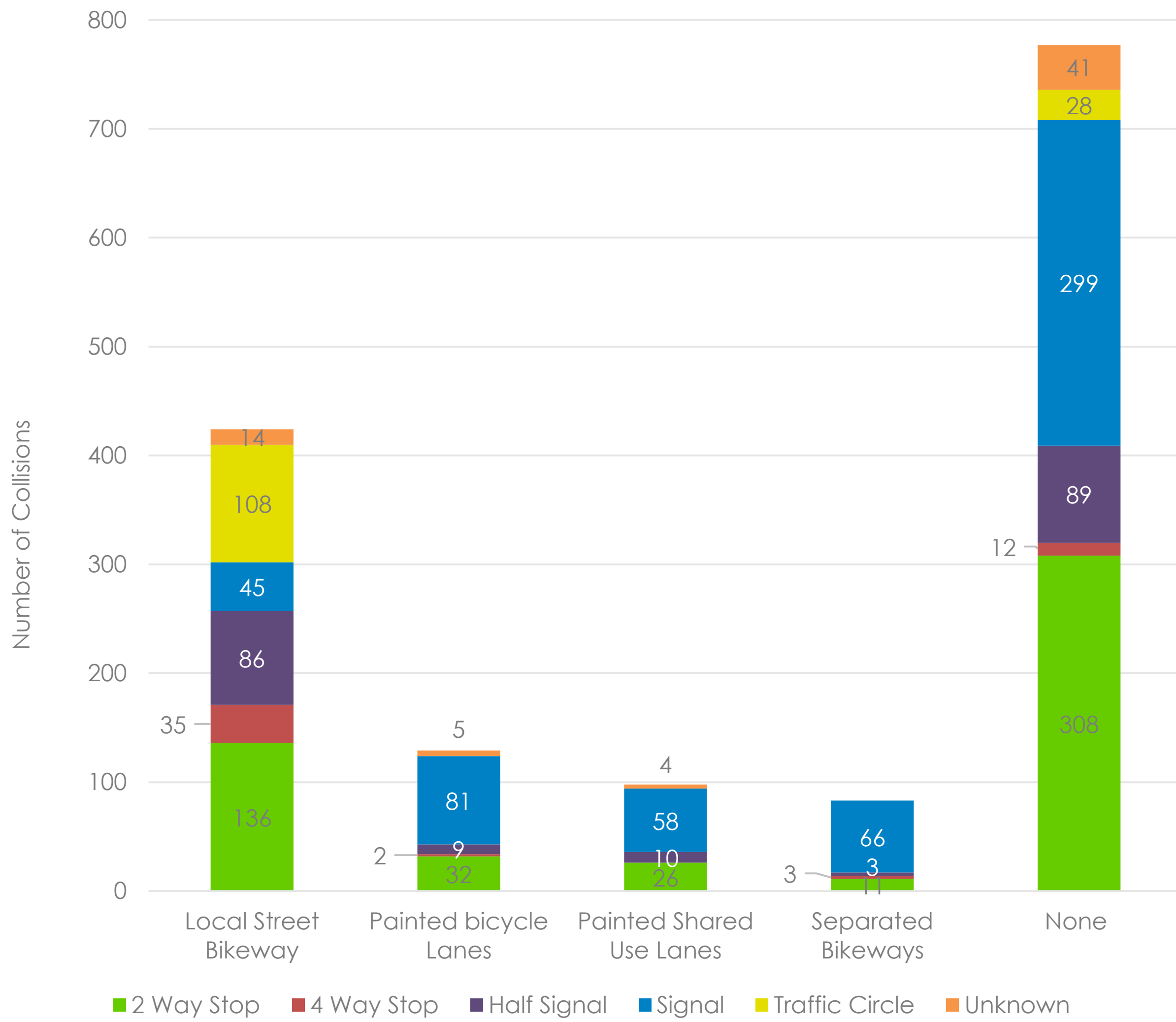
It is also important to note that the amount of bicycle infrastructure and the number of bikeways has continually increased during the period of time this data was collected. There were fewer bikeways in the City in 2007 at the start of the study period than in 2012.

Further details regarding the types of collisions that occurred at these types of intersections are provided in Chapter 5.

Figure 4.14

Cycling Collisions by Intersection Traffic Control and Bicycle Facility (2007 – 2012)

Source: ICBC Collision Data (2007-2012)



Injuries (BICE)

In the BICE study, 33% of all injury crash types were at intersections, and 56% of all collisions with motor vehicles were at intersections (very similar to the proportion reported in the ICBC motor vehicle collision data above).

Most injury crashes at intersections were collisions with motor vehicles (63%). The types of traffic controls at intersections with injury crashes are presented in **Table 4.8**. The highest numbers were at stop signs, followed by fully signalized intersections.

Table 4.8
Cycling Injury Crashes at Intersections, Type of Intersection Control (2008 – 2009)
Source: UBC BICE data, May 2008 – November 2009

Intersection Control	Cycling Intersection Injury Crashes	
	#	%
Full Traffic Signal	33	24%
Half Signal	17	13%
Traffic Circle	19	14%
Stop Sign (2-way or 4-way)	61	45%
Unknown	6	4%
Total	**136**	**100%**

The above table shows the numbers of injuries by intersection traffic control, but once again, looking a number alone does not indicated whether the high numbers of injuries at certain traffic control types is because there are many cyclists there or because there is increased danger with that control type.

As seen in **Figure 4.15**, the intersection controls have been ranked from lowest to highest likelihood of an injury. It also indicates the types of streets associated with each type of intersection control. This shows that although local streets with stop sign controls were the most frequent location of intersection injury crashes, they are also the most common kind of intersection through which cyclists travelled. The likelihood of an injury crash was lowest at this type of intersection. Full traffic signal intersections at arterials or collectors had both high numbers of crashes and high likelihoods of a crash, and therefore deserve particular attention. Traffic circles at local street intersections had smaller numbers of crashes, but the likelihood of a crash was the highest of all intersection control types. The proportion of traffic circles crashes in the BICE study data was higher than for ICBC data. It is important to note that approximately half of traffic circle injury crashes did not involve motor vehicles, and instead involved hitting the curb or slipping when the cyclist was trying to go around the traffic circle.

Figure 4.15

Relative Likelihood of an Intersection Injury Crash by Intersection Control and Street Type (2008 – 2009)

Source: UBC BICE data, May 2008 – November 2009

Other features at intersections also affected likelihood of an injury crash. The number and likelihood of intersection injury crashes were low when motor vehicles speeds at the intersection were ≤ 30 km/h (as measured by researchers with a radar gun; 29 crashes, 21%). Another kind of intersection characteristic that was rare, but had a high likelihood of injury was entering the intersection while travelling in the direction opposite to traffic (wrong way) (12 crashes, 9%). These types of crashes occurred when cyclists had been riding on a local street or on a sidewalk prior to entering the intersection. As noted, previously and defined in **Section 4.1**, collision likelihood is based on BICE data and represents the number of injuries divided by the bicycling trips through that location.

4.3 Summary

The key findings identified in this section are outlined below:

- The highest number of reported cycling collisions was in the Downtown core and the Metro Core of Vancouver, particularly along key corridors including Burrard Street, Main Street, 10th Avenue, Commercial Drive and Cypress Street.
- 61 locations throughout the City had at least one reported cycling collision per year between 2007 and 2012; these 61 locations represent 4% of all reported cycling collision locations, but 20% of all reported cycling collisions.
- The top five cycling collision locations were:
    - Burrard Street at Pacific Street;
    - Main Street at East 2nd Avenue;

- Clark Drive at East 10th Avenue;
- Pine Street at West 10th Avenue; and
- Burrard Street at Davie Street.

The City has made significant steps over the past several years to implement changes at each of these intersections, including intersection reconfigurations, addition of green conflict zone pavement markings, and changes in traffic control devices

- Many major streets had both high frequency and high likelihood of cycling collisions with motor vehicles, whereas certain local street bikeways showed high numbers of reported cycling collisions involving motor vehicles, but did not necessarily have a high likelihood of collisions with motor vehicle due to the relatively high cycling volumes along those corridors.
- Certain locations and corridors had both high frequency and likelihood of cycling collisions. When both the frequency and likelihood of cycling collisions were compared for specific locations and corridors, a number of locations emerged, including Burrard Street, Commercial Drive, Clark Drive, Pacific Street, Cypress Street, Main Street, and 10th Avenue. The BICE study also found a high likelihood at some of these locations and included some sections of the Seawall (as seen in **Table 4.9**).

Table 4.9

Cycling Injury Crashes at Intersections, Type of Intersection Control

Source: UBC BICE data, May 2008 – November 2009

TOP CORRIDORS for Bicycle-Motor Vehicle Collisions (ICBC)	TOP LOCATIONS for Bicycle-Motor Vehicle Collisions (ICBC)	High Bicycle-Motor Vehicle Collisions LIKELIHOOD (ICBC)	High Injury Crash LIKELIHOOD (BICE)
Burrard Street (West Hastings Street to Harwood Street)	Burrard & Pacific, Burrard & Davie	Burrard near Robson	Burrard Bridge
Commercial Drive (Adanac Street to East 12th Avenue)			
Clark Drive (Adanac Street to West 10th Avenue)	Clark & 10th		
Main Street (Powell Street to West Kent Avenue)	Main & 2nd	Main (16th to 25th)	Main (16th to 25th)
10th Avenue (Trafalgar Street to Victoria Drive)	10th & Pine	10th (Main to Oak)	10th (Main to Oak)
Cypress Street (Cornwall Avenue to West19th Avenue)	Cypress & Cornwall		
			Seawall (Plaza of Nations) Seawall (Ontario to Cambie

- The majority (56%) of reported cycling collisions between 2007 and 2012 were on streets without designated bikeways. Injury crash data from the BICE study found similar results. Of the reported cycling collisions on streets without designated bikeways, the majority (71%) occurred on arterial streets, as shown below:

Collisions on Streets without Designated Bikeways = 56%	
Arterial Streets	71%
Collector Streets	2%
Local Street	27%

- Streets with designated bikeways accounted for 44% of all reported cycling collisions. Local street bikeways had the highest proportion of reported collisions and injury crashes among all designated bikeway facility types. Although local street bikeways account for the majority of reported collisions (53%) and injury crashes (41%) on designated bikeways, local street bikeways make up nearly three quarters (72%) of the City's bicycle network. As such, local street bikeways had a lower proportion of collisions compared to their length. In contrast, shared use lanes, painted bicycle lanes, and protected bicycle lanes all had a higher ratio of collisions as compared to their length, as shown below:

Collisions on Streets with Bikeways = 44%			
	ICBC Data	BICE Data	Total Length
Local Street Bikeways	53%	41%	72%
Painted Bicycle lanes	22%	12%	19%
Shared Use lanes	15%	9%	6%
Protected Bicycle lanes	11%	1%	3%

- Protected bicycle lanes had a higher proportion of collisions than would be expected based on their length. To understand these results, a detailed corridor analysis of the Dunsmuir Street and Hornby Street protected bicycle lanes was conducted. The results found that most of these collisions occurred on Dunsmuir Street and were a result of vehicles turning right and colliding with a bicycle user in locations with right turning restrictions or signage providing bicycle users with the right of way. It also showed that intersections with dedicated bicycle signals appeared to be the safest intersections. Enforcement of prohibited and yielded right turns by motor vehicles could greatly improve the safety of protected bicycle lanes by reducing the collisions.
- Intersections accounted for 50.5% of all reported ICBC cycling collisions between 2007 and 2012. Of these, signalized intersections accounted for nearly half (48%) of all reported intersection collisions, including 35% at full traffic signals and 13% at pedestrian and cyclist activated half signals. Collisions at two-way stops accounted for 31% of all collisions. The BICE study found similar results, as 56% of all injury crashes with motor vehicles from the BICE study were at intersections.
- Traffic circles were present in approximately 8.5% of all reported cycling collisions at intersections. Traffic circles are only located at approximately 2% of intersections in the City; however, 66% of all traffic circles in the City are located on local street bikeways. Of the approximately 260 traffic circles in the City, only four locations had at least one reported cycling collision per year on average. Prior to the Cycling Safety Study being conducted, the City had already implemented changes at two of these four locations to address safety issues. These results indicate that collisions at locations with traffic circles may be a localized issue. In addition, the BICE Injury crash data found that approximately half of the injuries at traffic circles did not involve motor vehicles.

- When bicycle volumes were taken into account by neighbourhood, neighbourhoods with the highest collision likelihoods were Sunset, Shaughnessy, Victoria-Fraserview and Killarney. This suggests that the neighbourhoods with the least amount of cycling and cycling infrastructure had the highest cycling collision likelihood.

5.0

What & How Analysis

5.1 Introduction

This section provides a summary of the types of reported cycling collisions (as reported by ICBC collision data) and the types of cycling injury crashes requiring treatment at a hospital emergency department (as reported by BICE data). Through the analysis of what types of incidents occurred, this section summarizes the most common types of cycling collisions and injury crashes.

WHAT ANALYSIS INCLUDES:

1. Top Injury Crash Types
2. Top Collision Types
3. Doorings
4. Conflict Zones
5. Right Turning Vehicles
6. Left Turning Vehicles
7. Traffic Circles
8. Sidewalks
9. Motor Vehicle Speeds

5.2 Detailed Findings

5.2.1 Top Injury Crash Types

Injuries (BICE)

The BICE study included data from cycling injuries serious enough to result in a hospital emergency department treatment in one of the two largest hospitals in the City of Vancouver. As noted in the previous section, the BICE data found that 37% of cycling injury crashes were a result of collisions with motor vehicles, including 8%, which were a result of a collision with a motor vehicle door. A further 12% were a result of a fall to avoid a collision, including 10% to avoid a motor vehicle and 2% to avoid another type of collision. As such, just under half (47%) of recorded cycling injury crashes were a result of an interaction with a motor vehicle. The remaining cycling injury crashes (53%) resulted from collisions with surfaces (such as potholes, gravel, leaves, tracks, roots, icy or wet surfaces), infrastructure (such as bollards, furniture, curbs, fences, speed bumps, stairs), or other route users (such as pedestrians, other bicycle users or animals).

The BICE study found that, on average, cycling injury crashes with motor vehicles were more serious than other crashes. Bicycle users injured in motor vehicle collisions were more likely to need transportation to hospital by ambulance, more likely to require urgent treatment, and more likely to be admitted to hospital for treatment beyond the emergency department.

5.2.2 Top Collision Types

Collisions (ICBC)

As noted in the previous section, only 47% of the cycling injury crashes from the BICE study were a result of an interaction with a motor vehicle. However, it is still important to consider the detailed motor vehicle collision data provided by ICBC to understand the types of reported cycling collisions that have occurred with motor vehicles. The ICBC dataset is larger than the BICE study dataset with a longer time frame and overall resulted in more injuries, including fatalities. In addition, the BICE study found that collisions with motor vehicles were more serious on average than other types of cycling injury crashes. Although this section includes a detailed analysis of reported cycling collisions with motor vehicles based on ICBC data, it is recognized that this analysis under-represents the total number of cycling collisions that occurred in the City of Vancouver during this period.

The ICBC collision data was analyzed to determine trends and to help identify situations that resulted in cycling collisions. The incident description field for each individual collision record was reviewed to determine, based on the limited information provided, the scenario that resulted in a collision. This included understanding where the collision occurred, the vehicle drivers' and cyclists' movement, the type of intersection control, and other characteristics. Based on this review of the incident description, each reported cycling collision was then classified based on an objective and systematic classification framework that was developed based on the following six factors:

- **Collision location** (intersection, mid-block, alley, parking lot, and unknown locations);
- **Driver movement** (straight, left turn, right turn, passing, changing lanes, parking, opening door, and completing a U-turn);
- **Cycling movement** (straight, left turn, right turn, passing, changing lanes, and stopped);
- **Traffic control device** (traffic signal, half signal, stop sign (two-way or four-way), traffic circle, and crosswalk);
- **Cycling action** (bicycle user crossing with right of way, did not stop at stop sign, stopped waiting to cross, and cross against signal); and
- **Other characteristics** (travel direction, and riding on sidewalk).

The classification framework combined each of the possible results for each of these six factors, resulting in a total of 85 potential types of cycling collisions (as shown in **Appendix C)**. However, because of the level of detail associated with this classification system, collision classifications were grouped together to reflect common features, resulting in 35 collision types.

Based on this classification, approximately 90.9% of all reported cycling collisions based on the ICBC dataset could be classified into one of these 35 cycling collision types. In the remaining cases, the cycling collision type could not be determined based on the limited information available. Of the remaining 9% of reported cycling collisions, less than 1% of the collisions involved an incident that was in an alleyway or parking lot, 6.1% of collisions occurred when a bicycle user was riding on the sidewalk and 2.3% of collisions were not able to be classified because not enough information was known based on the level of detail provided in the incident description.

The collision classification framework also allowed for the right-of-way to be assumed for each cycling collision. Right-of-way was assumed based on the location of each collision, including the type of infrastructure and traffic control device present at each location, as well as the comments in the incident description. Right-of-way was assumed based on which party had the right-of-way to make the movement within the intersection. Right-of-way was assumed, for example, based on which party was facing the stop sign at a two-way stop, or who was making a left turn off of the major street when the two parties were travelling in opposite directions on the same street. Right-of-way could be assumed for approximately 1,600 of the 2,994 reported cycling collisions. In 93% of these cases, the cyclist was assumed to have the right-of-way. This calculation included all intersection locations where the bicycle user was assumed to have the right-of-way, and all mid-block collisions that occurred as a result of doorings and entering or exiting alleyways, parking lots, or driveways. In no way are these classifications attempting to assign fault or conclusively determine right-of-way, as ICBC has their own process for determining this separate from this study.

The top ten identified cycling collision types are listed below and shown in **Figure 5.1**. These top ten types of cycling collisions accounted for 69% of all cycling collision types, with the top five cycling collision types in particular accounting for 44% of all collision types. Motor vehicle right and left turning movements at intersections accounted for nearly 28% of all cycling collision types. A detailed summary of the 35 collision types and their frequency is provided in **Table 5.1.**

	Collision Type	Collision Description	Percentage
1.	Dooring	Vehicle and bicycle user collided **mid-block** as motor vehicle **door was opening**	15.2%
2.	Conflict Zone	Vehicle and bicycle user collided **mid-block** as motor vehicle was **entering or exiting an alley, parking lot, or driveway**	10.7%
3.	Right Hook	Motor vehicle turned right at a **signal** as bicycle user crossed at signal with right-of-way	6.5%
4.	Sidewalk Riding	Bicycle user was **riding on the sidewalk** prior to collision (2.7% mid-block and 3.4% intersection)	6.1%
5.	Mid-block	Motor vehicle and bicycle user collided while travelling in the **same direction**	5.7%
6.	Left Cross (Signal)	Motor vehicle **turned left at signal** while a bicycle user entered the **intersection** with right-of-way	5.4 %
7.	Intersections	Motor vehicle proceeded **straight through a signal** when right of way was unclear	5.2%
8.	Traffic Circles	Motor vehicle and bicycle user collided in an intersection with a **traffic circle**	4.9%
9.	Left Cross (Stop Sign)	Motor vehicle **turned left** as bicycle user crossed at **two-way stop** with right of way	4.6%
10.	2-way Stops	Motor vehicle went **straight** as bicycle user crossed at **two-way stop** with right of way	4.5%

Figure 5.1
Reported ICBC Collision Locations and Types
Source: ICBC Collision Data (2007-2012)

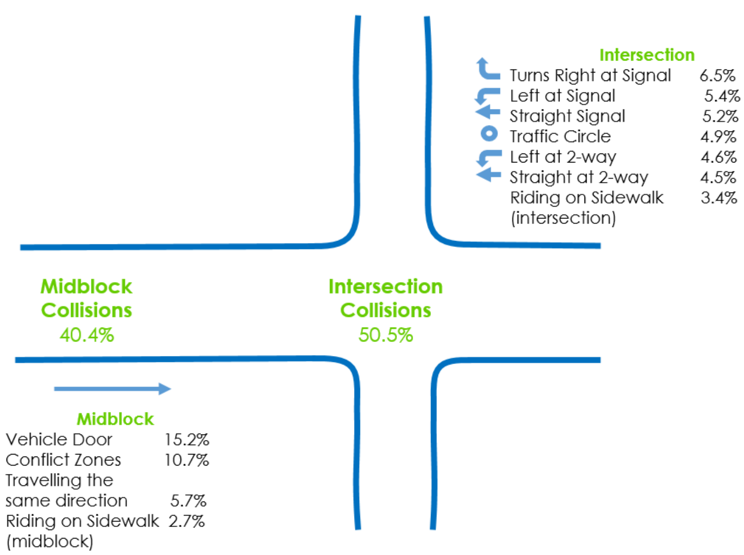


Table 5.1
Cycling Collision Classification and Frequency (2007 – 2012)
Source: ICBC Collision Data (2007-2012)

Collision Description	Number of Collisions	Proportion of All Collisions	Rank
Intersection Location			
Vehicle Turns Left			
Cyclist crosses at **Signal with Right of way**	152	5.4%	6
Cyclist crosses at **Signal without Right of way**	7	0.2%	34
Cyclist crosses at **Half-Signal with Right of way**	24	0.9%	23
Cyclist crosses at **2-Way Stop with Right of way**	130	4.6%	9
Cyclist crosses at **2-Way Stop without Right of way**	11	0.4%	30
Cyclist crosses intersection when **Right of way is Unclear**	96	3.4%	12
TOTAL LEFT MOVEMENTS	**420**	**14.9%**	
Vehicle Turns Right			
Cyclist crosses at **Signal** with **Right of way**	184	6.5%	3
Cyclist crosses at **Signal** without **Right of way**	3	0.1%	29
Cyclist crosses at **Half-Signal** with **Right of way**	26	0.9%	22
Cyclist crosses at **2-Way Stop** with **Right of way**	50	1.8%	16
Cyclist crosses intersection when **Right of way is Unclear**	78	2.8%	14
Cyclist **rear ends vehicle** as vehicle is turning right	14	0.5%	28
TOTAL RIGHT MOVEMENTS	**355**	**12.6%**	
Vehicle Goes Straight			
Cyclist crosses at **Signal** with **Right of way**	20	0.7%	24
Cyclist crosses at **Signal without Right of way**	13	0.5%	35
Cyclist crosses at **Half-Signal** with **Right of way**	33	1.2%	21
Cyclist crosses at **Half-Signal without Right of way**	16	0.6%	25
Cyclist crosses at **2-Way Stop** with **Right of way**	128	4.5%	10
Cyclist crosses at **2-Way Stop without Right of way**	46	1.6%	17
Cyclist crosses intersection when **Right of way is Unclear**	146	5.2%	7
TOTAL STRAIGHT MOVEMENTS	**402**	**14.3%**	
Other Actions in Intersection			
Cyclist is **stopped** at intersection	39	1.4%	19
Cyclist turns **left** at intersection	15	0.5%	26
Vehicle hits cyclist while **changing lanes** in an intersection	44	1.6%	18
Cyclist collides with **stopped vehicle** at intersection	9	0.3%	31
Vehicle and cyclist collided in **traffic circle**	137	4.9%	8
SUBTOTAL INTERSECTION	1421	50.5%	

Collision Description	Number of Collisions	Proportion of All Collisions	Rank
Midblock Location			
Vehicle and cyclist collide mid block as vehicle door is opening	427	15.2%	1
Vehicle and cyclist collide as entering/exiting an alley/parking lot/gas station mid block	301	10.7%	2
Vehicle and cyclist collide while travelling in the same direction (passing)	161	5.7%	5
Vehicle and cyclist collide mid block as vehicle is leaving/entering an on street parking space	110	3.9%	11
Vehicle hits a cyclist while changing lanes	89	3.2%	13
Other incident occurs mid block	15	0.5%	27
Vehicle and cyclist collide mid block while the vehicle is making a U-Turn	35	1.2%	20
SUBTOTAL MIDBLOCK	1138	40.4%	

Other Locations			
Vehicle and cyclist collide in a parking lot	9	0.3%	32
Vehicle and cyclist collide in an alleyway	8	0.3%	33
Cyclist was riding on the **sidewalk** prior to collision	173	6.1%	4
Unknown Location			
Cyclist and vehicle action is not known	66	2.3%	15
SUBTOTAL OTHER/UNKNOWN	256	9.1%	
SUBTOTAL INTERSECTION	1421	50.5%	
SUBTOTAL MIDBLOCK	1138	40.4%	
TOTAL	2815		

The following sections summarize key findings for the more frequent types of reported cycling collisions.

5.2.3 Doorings

Collisions (ICBC)

The most common type of reported cycling collision occurred mid-block when cyclists were travelling along a street and were struck by or struck the door of a parked car being opened, typically on the driver side. This type of collision is referred to as a dooring and accounted for 15.2% of all reported cycling collisions. The injury data presented in the BICE study also found that doorings resulted in a significant number of cycling injuries. The location of dooring collisions is shown in **Figure 5.2.** Approximately two-thirds (67%) of all doorings occurred on arterial streets without designated bikeways, including Broadway, Commercial Drive and Main Street. Doorings were particularly frequent under the following conditions and at the locations described below:

Arterial streets without bikeways

- **Broadway** between Trafalgar Street and Main Street (4.6km) accounted for 29 dooring incidents (6.3 doorings/km). Doorings were most frequent at the following locations on Broadway: Granville Street (5), Hemlock Street (3), Burrard Street (2), and Heather Street (2).
- **Commercial Drive** between Adanac Street and Broadway (1.7 km) accounted for 26 dooring incidents (15.3 doorings/km). Doorings along Commercial Drive were most frequent between 10th Avenue and Venables Street, particularly at the following locations: 1st Avenue (5), 7th Avenue (2), 3rd Avenue (2), Kitchener Street (2), and Charles Street (2).
- **Cornwall Avenue** between Chestnut Street and Trafalgar Street (1.3 km) accounted for 10 dooring incidents (7.7 doorings/km). There were no dedicated bikeways on Cornwall Avenue. Doorings were the most frequent at the following locations on Cornwall Avenue: Cypress Street (4), Larch Street (2), and Arbutus Street (2).
- **41st Avenue** between Dunbar and Cambie (5 km) accounted for 9 dooring incidents (1.8 doorings/km). 41st Avenue has no designated bikeways, with the exception of a portion of 41st Avenue between Willow Street and Cambie Street that has painted bicycle lanes in the eastbound direction. Doorings were the most frequent at three locations on 41st Avenue: Willow Street (2), Collingwood Street (2), and East Boulevard (2).
- **Davie Street** between Denman and Granville (1.6 km) accounted for 8 dooring incidents (5 dooring/km). Doorings were the most frequent at Thurlow Street (2), Bute Street (3), and Jervis Street (2).

Arterial Streets with Shared Use Lanes

- **Main Street** between Powell and 33rd Avenue (4.7 km), accounted for 33 dooring incidents (7.0 doorings/km). Main Street is an arterial street that has shared use markings ("sharrows") in both directions. Doorings were the most frequent along Main Street between Broadway and 33rd Avenue, and particularly at the following locations: 14th Avenue (4), 10th Avenue (3) and 28th Avenue (3).
- **Pender Street** between Thurlow Street and Main Street (1.8 km), has shared use lanes and accounted for 5 doorings (2.8 doorings/km).

Local Street Bikeways

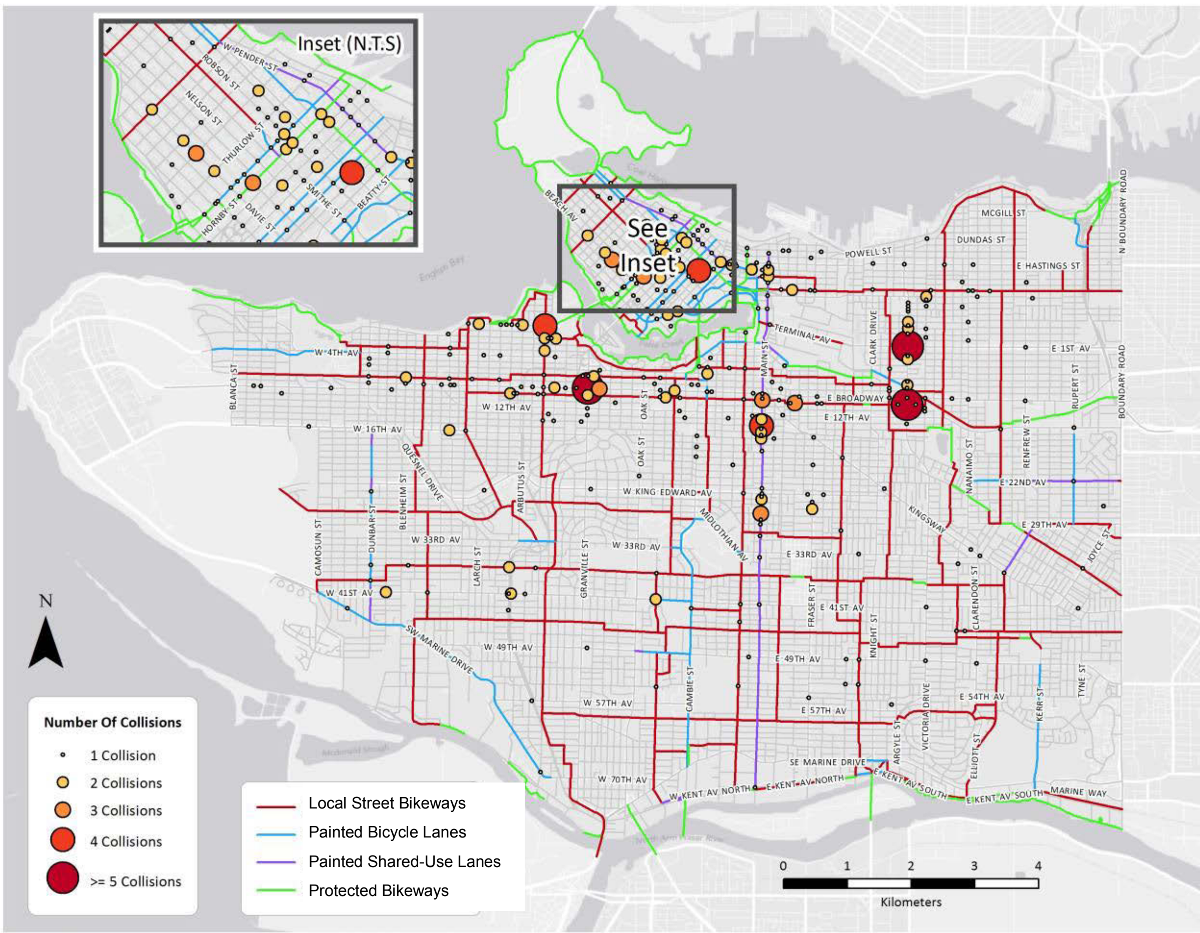
- **10th Avenue** between Trafalgar Street and Victoria Drive (7.2 km) accounted for 28 dooring incidents (3.9 doorings/km). This section of 10th Avenue is a local street bikeway. Some particular locations that had a high number of dooring incidents included: Commercial Drive (6), Main Street (3), and near Granville Street (2).

- **Union Street** between Main Street and Union Street (0.7 km), accounted for 4 dooring incidents (5.7 doorings/km).

Figure 5.2

Frequency of Reported Dooring Collisions (2007 – 2012)

Source: ICBC Collision Data (2007-2012)



5.2.4 Driveways, Alleyways and Parking Lots

Collisions (ICBC)

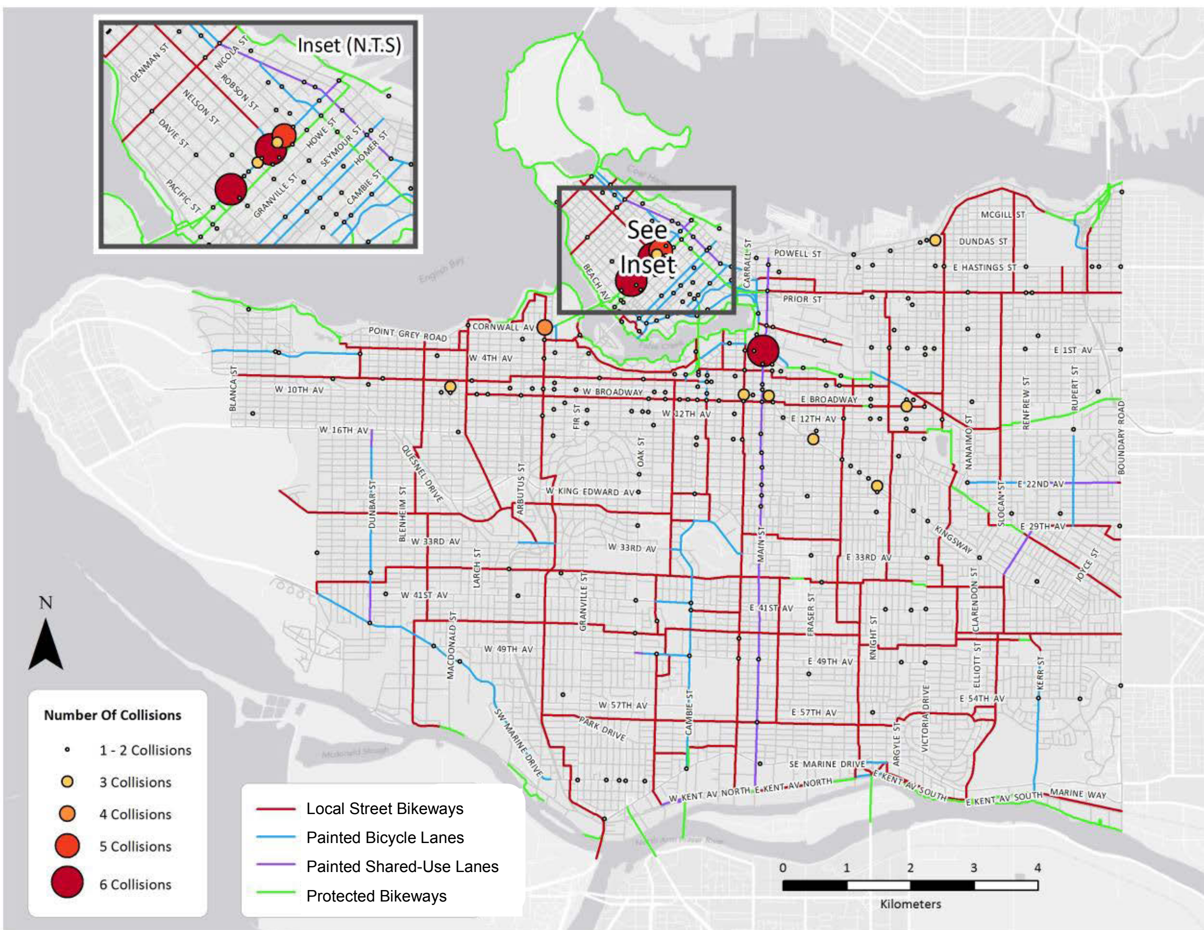
The collision analysis identified that collisions at mid-block conflict zones such as driveways, parking lots and alleyways were the second most frequent type of reported cycling collision, accounting for approximately 10.7% of all reported cycling collisions. This type of collision occurred when a bicycle user or a motor vehicle entered or exited an alleyway, parking lot, or driveway. In most cases, bicycle users were proceeding straight ahead along a street segment and motor vehicles failed to yield when they were pulling in and out of these locations.

The majority (58%) of these types of collisions occurred on arterial streets, including 30% which occurred on arterial and secondary arterial streets without designated bikeways. Several locations were identified as hot spots for these types of collisions, including Burrard Street, Main Street, Broadway, Kingsway, 1st Avenue and 10th Avenue. The location of all reported conflict zone collisions are shown in **Figure 5.3.**

Figure 5.3

Frequency of Reported Conflict Zone Collisions (2007 – 2012)

Source: ICBC Collision Data (2007-2012)



5.2.5 Right Turning Vehicles

Collisions (ICBC)

Reported cycling collisions involving right turning vehicles at signalized intersections, also known as 'right hooks' as illustrated in **Figure 5.4**, accounted for approximately 7.5% of all reported cycling collisions. When intersections with traffic signals and stop signs are counted, collisions involving right turning vehicles accounted for 12.6% of reported cycling collisions. Most of the right hook collisions within the City of Vancouver occurred in the Downtown core of the City as seen in **Figure 5.5**. The majority of the right hooks occurred on arterial streets (82%), including 41% of right turn collisions that occurred on arterial streets with no designated bikeways.

Of particular note is that 23% of all right hook collisions at signalized intersections occurred on protected bicycle lanes, particularly Dunsmuir Street. Since the installation of the protected bicycle lanes on Dunsmuir Street in 2010, there have been 23 reported cycling collisions in total, 17 of which (70%) were a result of right hooks. These right hook collisions occurred at intersections where motor vehicle right turns were either prohibited, or where there was signage in place advising motor vehicles to yield to bicycle users. Of these 17 collisions, 16 occurred when the bicycle user and the right turning vehicle were travelling along the street in the same direction, with one collision occurring when the bicycle user was travelling on the cross street.

Figure 5.4
Example of a Right Hook
Source: FHWA Bicycle Road Safety Audit Guidelines and Prompt List

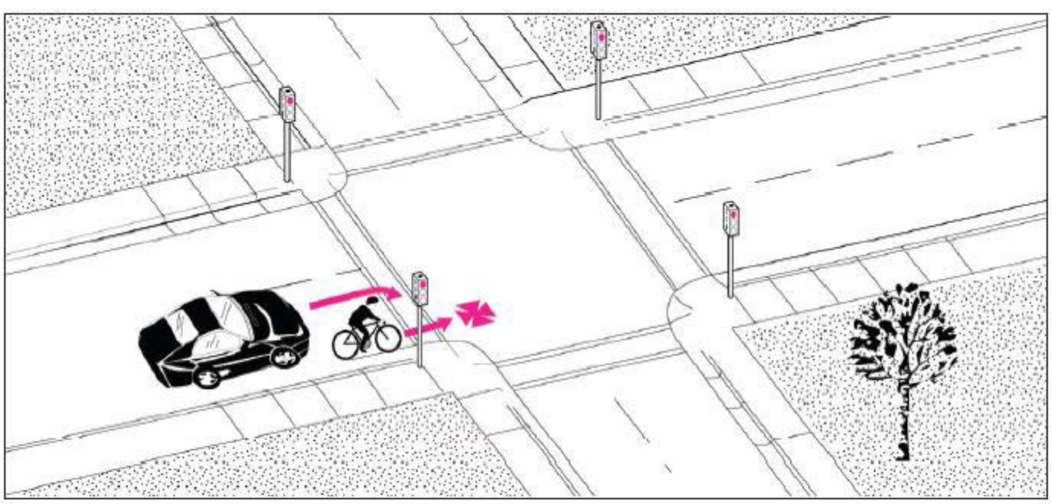
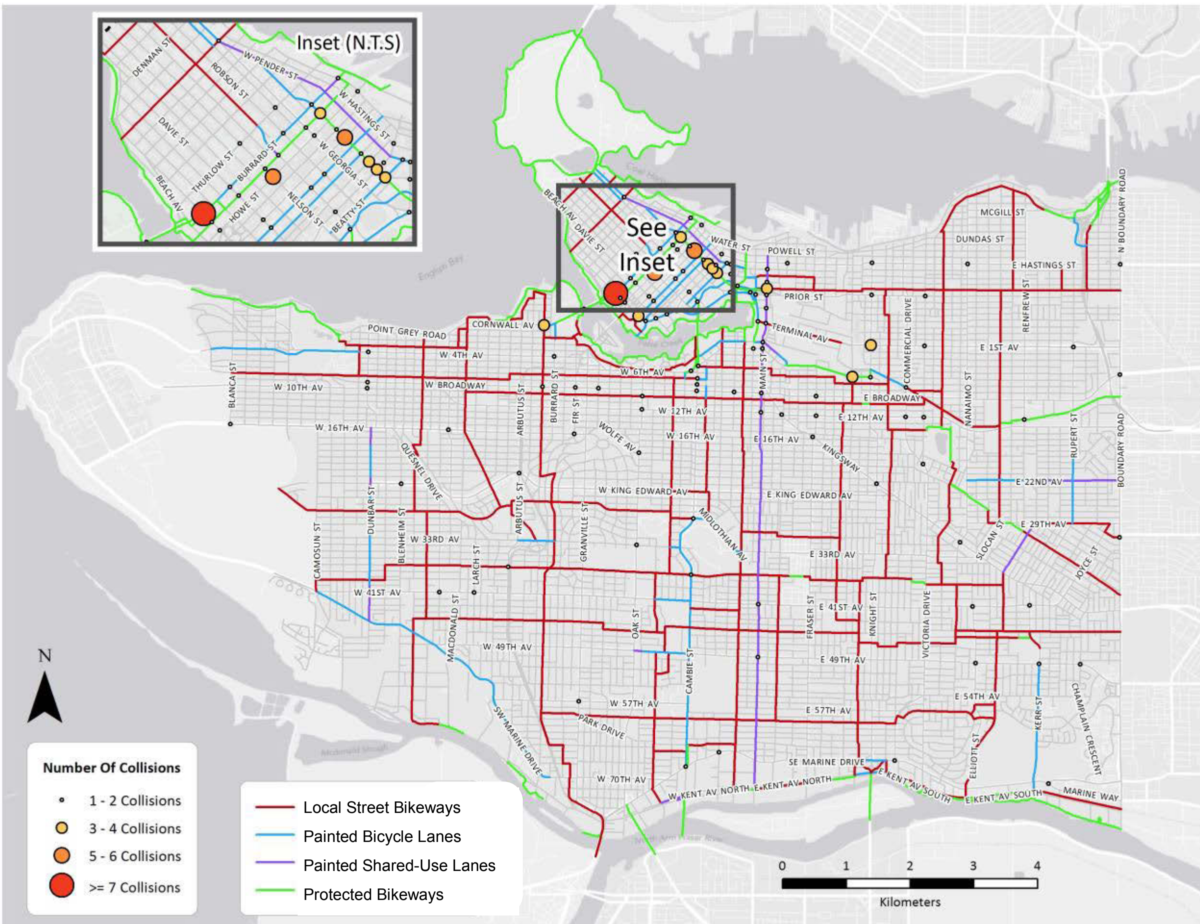


Figure 5.5
Frequency of Reported Right Hook Collisions (2007 – 2012)
Source: ICBC Collision Data (2007-2012)



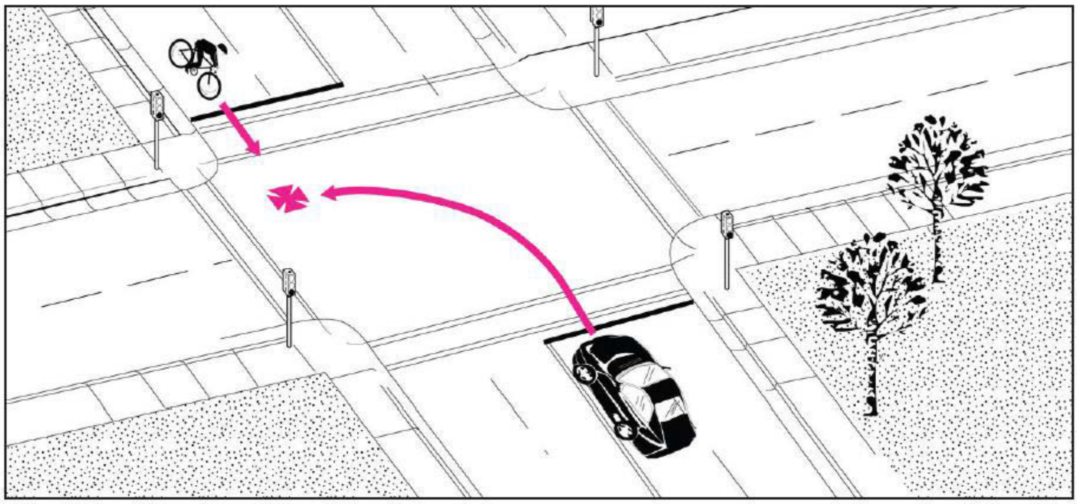
5.2.6 Left Turning Vehicles

Collisions (ICBC)

Reported cycling collisions involving left turning vehicles at signalized intersections, also known as 'left crosses', accounted for 6.5% of all reported cycling collisions, as illustrated in **Figure 5.6**. When intersections with traffic signals and stop signs were counted, left turning vehicles were the most common type of vehicle turning movement that resulted in a collision, accounting for 14.9% of all reported cycling collisions. Similar to collisions involving right turning vehicles, many of these left crosses occurred at signalized intersections when the bicycle user was crossing the intersection with the signal. The majority of left cross collisions also occurred on arterial streets, with 36% occurring on arterial streets with no bikeways. The majority

(77%) of left cross collisions occurred while the bicycle user and motorist were travelling in opposing directions on the same street.

Figure 5.6
Example of a Left Turing Vehicle Collision
Source: FHWA Bicycle Road Safety Audit Guidelines and Prompt List



5.2.7 Traffic Circles

Collisions (ICBC)

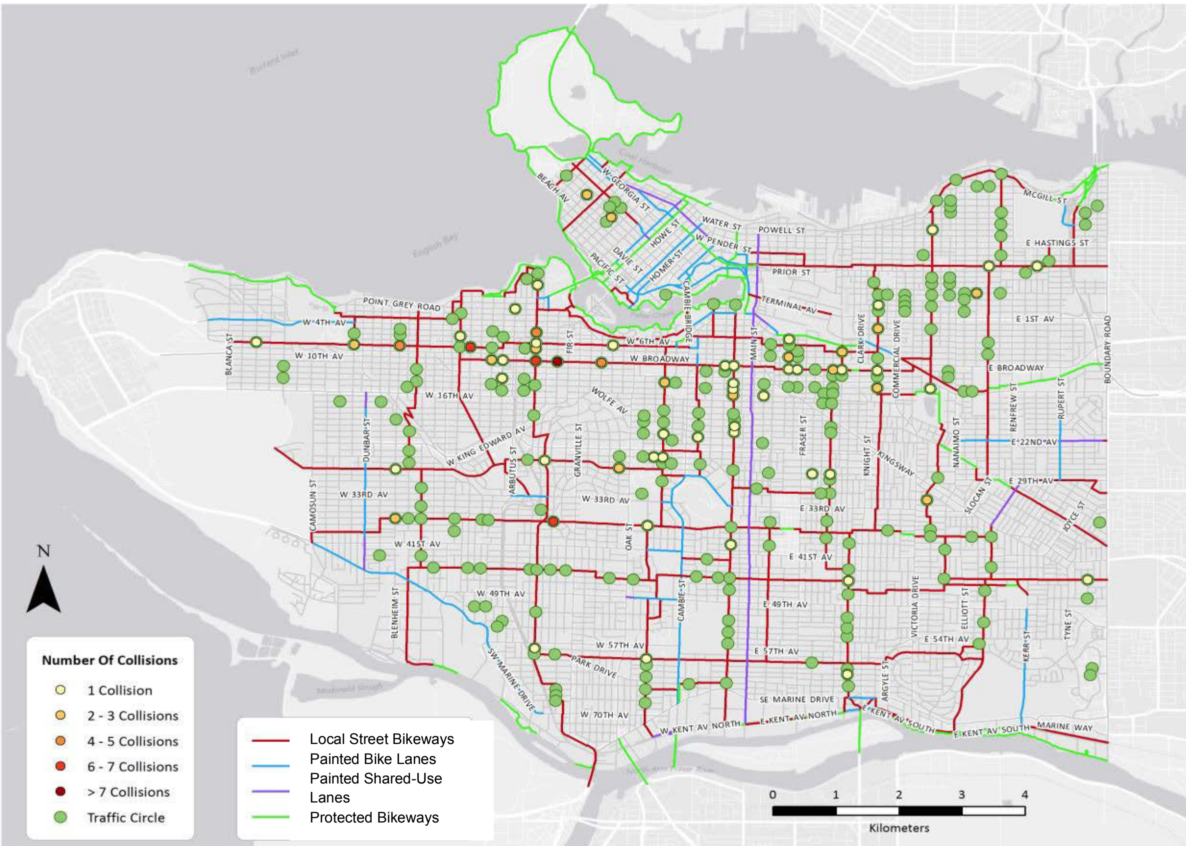
A total of 137 reported cycling collisions occurred at intersections with traffic circles between 2007 and 2012. This represented approximately 4.9% of all reported cycling collisions, and approximately 8.5% of all reported collisions at intersections. As noted in the previous chapter, there are approximately 260 traffic circles at intersections of local streets in the City of Vancouver, or approximately 2.1% of all intersections in the City. Also noted in the previous chapter, of these 137 reported cycling collisions at traffic circles, the majority (80%) occurred at traffic circles located on a local street bikeway. These are also the routes with the majority of traffic circles, as 66% of all traffic circles in the City are located on local street bikeways. All reported cycling collisions at traffic circles were combined into one category as the incident descriptions did not provide sufficient information in most cases to determine the direction of vehicle driver or bicyclist movement through the intersection.

Only 63 of the approximately 260 traffic circle locations in the City had any reported cycling collisions over this period, as seen in **Figure 5.7**. Further, of these 63 traffic circles, only four had at least one reported cycling collision per year on average. These four locations totaled 35 reported cycling collisions over this period, or approximately one quarter (25.5%) of all reported cycling collisions at traffic circles. Prior to the Cycling Safety Study being conducted, the City had already implemented changes at two of these four locations to address safety issues as summarized in **Table 5.2**. These results indicate that collisions at locations with traffic circles may be a localized issue.

Table 5.2
Top Traffic Circle Collision Locations (2007 – 2012)
Source: ICBC Collision Data (2007-2012)

Location	Designated Bikeways	Number of Reported Collisions	Improvements Prior to Cycling Safety Study
Pine Street at 10Th Avenue	Local Street Bikeway (10th Avenue only)	16	Traffic circle removed, replaced with two-way stop
Larch Street at 8th Avenue	Local Street Bikeway (8th Avenue only)	7	
Marguerite Street at 37th Avenue	Local Street Bikeway (37th Avenue only)	6	Traffic circle removed, replaced with two-way stop
Cypress Street at 10th Avenue	Local Street Bikeway (Both)	6	

Figure 5.7
Frequency of Reported Cycling Collisions at Traffic Circles (2007-2012)
Source: ICBC Collision Data (2007-2012)



Injuries (BICE)

Bicyclists' injury data from the BICE study found that 10.4% of cycling injury crashes occurred at traffic circles. Approximately half of traffic circle injury crashes were collisions with motor vehicles; the others involved falls during collision avoidance manoeuvres or hitting the curb or slipping when the cyclist was trying to go around the traffic circle.

5.2.8 Sidewalks and Off-Street Pathways

Several studies have found that collisions between bicycle users and pedestrians are under-reported, as collision data in most jurisdictions, including ICBC data, only includes collisions between motor vehicles and bicycle users. Data from the BICE study helps to address this limitation, as the BICE study reports on all types of injury crashes among people who required treatment at a hospital emergency department. These include collisions with pedestrians, bicycle users or animals, and collisions that occurred on off-street routes such as sidewalks and off-street pathways. Although ICBC collision data does not allow for an assessment of pedestrian-cycling collisions, the information in the ICBC collision data does provide sufficient information to determine when collisions occurred with a motor vehicle and bicycle user when the bicycle user was cycling on the sidewalk or had been riding on the sidewalk prior to entering an intersection.

Collisions (ICBC)

Occurrences of sidewalk cycling were recorded through the incident descriptions in the ICBC collision records. In total, 173 cycling collisions were reported when the bicycle user was noted to have been riding on the sidewalk, or had been riding on the sidewalk prior to entering the intersection or conflict zone. Sidewalk cycling accounted for 6.1% of all reported cycling collisions, including 2.7% of these collisions which occurred at mid-block locations, and 3.4% of these collisions which occurred at intersections. The location of sidewalk cycling collisions is shown in **Figure 5.8**. The top collision locations where bicycle users were riding on the sidewalk included: Kingsway (8 reported collisions), Hastings Street (8), Clark Drive (6), Main Street (5), Commercial Drive (4), Victoria Drive (4), and 10th Avenue (4). The majority of these streets do not have any designated bikeways, with the exception of Main Street (shared use lane) and 10th Avenue (local street bikeway). The types of collisions that most often occurred when bicycle users were riding on the sidewalk were:

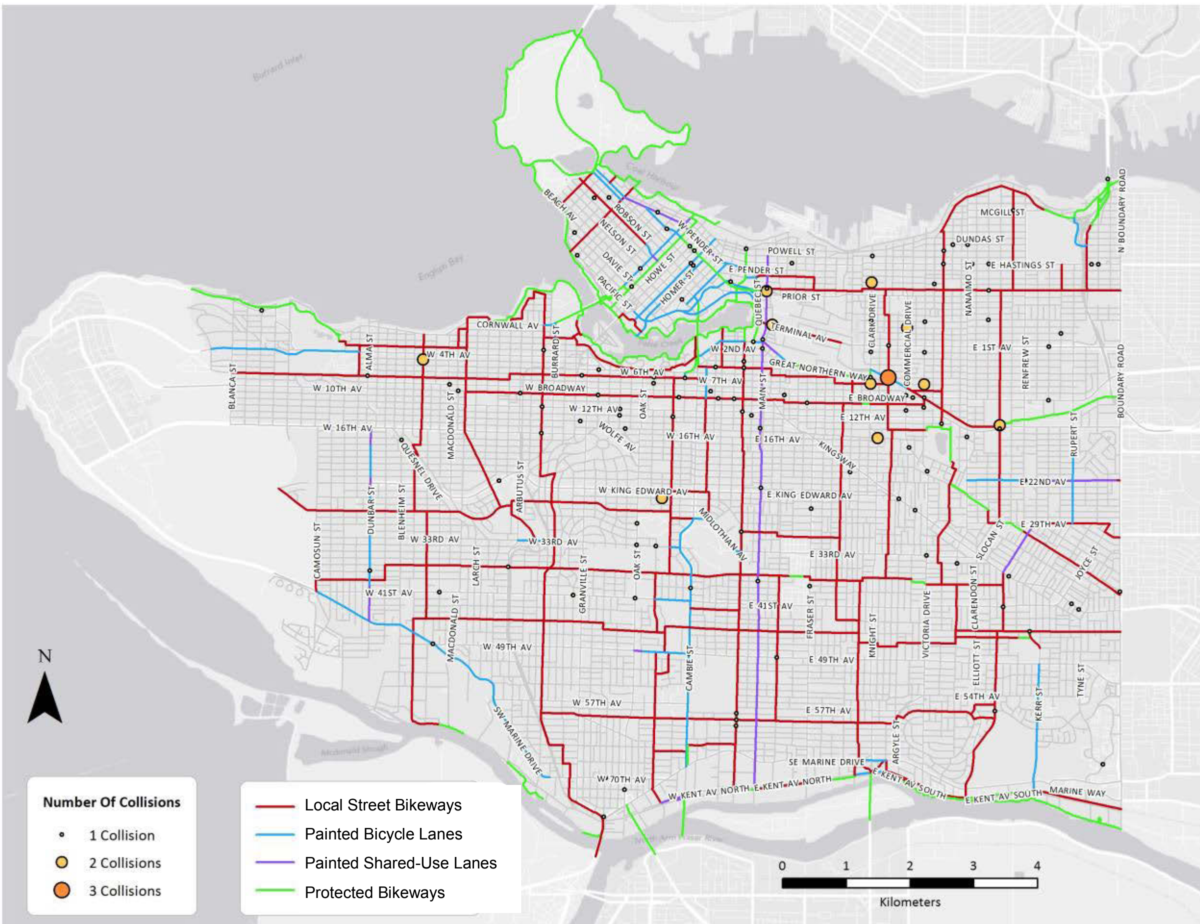
- Mid-block collision while the vehicle was **entering or exiting an alley, parking lot, or driveway** (44% of collisions with bicycle users travelling on the sidewalk);
- Collision while a **vehicle turned right at a two-way stop** as the bicycle user entered the intersection from the sidewalk (15%); and
- Collision while a **vehicle turned right at a signal** as the bicycle user entered intersection from the sidewalk (11%).

These findings indicate that there is a key safety issue related to sidewalk cycling. Motor vehicle drivers may not be looking or expecting a bicycle user to be travelling on the sidewalk as they enter intersections or exit/cross conflict zones such as driveways or alleyways.

Figure 5.8

Frequency of Reported Sidewalk Cycling Collisions (2007 – 2012)

Source: ICBC Collision Data (2007-2012)



Injuries (BICE)

Injury data from the BICE study found that 8% of all injuries resulting in hospital emergency room treatment were a result of a collision with pedestrian, bicycle user or animal. Approximately one third (32%) of these collisions with pedestrians, bicycle users or animals occurred on paved multi-use pathways, while 19% occurred on dedicated bicycle pathways, and 6.5% occurred on sidewalks or other pedestrian pathways. Collisions with pedestrians, bicyclists, or animals were more frequent at these route types than expected, given the number of cycling trip control sites on such routes.

The BICE study also found that certain types of injury crashes were unusually frequent given bicycle users' use of the various types of bicycle routes. The following types of injury circumstances were found to be unusually frequent for various types of off-street routes:

- **Sidewalks or other pedestrian paths:** Collisions with infrastructure such as bollards and curbs, collisions with surface treatments, and falls to avoid collisions;
- **Paved multi-use pathways:** Collisions with infrastructure such as bollards and curbs, collisions with pedestrians, bicycle users or animals, and falls to avoid collisions;
- **Unpaved multi-use pathways:** Collisions as a result of surface treatments; and
- **Bicycle only pathways:** Collisions with infrastructure such as bollards and curbs, and collisions with pedestrians, bicycle users or animals.

5.2.9 Motor Vehicle Speeds

Injuries (BICE)

The data from the BICE study included research on the impact of speed on collision frequency. The BICE study included measured speed (as opposed to posted speed) based on measurements of vehicle speeds at intersections using a radar gun. Speeds through intersections were measured both at injury sites and at control sites. The data from the BICE study indicated that bicycle users had half the chance of being in a crash when they were at intersections where the measured motor vehicle speed averaged less than or equal to 30 kilometres per hour. This suggests that an option for improving safety at high collision intersections could be to decrease the speed limit.

5.3 Summary

The What and How analysis provided insight into what interaction was happening between the bicycle user and motor vehicle at collisions locations. A summary of key findings from this section includes:

- The top ten types of reported cycling collisions accounted for 69% of all known collision types, while the top five accounted for 44%. The top collision types are shown in**Figure 5.9**.
- Approximately half of all reported collisions involving bicycle users and motor vehicles took place when the bicycle user was crossing an intersection. The majority of intersection collisions occurred when the cyclist was travelling straight through the intersection, while a vehicle turned either right or left.

Figure 5.9
Top Collision Types
Source: ICBC Collision Data (2007-2012)

Top Collision Types	
Intersections – 50.5%	**Mid-Block Collisions – 40.4%**
Right turning vehicles – 12.6%	Doorings – 15.2%
Left turning vehicles – 14.9%	Driveways, alleyways, and parking lots – 10.7%
Traffic circles – 5%	Travelling the same direction – 5.7%
Sidewalk riding – 3.4%	Sidewalk riding – 2.7%

- The most common type of reported cycling collisions were doorings, which occurs when a driver opens the motor vehicle door and a cyclist collides with it. **Doorings** occurred mostly on arterial streets without designated bikeways, particularly on sections of the street where there were attractive destinations, such as commercial high streets.
- In the majority of cases, when collisions occurred at mid-block conflict zones such as **driveways, alleyways, and parking lots,** the bicycle user was usually proceeding straight ahead and the motor vehicle failed to yield. The majority of these collisions occurred on arterial streets.
- Collisions involving **right turning vehicles** occurred mostly at signalized intersections, and 82% were on arterial streets.
- Collisions involving **left turning vehicles** occurred mostly at signalized intersections, and mostly on arterial streets.
- **Traffic circles** appear to be a localized issue for collisions with motor vehicles based on ICBC data; however, the BICE Injury crash data found that approximately half of the injuries at traffic circles did not involve motor vehicles. This suggests that the design treatments and intersection geometry should be carefully considered with traffic circles.
- Collisions resulting from **sidewalk riding** were found to occur when the bicycle user entered the intersection from the sidewalk or crossed a conflict zone on a sidewalk; these are locations where the motor vehicle driver typically would not expect to be encountering a bicycle.
- In nearly 1,600 of the 2,994 collisions, ICBC data allowed the right-of-way to be evaluated. In approximately 93% of cases, the **cyclist appeared to have the right-of-way**.
- The majority of collisions at intersections occurred when the **bicycle user was travelling with the right-of-way**. These actions indicate that

educational and enforcement campaigns directed to motor vehicle drivers would greatly benefit the safety of cyclists.

6.0

When Analysis

6.1 Introduction

This section summarizes when reported cycling collisions occurred. It includes a summary of collision patterns on annual, monthly, seasonal, day of week, and time of day bases, as well as an assessment of cycling collision trends based on weather and lighting conditions.

The when analysis is based on the reported motor vehicle collision data provided by ICBC, as well as ancillary data such as weather data from Environment Canada, and lighting data from the National Research Council Sunrise / Sunset Calculator. The analysis in this section does not include the injury data from the BICE study due to the limited time duration of the BICE study.

WHEN ANALYSIS INCLUDES:

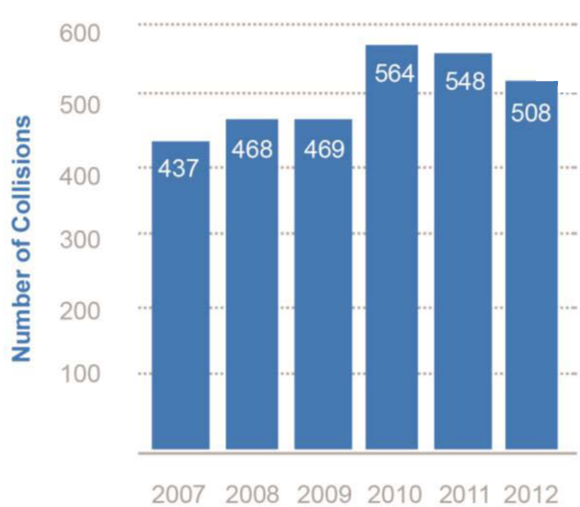
1. Annual
2. Seasonal
3. Monthly
4. Day of Week
5. Time of Day
6. Lighting
7. Weather

6.2 Detailed Findings

6.2.1 Annual Collision Trends

As noted in previous sections, there were 2,994 reported cycling collisions between 2007 and 2012, representing an average of approximately 500 reported collisions per year over this period. As shown in **Figure 6.1**, the number of reported cycling collisions has actually increased over the last six years, likely relating to the increase in the volume of bicycle users over this time, although the number of collisions has decreased slightly since peaking in 2010.

Figure 6.1
Number of Reported Motor Vehicle – Bicycle Collisions by Year (2007 – 2012)
Source: ICBC Collision Data (2007-2012)



6.2.2 Seasonal Collision Trends

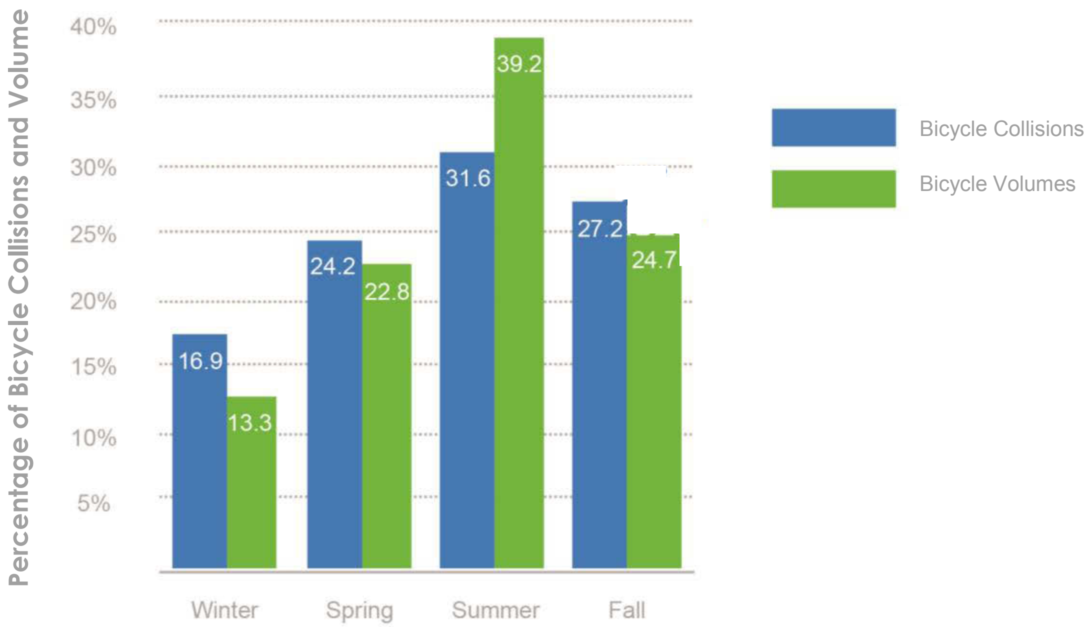
Although there has been an average of approximately 500 reported cycling collisions per year over the past six years, these collisions have followed a distinct seasonal pattern, as shown in **Figure 6.2**. As a reference, the seasons were broken down by month as follows:

- **Winter**: December, January and February
- **Spring:** March, April, and May
- **Summer:** June July and August
- **Fall**: September, October and November

Nearly a third (31.2%) of all reported cycling collisions occurred in the summer months, followed by fall (27.2%) and spring (24.2%). The fewest reported cycling collisions occurred in the winter months (16.9%).

Although the greatest number of reported cycling collisions occurred in the summer, this is also when the greatest bicycle volumes are found. Based on bicycle count data provided by the City of Vancouver at four downtown locations, the summer months accounted for 39.2% of all annual bicycle trips, compared to 31.6% of all annual reported cycling collisions. As such, a lower proportion of reported cycling collisions occurred during the summer months than would be expected based on the corresponding bicycle volumes in the summer months. In all other seasons, the proportion of reported cycling collisions was higher than the corresponding bicycle volumes. This was most pronounced in the winter months, when 16.9% of reported annual cycling collisions occurred, as compared to 13.3% of annual bicycle volumes (difference of 3.6%).

Figure 6.2
Percentage of Reported Motor Vehicle – Bicycle Collisions by Season (2007 – 2012)
Source: ICBC Collision Data (2007-2012), City of Vancouver Bicycle Count Data (2011)



6.2.3 Monthly Collision Trends

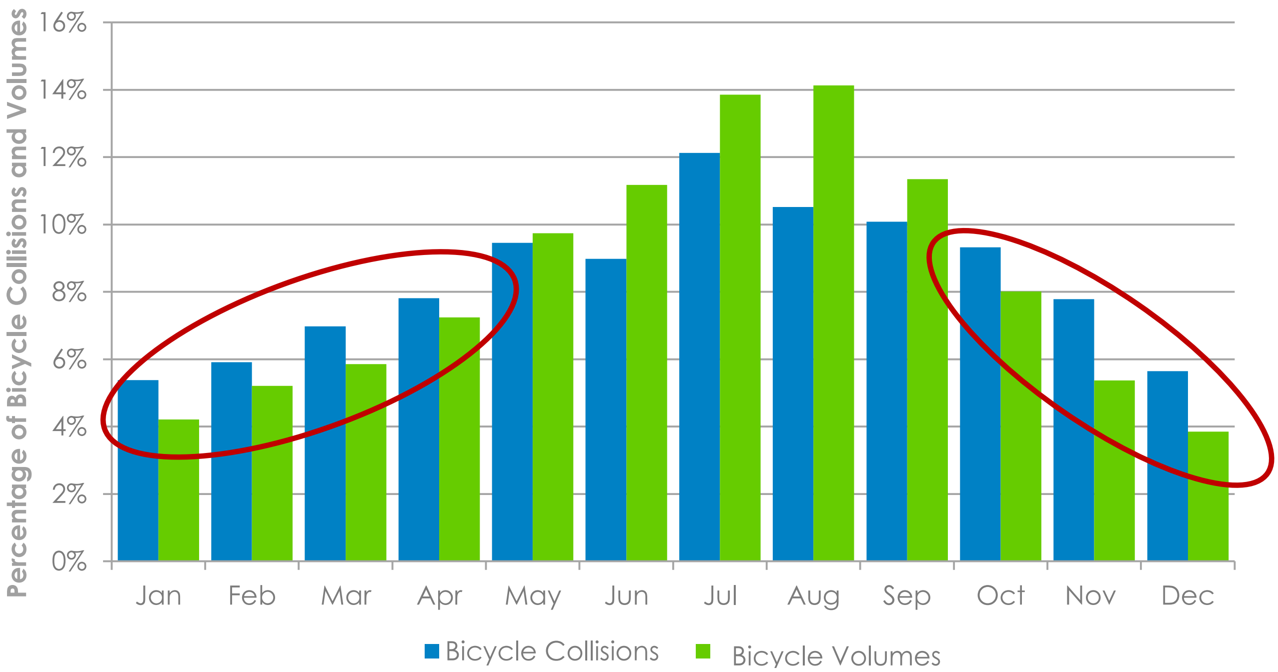
Similar to the seasonal trends, reported cycling collisions also followed a distinct monthly pattern as shown in **Figure 6.3**. As noted above, nearly a third of all reported cycling collisions occurred in the summer months, with the highest proportion of reported cycling collisions occurring in the month of July. Looking at patterns in further detail on a monthly basis, the highest levels of ridership throughout the year occur between May and September, and in each of these months there was a greater proportion of bicycle volumes than reported cycling collisions. This relationship also illustrates the safety in numbers phenomenon discussed previously.

In contrast, for all other months, and particularly between November and January, there is a higher proportion of reported cycling collisions than bicycle volumes. Therefore, although the proportion of cycling collisions is lower in the winter months, there is a higher likelihood of collisions occurring between October and April. In fact, although only 39.7% of bicycle trips are made between October and April, this period accounts for nearly half (48.8%) of all reported cycling collisions.

Figure 6.3

Proportion of Bicycle Trips and Reported Motor Vehicle – Bicycle Collisions by Month

Source: ICBC Collision Data (2007-2012), City of Vancouver Bicycle Count Data (2011)



6.2.4 Daily Collision Trends

Reported cycling collisions were more frequent on weekdays, although more bicycle trips also occurred on weekdays based on bicycle count data provided by the City of Vancouver at four downtown locations. In fact, approximately 80% of all reported cycling collisions occurred on weekdays, almost identical to the proportion of bicycle volumes on weekdays (81%), as shown in **Table 6.1.**

On average, approximately 37% more reported cycling collisions occurred on weekdays compared to weekends, with an average of 9.2 collisions occurring on weekdays compared with 5.8 collisions on weekends.

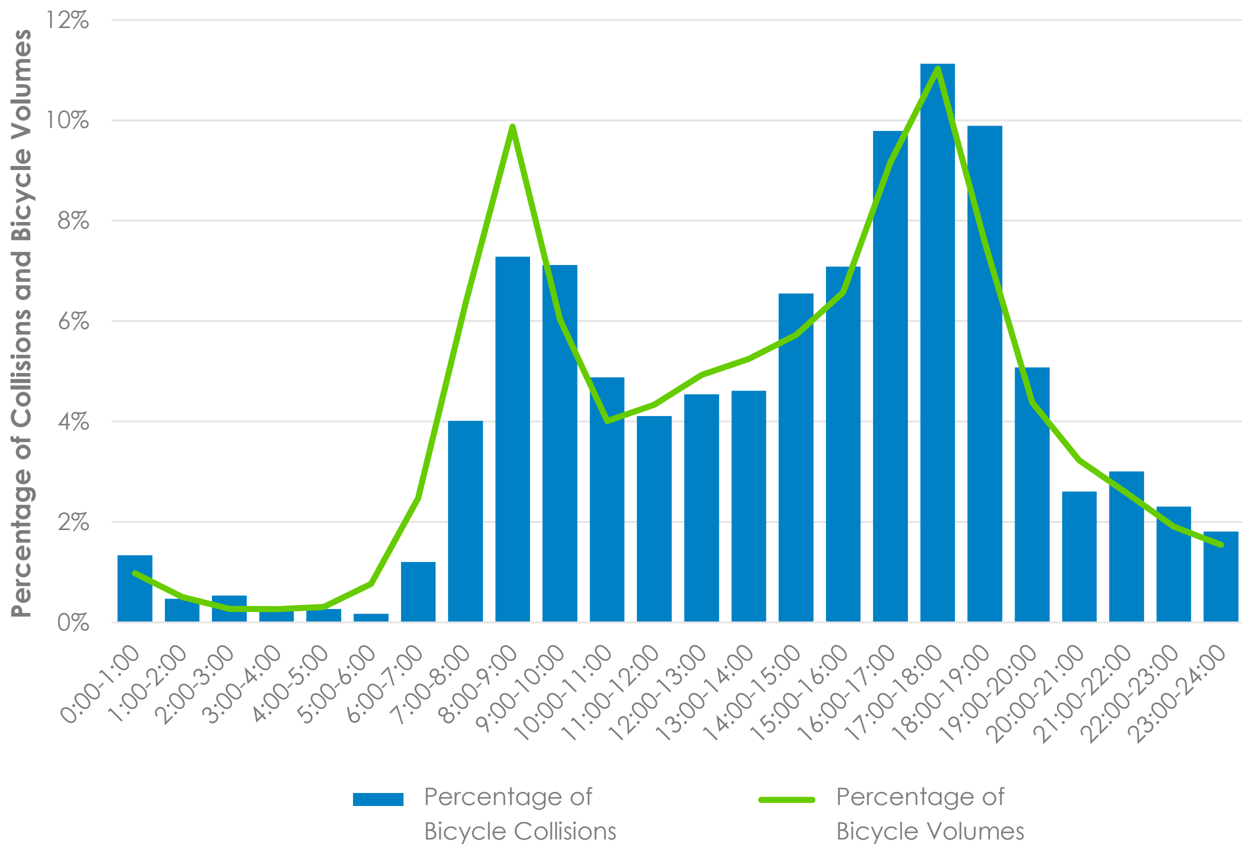
Table 6.1
Average Proportion of Bicycle Volumes by Reported Motor Vehicle – Bicycle Collisions
Source: ICBC Collision Data (2007-2012), City of Vancouver Bicycle Count Data (2011)

Day of the Week	Proportion of Bicycle Volumes (2011)	Proportion of Collisions
Monday	13%	14%
Tuesday	16%	16%
Wednesday	18%	16%
Thursday	17%	18%
Friday	16%	16%
Total Weekday	***81%***	***80%***
Saturday	10%	11%
Sunday	9%	9%
Total Weekend	***19%***	***20%***

6.2.5 Collision Trends by Time of Day

As shown in **Figure 6.4**, the highest proportion of reported cycling collisions occurred during the afternoon peak period (between 4:00 pm and 7:00 pm), which accounted for over a quarter (28%) of all reported collisions. More specifically, on an hourly basis the highest proportion of cycling collisions occurred between 5:00 pm and 6:00pm (11.1% of cycling collisions), followed by 6:00 pm to 7:00pm (9.9% of cycling collisions).

Figure 6.4
Reported Motor Vehicle – Bicycle Collisions by Hour (2007 – 2012)
Source: ICBC Collision Data (2007-2012), Vancouver Bicycle Count Data 2011



In order to identify broader trends at different time periods throughout the day, **Table 6.2** compares the proportion of bicycle volumes per time period with the proportion of reported cycling collisions during the same time periods. During the AM peak period, there were fewer reported cycling collisions (12%) than bicycle trips (19%). Conversely, a slightly higher proportion of reported cycling collisions occurred at all other time periods of the day.

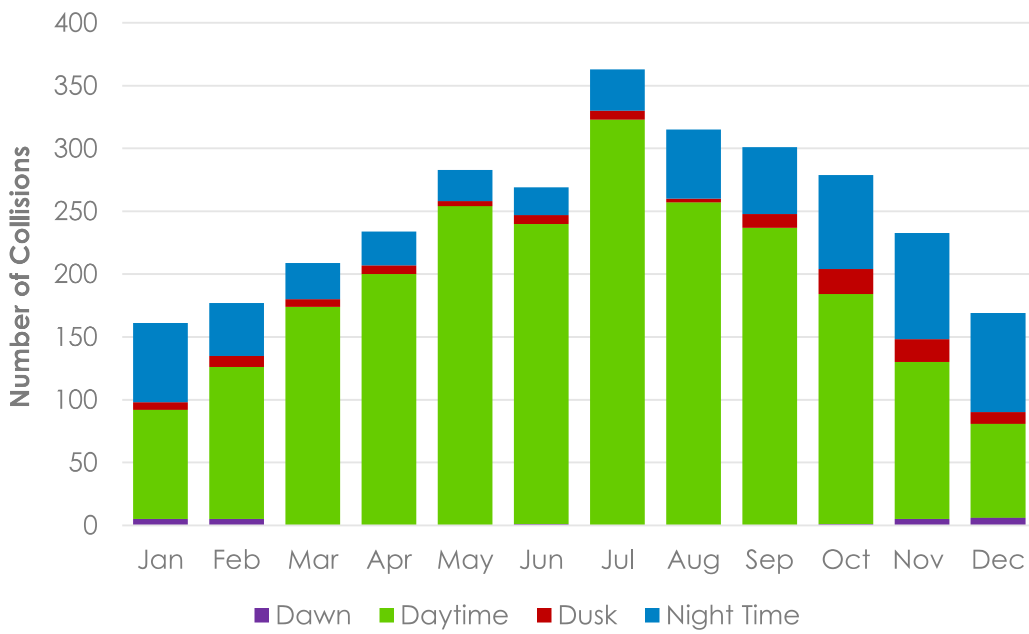
Table 6.2
Average Proportion of Bicycle Trips by Proportion of Reported Motor Vehicle – Bicycle Collisions (Time of Day)
Source: ICBC Collision Data (2007-2012), City of Vancouver Bicycle Count Data (2011)

Time Period	Proportion of Bicycle Volumes (2011)	Proportion of Collisions
AM Peak (06:00-09:00)	19%	12%
Mid-Day (9:00-16:00)	37%	39%
PM Peak (16:00-19:00)	28%	31%
Evening (19:00 – 23:00)	12%	13%
Night Time (23:00-06:00)	5%	5%

6.2.6 Collision Trends by Lighting Conditions

When monthly cycling collision patterns are compared with light conditions based on daily sunrise and sunset data, it can be seen that the majority of reported cycling collisions occurred during daytime hours in all months of the year, as shown in **Figure 6.5**. However, between October and January, there was an increase in the number of reported cycling collisions that were occurring during the night time hours, which is important because there is an increase in the number of night time hours during these months, with shorter days and longer nights. Overall, approximately 76% of all cycling collisions during the year occurred during daylight hours, with approximately 20% occurring during the nighttime.

Figure 6.5
Reported Motor Vehicle – Bicycle Collisions by Month and Light Conditions (2007 – 2012)
Source: ICBC Collision Data (2007-2012); Government of Canada National Research Council Canada (2007-2012)

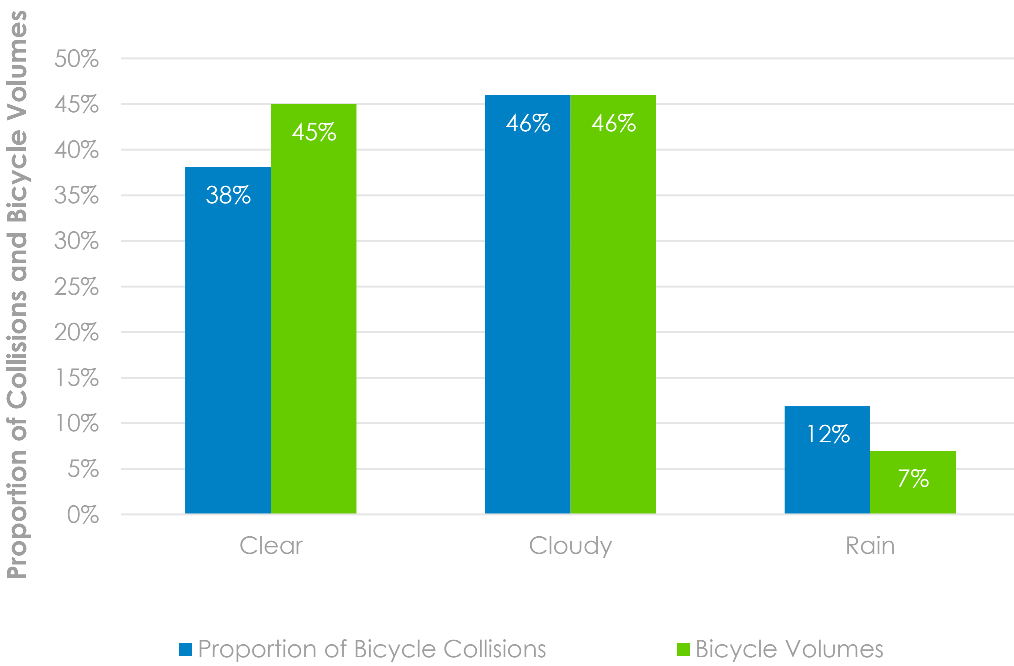


6.2.7 Collision Trends by Weather Condition

The weather conditions associated with each reported cycling collision were determined based on hourly weather data provided by Environment Canada's National Climate Data for all days between January 1, 2007 and December 31, 2012. As shown in

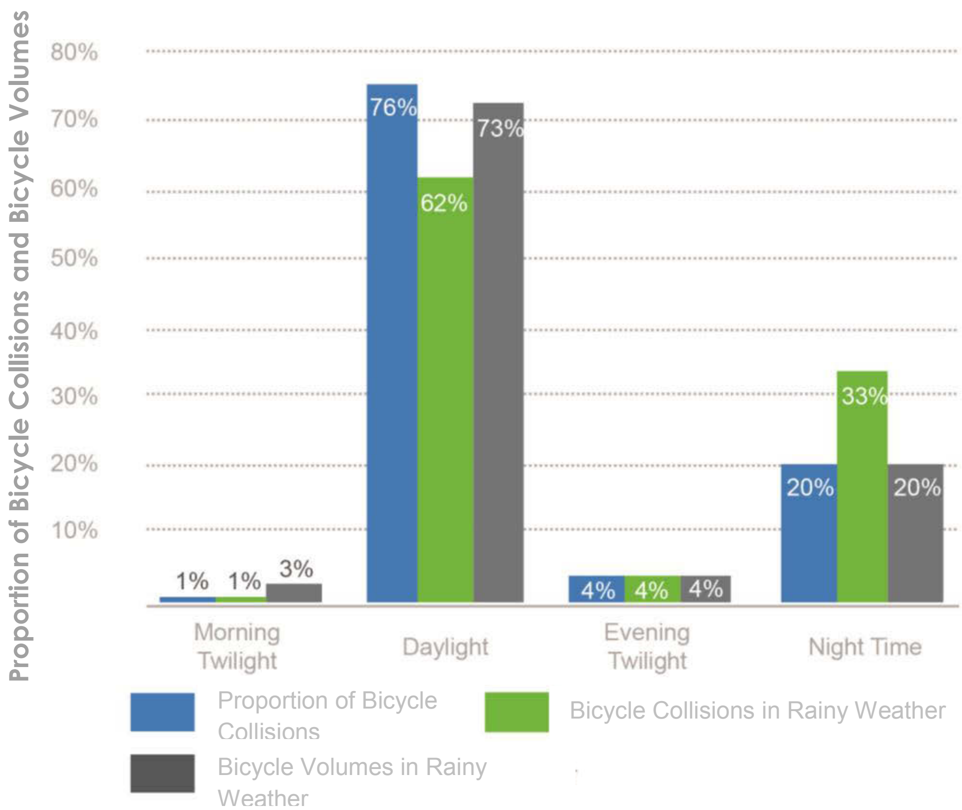
Figure 6.6, the overwhelming majority (84%) of reported cycling collisions occurred on clear or cloudy days (38% and 46% of all cycling collisions, respectively). Reported cycling collisions were underrepresented in clear weather conditions when compared to the number of bicycle volumes on days it was clear. In contrast, there was a higher proportion of reported cycling collisions in rainy weather conditions (12%) compared to the overall number of bicycle trips on days it was raining (7%) and therefore a higher likelihood of collisions on rainy days.

Figure 6.6
Reported Motor Vehicle – Bicycle Collisions by Weather Conditions (2007 – 2012)
Source: ICBC Collision Data (2007-2012), City of Vancouver Bicycle Count Data (2011)



When comparing weather and lighting conditions, a higher proportion of reported cycling collisions in rainy weather occurred when there were dark light conditions. As shown in **Figure 6.7**, although in total only 20% of total cycling collisions occurred in dark lighting conditions, approximately 33% of cycling collisions in rainy weather occurred in dark lighting conditions. Not surprisingly, this suggests that bicycle users are particularly vulnerable when it is both dark and rainy.

Figure 6.7
Reported Motor Vehicle – Bicycle Collisions in Rainy Weather by Light Conditions (2007 – 2012)
Source: ICBC Collision Data (2007-2012), Government of Canada Climate Office (2007-2011), City of Vancouver Bicycle Count Data (2011)



6.3 Summary

This section provided a summary of when reported cycling collisions have occurred in the City of Vancouver. It includes a summary of collision patterns on annual, monthly, seasonal, day of week, and time of day bases, as well as an assessment of cycling collision trends based on weather and lighting conditions. A summary of key findings from this section includes:

- Winter months (December, January and February) had a higher likelihood of cycling collisions, as the proportion of reported cycling collisions was higher than would be expected based on bicycle volumes during these months.
- The highest proportion of cycling collisions occurred during the afternoon peak periods (between 4:00 pm and 7:00 pm). This is also when the highest proportion of cycling volumes occurred.

- A higher proportion of reported cycling collisions occurred when it was dark.
- Bicycle users were particularly vulnerable when it was both dark and rainy, particularly during the winter months when these conditions were more prevalent.

7.0

Who Analysis

7.1 Introduction

This section provides a summary of the demographics of bicycle users who were either involved in reported collisions with motor vehicles (as reported by ICBC collision data), or who were injured in a bicycling crash and treated at a hospital emergency room (as reported by data from the BICE study).

Demographic information is limited to the age and gender of the bicycle user who was involved. Demographic information for the drivers involved in any collisions was not available for this study. Additional data about the characteristics of either the bicycle user or the driver (such as alcohol use, income level, place of residence, or other factors) was not available for this study.

WHO ANALYSIS INCLUDES:

1. Age
2. Gender
3. Combined Age and Gender

7.2 Detailed Findings

7.2.1 Age of Bicycle User

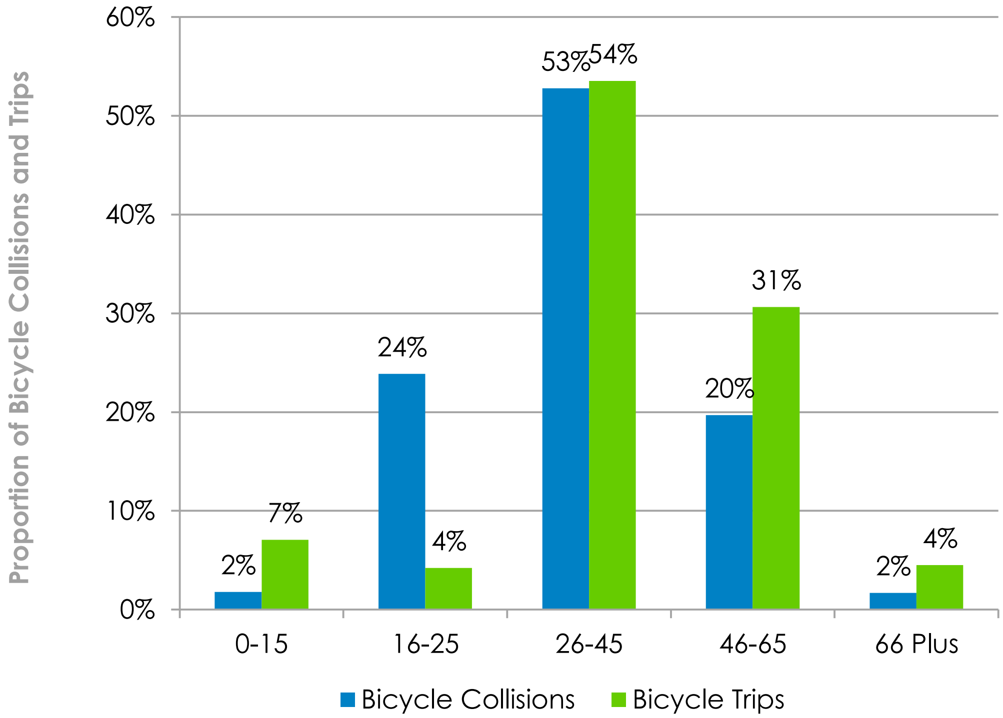
Collisions (ICBC)

As seen in **Figure 7.1**, young adults, ages of 16 and 25 had the highest likelihood of being of being involved in a reported cycling collision. This age group only accounted for 4% of all daily bicycle trips originating in the City of Vancouver, but accounted for 24% of all reported cycling collisions.

Older adults between the ages of 46 and 65 were involved 20% of reported cycling collisions. Unlike young adults, however, bicycle users among this group were involved in fewer collisions than would be expected based on the proportion of daily bicycle trips made, as this age group accounted for nearly a third (31%) of all bicycle trips originating in the City of Vancouver.

Children and youth (aged 15 and under) and seniors (aged over 65) were both involved in only 2% of reported cycling collisions, respectively. Both these age groups had a low likelihood of being involved in a collision.

Figure 7.1
Proportion of Reported Motor Vehicle – Bicycle Collisions and Bicycle Trips by Age
Source: ICBC Collision Data (2007-2012), TransLink Trip Diary Survey (2011)



Injuries (BICE)

As shown in **Table 7.1**, the injury data from the BICE study showed very similar age distributions to the ICBC reported cycling collision data. However, as the BICE study included only adults, the youngest age group included in the BICE study was young adults aged 19 to 25. This age group accounted for 19% of the total of injury crashes, compared to 4% of total daily bicycle trips, as noted in the previous section. As such, this age group was more likely be involved in a cycling collision and a cycling injury crash than would be expected based on the number of bicycle trips made by this group.

Table 7.1

Proportion of Reported Motor Vehicle – Bicycle Collisions, Cycling Injuries and Bicycle Trips by Age

Source: ICBC Collision Data (2007-2012), TransLink Trip Diary Survey (2011), BICE Data (2008-2009)

Category	Age Group		Proportion of Daily Bicycle Trips (Trip Diary)	Proportion of Motor Vehicle Collisions (ICBC)	Proportion of Injuries (all crash types) (BICE)
	ICBC/ Trip Diary	BICE			
Children and Youth	0-15	n/a	7%	2%	n/a
Young Adults	16-25	19-25	4%	24%	19%
Adults	26-45	26-45	55%	53%	53%
Older Adults	46-65	46-65	31%	20%	25%
Seniors	> 65	> 65	4%	2%	3%

7.2.2 Gender of Bicycle User

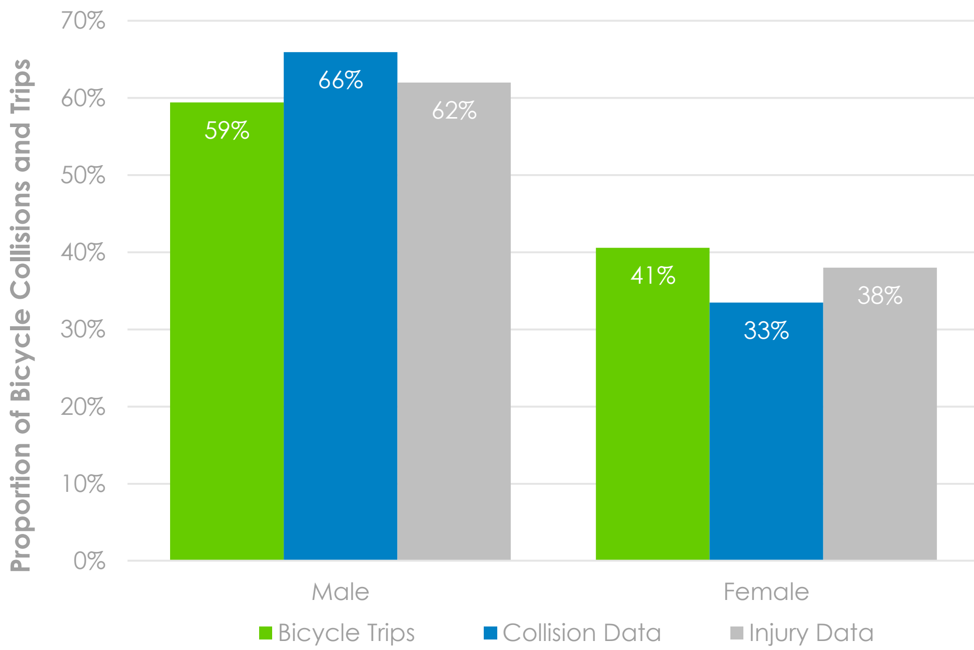
Collisions (ICBC)

Despite the population distribution in Vancouver being almost equal among genders (51% females, 49% males), males were involved in approximately two-thirds (66%) of all reported cycling collisions. As shown in **Figure 7.2**, males also accounted for the majority (59%) of daily bicycle trips made in the City of Vancouver. As a result, the likelihood of being involved in a collision with a motor vehicle was slightly greater for males.

Injuries (BICE)

The injury data from the BICE study found similar results to the ICBC reported collision data, as 62% of injured participants were male, compared with 38% females.

Figure 7.2
Proportion of Reported Motor Vehicle – Bicycle Collisions, Cycling Injuries, Bicycle Trips, and Population by Gender
Source: ICBC Collision Data (2007-2012), TransLink Trip Diary Survey (2011), BICE Data (2008-2009), Population 2011 Canadian Census NHS

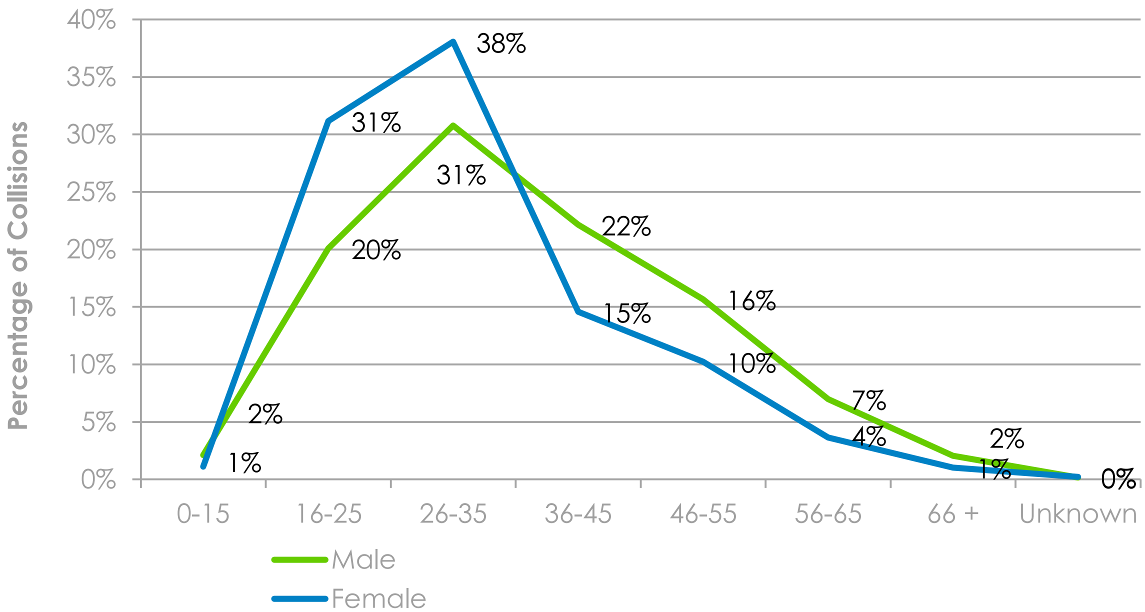


7.2.3 Gender and Age of Bicycle User

Collisions (ICBC)

When comparing the distribution of reported cycling collisions by both gender and age, among both genders the majority of reported cycling collisions occurred between the ages 16 to 45. Female cycling collisions were more concentrated among the 16 to 35 age groups (69%) and male cycling collision were more spread out over the three age groupings between 16 and 45, as shown in **Figure 7.3.**

Figure 7.3
Distribution of Reported Motor Vehicle – Bicycle Collisions by Gender and Age
Source: ICBC Collision Data (2007-2012)



7.3 Summary

This section provided a summary of the demographics of bicycle users who were either involved in reported collisions with motor vehicles (as reported by ICBC collision data), or who were injured while bicycling and attended a hospital emergency room due to their injuries (as reported from the BICE study). A summary of key findings from this section includes:

- Adults between the ages of 26 and 45 were involved in the majority of collisions involving motor vehicles, although this age group also accounted for the highest proportion of daily bicycle trips.
- Young adults between the ages of 16 and 25 were significantly more likely to be involved in reported cycling collisions and cycling injuries than would be expected based on the proportion of bicycle trips made by this age group.
- Gender does not significantly affect the likelihood of being in a collision with a motor vehicle or being involved in an injury crash.

8.0 Action Plan

8.1 Introduction

Based on the analysis of reported cycling collision data from ICBC and supported by the cycling injury crash data from the BICE study, this study identified the following twelve key cycling safety issues in the City of Vancouver:

- **Key Issue 1** Doorings
- **Key Issue 2** Conflict Zones
- **Key Issue 3** Right Hooks
- **Key Issue 4** Left Crosses
- **Key Issue 5** Sidewalk Cycling
- **Key Issue 6** Two-way Stop Signs
- **Key Issue 7** Non Motor Vehicle Collisions
- **Key Issue 8** Collision Hotspots
- **Key Issue 9** High Collision Locations
- **Key Issue 10** Designated Bikeways
- **Key Issue 11** PM Peak
- **Key Issue 12** Adverse Weather and Low Light

This chapter provides an action plan to address these twelve key cycling safety issues based on a number of engineering, education and enforcement countermeasures recommended.

8.2 Cycling Safety Toolkit

This section summarizes the 'toolkit' of engineering countermeasures that are included in the action plan to address each cycling safety issue, including corridor treatments for on-street and off-street facilities, as well as intersection treatments. Further details regarding each of these engineering countermeasures are provided in **Appendix D.** In addition to engineering countermeasures, the action plan includes a range of education and enforcement measures. Best practices and examples of education campaigns are provided in **Appendix E.**

CORRIDOR TREATMENTS (ON-STREET)

Protected Bicycle Lanes, also referred to as cycle tracks, are on-street facilities physically separated from motor vehicles and from pedestrians on the sidewalk.

Parking Protected Bicycle Lanes are located between on-street parking and the curb. The parked motor vehicles act as a buffer for the cyclists from moving traffic.

Buffered Bicycle Lanes are conventional painted bicycle lanes with a painted buffer between cyclists and motor vehicles or parked vehicles or both.

Painted Bicycle Lanes are on-street travel lanes designated for bicycles. They are identified with a white line and a bicycle symbol.

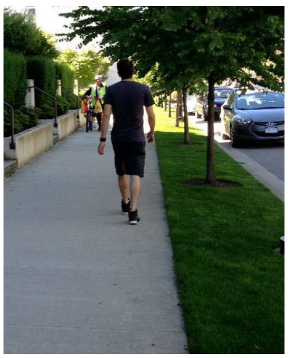
Local Street Bikeways are located on local streets with lower traffic volumes and are designated routes for cyclists, they often have some form of traffic calming.

Shared Use Lanes are often denoted by the use of a "sharrow" pavement marking to indicate that this is a shared space. Bicycles and motorists have to share the lane.

CORRIDOR TREATMENTS (OFF-STREET)

Separated Bicycle and Pedestrian Pathways are off-street pathways that provide separate pathways for pedestrians and cyclists.

Multi-Use Pathways are off-street pathways where pedestrians, cyclists and other users share the same travel space.



Sidewalks are paved pathways that are located on the side of the road. They are designated space for pedestrians and are not legal for the use of cyclists unless otherwise noted. Although not a bicycle facility, the study found that some cyclists may use sidewalks.

INTERSECTION TREATMENTS

Full Traffic Signals are located at major intersections and are used to direct and regulate traffic in all directions.

Dedicated Bicycle Signals provide cyclists with a separate signal head to indicate when they may enter an intersection.

Bicycle and Pedestrian Activated Signals, also referred to as a half signals, are used to assist pedestrians and cyclists in crossing major streets in areas where there is high cyclist demand, but where a full traffic signal is not warranted.

Signal Timing can be adjusted to reduce wait times for cyclists at intersections. Other options include providing leading bicycle intervals and separate bicycle signal phases.

Coloured Conflict Zone Markings can be used to designate conflict zones and areas where cyclists are travelling. They provide visual cues to motorists as to the potential presence of cyclists.

Bike Boxes and Advance Stop Lines provide space for cyclists to wait to cross the intersection. They are often located in advance of the automobile stop line and provide the cyclists a "head start".

Launch Pads/ Two-Stage Left Turns enable cyclists to make a left turn from by continuing through an intersection to a location that sets them up to safely wait to cross the intersection and complete the turning movement.

Median Refuges provide a space in the middle of the road for cyclists to cross one direction of traffic and wait until there is a clearing to cross the other half of the intersection.

Protected Intersections incorporate a combination of treatments, including bicycle signal phases, specific design elements, and space allocation that protect cyclists when travelling through intersections.

8.3 Key Issues and Action Plan

This section outlines the action plan that was developed to address each of the twelve key cycling safety issues that were identified in the City of Vancouver. The action plan includes a description of each issue as well as engineering, education, and enforcement countermeasures recommended to address each issue. The potential cycling safety measure listed under each key issue should not be considered an exhaustive list, but rather are a set of potential cycling safety measures that can be considered for addressing the primary types of cycling collisions in Vancouver. It is likely that there are other measures not considered in this study that may also be appropriate for improving cycling safety. The recommendations are based on a review of literature that has addressed cycling safety as well as the analysis of collision and injury data.

Key Issue 1 Doorings

Doorings were the most common type of reported cycling collision in the City of Vancouver. Doorings occur when bicycle users are struck by or strike a door of a parked motor vehicle, typically on the driver side. Key facts regarding doorings include:

- Approximately 15.2% of all reported cycling collisions involved doorings.
- Approximately 67% of all doorings occurred on arterial streets without designated bikeways.
- The majority of dooring locations were on sections of arterial streets where there were attractive destinations (such as restaurants and shops), including:
  - Broadway;
  - Commercial Drive; and
  - Main Street.
- Approximately 20% of doorings occurred on local street bikeways, including 10th Avenue.

Potential Cycling Safety Measures

Engineering

- On arterial streets without bikeways:

- Investigate the feasibility of providing buffered, parking protected, or protected bicycle lanes.

- On arterial streets with shared use lanes:
  - Investigate the feasibility of upgrading to protected bicycle lanes.
  - Improve paint and frequency of sharrow markings.
  - Review the lateral placement of sharrow markings and, in particular, whether they are placed within the door zone.
- On local street bikeways
  - Investigate the feasibility of removing some on-street parking in areas with constrained width.
  - Upgrade these corridors to provide bicycle lanes or protected bicycle lanes.
- In the design of all new and enhanced bikeways on streets with on-street parking, seek to reduce the risk of dooring by:
  - Removing on-street parking.
  - Providing protected bicycle lanes.
  - Providing parking protected bicycle lanes by placing bikeways on the passenger side of motor vehicle parking lanes.
  - Seek to provide a minimum buffer space of 0.5 metres if the bikeway is on the diver side of the motor vehicle.

Education

- Education campaigns for drivers reminding them to look for bicycles before opening their door.
- Education campaigns for bicycle users to raise awareness of the risk of dooring and how to position themselves in the roadway.
- Encourage ICBC and the Provincial government to add educational material similar to what is done in other cities (as discussed in **Appendix E**), regarding the importance of looking for bicycle users before opening the door in driver education and licensing.

Key Issue 2 Conflict Zones

Mid-block conflict zones such as driveways, parking lots and alleyways accounted for approximately 10.7% of all collisions involving bicycle users and motor vehicles. This type of collision occurred between a bicycle user and a motor vehicle entering or exiting an alleyway, paking lot, or driveway. As the bicycle users were proceeding straight ahead, motor vehicles were identified as failing to yield when they were pulling in or out of these locations.

The majority (58%) of conflict zone collisions occurred on arterial streets and 56% of these arterial streets did not have designated bikeways. Several locations were identified as hot spots for collisions that occurred when drivers were entering or exiting an alleyway, paking lot, or driveway, including: Burrard Street, Main Street, Broadway, Kingsway, 1st Avenue and 10th Avenue.

Potential Cycling Safety Measures

Engineering

- Continue to provide and retrofit existing conflict zone pavement markings at driveways and alleyways that have high collisions involving bicycle users and motor vehicles.
- Consider providing bikeways or upgraded existing bikeways on routes with conflict zones.
- Provide warning of high bicycle collision location signage at driveways and alleyways that have high collisions involving bicycle users and motor vehicles and where there is no existing bikeway.
- Remove on-street parking immediately adjacent to high activity driveways and alleyways to ensure bicycle user visibility.

Education

- Education campaigns to raise awareness of drivers to look for bicycle users when entering or exiting a parking lot or alleyway.

Key Issue 3 Right Hooks

Collisions involving right turning vehicles, also known as 'right hooks', accounted for approximately 12.6% of all reported cycling collisions. Most of the right hook collisions within the City of Vancouver occurred in the Downtown core. The majority of the right hooks occurred on arterial streets (82%), including 41% on arterial streets with no bikeways. Many of these collisions occurred at signalized intersections when the bicycle user was crossing with the signal.

A higher than expected number of right hooks occurred on Dunsmuir Street after the protected bicycle lanes were installed involved motor vehicles making prohibited right turns and colliding with bicycle users, or involved motor vehicles failing to yield to bicycles.

Potential Cycling Safety Measures

Engineering

- Prohibit right turns on red at locations with high cycling volumes and/or locations with a high number of right hook collisions.
- Use dedicated signal phasing to separate phases for motor vehicles and bicycle users and/or provide leading cycling intervals to give bicycle users an advanced signal, allowing them to clearly establish their right-of-way in the crossing before vehicles are given a green light; alternatively, provide leading vehicle intervals to allow them to clear the intersection before bicycle users are permitted to proceed straight.
- Pull back the motor vehicle stop bar behind the stop bar for the bicycles to increase visibility of the bicycle users.
- Implement right turn only lanes for motor vehicles at intersections where there is sufficient space. Dedicated right turn bays provide a dedicated space for motor vehicles to make a right turn; provide a clear signal to bicycle users that they can expect motor vehicles to turn right and removes ambiguity that may arise in a shared through/right-turn lane if the driver fails to signal; and removes pressure for the driver to make a turn with vehicles wishing to proceed straight through the intersection behind them.
- Consider installing protected intersections, which utilize a combination of bicycle signal phases and design elements as well as space allocation to help protect cyclists from turning vehicles. Installing these treatments at high collision intersections that use a combination of corner refuge islands, a forward stop bar for bicyclists, a setback bicycle and pedestrian crossing and protected bicycle phasing help protect bicycle users in intersections as they are riding along on-street protected bikeways.
- Continue to provide and retrofit green coloured conflict zone markings and dashed lane markings through intersections to identify places for bicycle users to safely wait to cross the intersection.
- Prohibit all right turns where there is a high number of right hook collisions and where it is not feasible to provide a dedicated right turn only lane, particularly where the right turn crosses a bi-directional protected bicycle lane.
- Raised bicycle and/or pedestrian crossings might also be considered for some intersections.

Education

- A road safety awareness campaign can be directed at both drivers and bicycle users, reminding them to look out for each other at intersections.

Enforcement

- Regular enforcement of restricted motor vehicle right-turns by police should be encouraged, with a focus on intersections with high numbers of cycling collisions or illegal movements, particularly Dunsmuir Street.

Key Issue 4 Left Crosses

Collisions involving left turning vehicles at intersections, also known as left crosses, were the most common type of vehicle movement resulting in a collision (14.9%). Similar to collisions involving right turning vehicles, many of these collisions occurred at signalized intersections when the bicycle user was crossing with the signal. Similar to other key issues, the majority of left cross collisions occurred on arterial streets, with 36% of left crosses occurring on arterial streets with no bikeways. For the majority (77%) of left crossing collisions, the collision occurred while the bicycle user and motorist were travelling in opposing directions on the same street.

Potential Cycling Safety Measures

Engineering

- Implement uni-directional protected bikeways where possible to minimize cyclists travelling in the opposing direction of motor vehicle traffic.
- Pursue design options that discourage cycling the wrong way in a bikeway.
- Implement left turn only lanes where there is sufficient space. Dedicated left turn lanes provide a dedicated space for motor vehicles to make a left turn; provide a clear signal to bicycle users that they can expect motor vehicles to turn left and removes ambiguity that may arise in a shared through/left-turn lane if the driver fails to signal; and removes pressure for the driver to make a turn with vehicles wishing to proceed straight through the intersection behind them.
- Continue to provide and retrofit green coloured conflict zone markings and dashed lane markings through intersections to indicate that bicycle users will be travelling through.
- Consider installing protected intersections at high collision intersections.

Education

- Educational campaigns that highlight the importance of vehicles being aware to look for bicycle users as they are making left turns and for bicycle users to make themselves more visible to motorists.

Key Issue 5 Sidewalk Cycling

Approximately 6% of collisions occurred where the bicycle users were reportedly riding on the sidewalk prior to entering the intersection or conflict zone. Sidewalk cycling can create visibility challenges with motor vehicles who may not be expecting them at intersections or conflict zones, and also can create safety concerns with pedestrians and other sidewalk users. Due to the location of the incidents of sidewalk cycling, in many cases it is likely that bicycle users may be using sidewalks because there are insufficient and/or uncomfortable bicycle routes on the adjacent street. Most sidewalk cycling incidents resulted in two types of collisions:

- Vehicle and bicycle user collided mid-block as the vehicle was entering or exiting a driveway, alleyway or parking lot (44% of collisions with bicycle users travelling on the sidewalk); and
- Vehicle turned right at an intersection (26% of collisions with bicycle users travelling on the sidewalk).

The top collision locations where bicycle users were riding on the sidewalk include:

Arterial Streets	Local Street Bikeways
Kingsway (8) Hastings Street (8) Clark Drive (6) Main Street (5) Commercial Drive (4) Victoria Drive (4)	10th Avenue (4)

None of the arterial streets noted above have designated bicycle facilities, with the exception of Main Street, which has shared use lanes.

Potential Cycling Safety Measures

Engineering

- One of the possible explanations as to why bicycle users are travelling on the sidewalk as opposed to the street is because riding on the street does not feel safe or comfortable. As such, provide on-street bikeways on streets with high numbers of bicycle users on sidewalks where possible.

Education

- Awareness and education campaigns directed to bicycle users informing them that riding on the sidewalk poses its own risks, is not safe, and is illegal in most cases. Vehicles are not expecting bicycle users to be on sidewalks and are not looking for them, and there is increased likelihood of bicycle users colliding with pedestrians on the sidewalk.

Enforcement

- Enforcement campaigns to highlight the risks of sidewalk cycling, particularly at conflict zones.
- Increased enforcement of sidewalk cycling.

Key Issue 6 Two-Way Stops

Collisions at two-way stops involving all motor vehicle turning movements (right turns, left turns, and straight motor vehicle movements) accounted for 31% of all intersection collisions and 17% of all reported cycling collisions. In all cases where right of way could be determined for two-way stops most of the collisions (84%) occurred as a result of the vehicle not stopping at the stop sign while the bicycle users had the right of way (was on the major street that did not have the stop sign).

Potential Cycling Safety Measures

Engineering

- Speed reduction treatments that slow all road users down as they are entering the intersection, such as curb extensions, raised crosswalks, and raised intersections.
- Remove on-street parking adjacent to the stop sign to improve bicycle user visibility.

Education

- Education campaigns to watch for bicycle users in intersections.

Enforcement

- Enforcement for road users not stopping at stop signs, especially at high collision locations such as:
  - Campbell Avenue and Union Street (8);
  - Burrard Street and Harwood Street (7);
  - Discovery Street and 16th Avenue (5);
  - Laurel Street and 10th Avenue (4);
  - Main Street and 4th Avenue (4);
  - Pine Street and 7th Avenue (4);
  - Ontario Street and 8th Avenue(4); and
  - Ontario Street and 3rd Avenue (4).

Key Issue 7 Non Motor Vehicle Collisions (BICE)

This key issue summarizes results cycling injury crash results from the BICE study It includes non-motor vehicle injury crashes between bicycle users and pedestrians, road infrastructure, and debris. Collisions between bicycle users and pedestrians are typically underreported or not reported at all6. A number of studies and researchers have worked to better understand the characteristics and frequency of collisions between bicycle users and non-motor vehicles including collisions with pedestrians and animals etc (see **Appendix F** for annotated bibliography). The BICE study found that a minority of injury crashes were a result of collisions with motor vehicles (37%), although another 10% involved avoidance manoeuvres to avoid a motor vehicle collision. It found that 12% of cycling injuries resulting in an emergency room visit were a result of bicycle users crashing because of surface conditions (holes, bumps, roots, debris, leaves, etc.), 11% were a result of infrastructure (curbs, bollards, posts, etc.), and 8% were a result of a collision with a cyclist, pedestrian or animal.

Potential Cycling Safety Measures

Engineering

- Develop a reporting program with local partners to create a database of non-motor vehicle collisions and near misses.
- Collaborate with Vancouver Coastal Health to improve the monitoring and analysis of cycling collisions and falls to supply pertinent and timely information about injuries to City of Vancouver.

- Provide separate pedestrian and bicycle pathways instead of shared multi-use pathways where feasible; when not possible, ensure sufficient width is provided for the multi-use pathway.
- Ensure signage and paint markings so that the protected routes are easily identifiable. For example, low signage, or markings on the ground, and lit at night.
- Provide separate marked crosswalks and marked bicycle crossings at intersections to separate pedestrians and bicycle users when crossing roadways.
- Ensure bikeways are well-maintained and clear of debris through ongoing maintenance and sweeping.
- Continue to monitor pavement quality on all bicycle facilities to ensure bicycle facilities have smooth surfaces.
- Ensure that signage, poles and bollards are in appropriate locations so as not to create vertical or horizontal obstructions.

Key Issue 8 **High Collision Corridors**

Several corridors throughout the City were identified that had a high density (collisions/km) of reported bicycle user and motor vehicle collisions. The top five collision corridors based on collision density included:

1. Burrard Street (West Hastings Street to Harwood Street) – 11.5 collisions / Km / year
2. Commercial Drive (Adanac Street to East 12th Avenue) – 6.3 collisions / Km / year
3. Clark Drive (Adanac Street to West 10th Avenue) – 5.3 collisions / Km / year
4. Pacific Street (Hornby Street to Homer Street) – 5.2 collisions / Km / year
5. Cypress Street (Cornwall Avenue to West 19th Avenue) – 5.0 collisions / Km / year

In addition, high collision frequencies were also found on 10th Avenue (Trafalgar Street to Victoria Drive), Main Street (Powell Street to West Kent Avenue), and Broadway (Highbury Street to Commercial Drive). The highest collision corridors generally corresponded with streets with bikeways. This likely indicates that they have a high level of usage. The BICE data can be used to help confirm this assumption, as it identified routes that had a higher likelihood of collisions involving motor vehicles. The findings of the BICE study recognized portions of Main Street and parts of 10th Avenue. While this study identified other routes with high collision frequencies, the likelihood of collisions was not as high due to the greater number of bicycle users on these routes.

Cycling safety issues along high collision corridors should be proactively addressed and monitored by utilizing the additional treatments recommended in this study.

Potential Cycling Safety Measures

Engineering

- Consider higher order bikeways on high collision corridors or, in cases where this is not possible, provide more comfortable routes on parallel streets for all ages and abilities.
- Consider collision prone corridors such as Main Street, Burrard Street, and Commercial Drive for complete streets policies and initiatives.
- Conduct corridor specific studies and/or in-service road safety reviews of high collision corridors to identify potential safety measures. This can be done by evaluating groups of intersections and mid-block locations along corridors and considering 'packages' of complementary mitigation measures to deal with primary collision types identified in the What & How Section.

Education

- Complement engineering measures with a road safety awareness campaign to alert both motorists and bicycle users of the prevalence of cycling collisions along corridors and at intersections and encourage more caution in these areas.

Enforcement

- Work with the VPD to perform enforcement actions along corridors with high occurrences of collisions to discourage unsafe behaviour on the part of both motorists and bicycle users.

Key Issue 9 High Collision Locations

In addition to identifying the corridors with the greatest number of collisions, it is important to identify the specific high collision locations within the City of Vancouver. Four of the top five intersections with the greatest number of recorded collisions are located along the identified hotspot corridors.

Collision Locations	Number of Collisions
Burrard Street Bridge & Pacific Street	37
Main Street & E 2nd Avenue	22
Clark Drive & E 10th Avenue	19
Pine Street & W 10th Avenue	17
Burrard Street & Davie Street	17

There were nineteen locations that had more than 10 reported collisions between 2007 and 2012 as identified by the ICBC data. Most of these collisions occurred at intersections that were controlled by a full signal (72%), followed by intersections with a half signal (17%) and a two-way stop (11%).

Potential Cycling Safety Measures

Engineering

- Install dedicated bicycle signals with separate bicycle signal phasing where feasible and ensure all intersections have bicycle detection, including bicycle activated pushbuttons or loop detectors.
- Continue to provide green coloured conflict zone markings and dashed lane markings through intersections that highlight areas where the bicycle user may be likely to cross.
- Implement dedicated left turn and right turn only lanes for motor vehicles at intersections where there is sufficient space.
- Provide a safe queuing area for bicycles at intersection including bike boxes or launch pads/two stage left turns.
- Installing full traffic signals at intersections where collision rates are high.

Key Issue 10 Designated Bikeways

This study has helped to identify some key collision locations based on the type of bike facility or designated bikeway. While the majority of collisions occurred on streets without designated bicycle facilities, there was still a significant percentage (44%) of collisions that occurred on bikeway routes. There were three main takeaways from the results of this study:

1. Arterial streets with no bicycle facilities were the most common location for collisions.
2. Collisions occurred frequently on shared use lanes, in particular the Main Street corridor was found to have a high occurrence of collisions. Main Street and East 2nd Avenue had the second highest number of bicycle

collisions for a single intersection, and Main Street and East 10th Avenue was ranked seventh.

3. Local street bikeways had the highest number of reported collisions out of all types of designated bikeways within the City of Vancouver, but are also the most common. These corridors also have high cycling usage. A fewer proportion of collisions occurred on local street bikeways as compared to their prevalence within the City's bicycle network.

Potential Cycling Safety Measures

Engineering

- Analyze the feasibility of installing bikeways on corridors with high cycling collisions, especially on routes with important neighbourhood destinations such as shopping streets (ex. Broadway and Main Streets).

Key Issue 11 PM Peak

The collision data indicated that the majority of reported cycling collisions occurred during the afternoon peak period. Reported cycling collisions were most common between 4:00 and 7:00 pm, which accounted for nearly a third (31%) of all reported cycling collisions. This is also when the highest proportion of cycling volumes occurred. The prominence of cycling collisions in the evening peak period offers opportunities to efficiently improve safety, such as coordinating enforcement actions during this time period. This time period has been identified as a high activity period with high volumes of bicycle users, motorists and pedestrians.

Potential Cycling Safety Measures

Engineering

- Provide more time for bicycle users at intersections by coordinating signal timings, decreasing the wait at push buttons, or installing bicycle friendly signal timing.
- Provide more visibility for bicycle users at intersections by installing advance stop line or bike boxes.

Education

- Road safety awareness campaign targeted at all road commuters to inform of the high collision rates in the PM peak periods and that all road users should exercise additional caution after a long work day.

Enforcement

- Concentrated enforcement action in the 4:00 and 7:00 pm time period at the collision hotspots and high risk locations.

Key Issue 12 Adverse Weather and Low Light

Research indicates that adverse weather and darker lighting conditions, which occur with shorter winter days, can increase the occurrence of cycling collisions. The number of bicycle trips is also significantly impacted by weather and seasonal conditions. The study found that a higher than expected number of collisions occurred in winter months, relative to the observed cycling volumes, particularly when it was dark and rainy.

Potential Cycling Safety Measures

Engineering

- Improve street lighting at intersections with high collisions and on bikeways, particularly local street bikeways.
- Ensure road surfaces on bikeways are skid resistant and provide adequate drainage to prevent water pooling and icy conditions.

Education

- Remind cyclists about additional equipment such as bicycle lights that can increase cyclist visibility in dark and low light conditions.

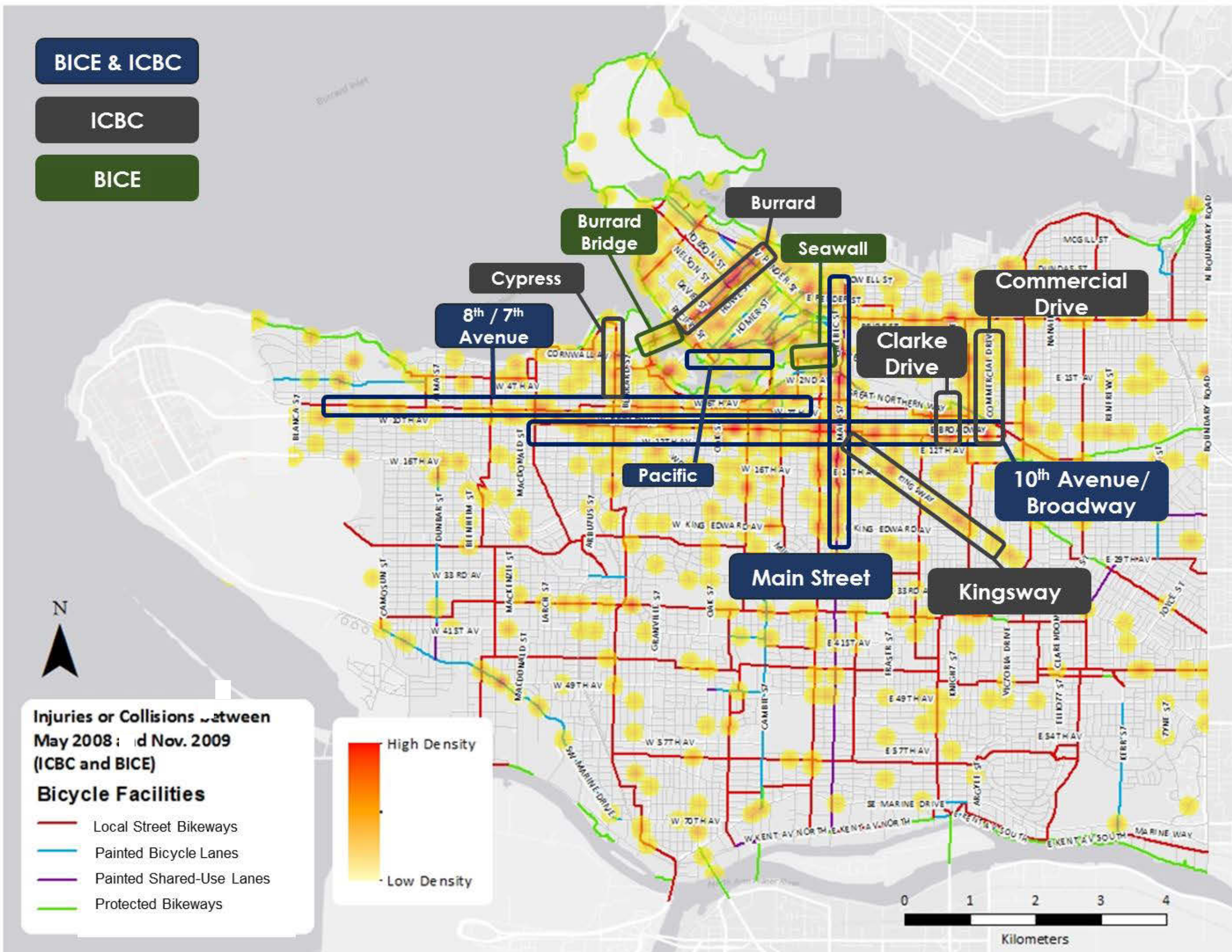
8.4 Priorities and Next Steps

The following section outlines the key findings from this study and highlights the areas and locations of focus for priority actions in terms of engineering, education and enforcement projects and initiatives.

Engineering

A number of corridors repeatedly emerged as having high collision frequency, density, or likelihood, and presented a range of cycling safety issues. **Figure 8.1** summarizes the corridors that most frequently emerged through the reported cycling collision data analysis based on ICBC data and the cycling injury crash data based on BICE data, including corridors that showed up through the analysis of both datasets.

Figure 8.1
Top Reported Cycling Collision and Cycling Injury Crash Corridors
Source: ICBC Collision Data (2007-2012), UBC BICE Data (May2008-Nov 2009)



The engineering priorities are broken down by top collision corridors as seen in **Table 8.1.** These findings are based on a review of both the reported cycling collision data provided by ICBC and the cycling injury crash study data from the BICE study. **Table 8.1** below summarizes the priorities for the top collision corridors within the City. The presence of full circles indicates that the corridor ranks high for the collision analysis results, the half circle indicates it has a medium ranking and the empty circle indicates the ranking for the corridor is low. Based on these factors, eight corridors presented cycling safety issues as shown in **Table 8.1**. Safety reviews should be conducted on these corridors in the following priority:

- **Highest priority:** Main Street and Burrard Street
- **Moderate priority:** Commercial Drive, 10th Avenue, and Broadway.

- **Lower priority:** Clark Drive, Pacific Street and Cypress Street.

The prioritization of each corridor was determined based on four criteria that are defined below:

Collision Frequency	Is based on ICBC data and the total number of collisions involving a bicycle user and motorized vehicle.
Collision Density	Is based on ICBC data and the number of collisions involving a bicycle user and motorized vehicles on the corridor divided by the length of the corridor.
Collision Likelihood	Is based on BICE data and represents the number of injuries divided by the bicycling trips through that location
Collision Types	Is based on ICBC and BICE data and is a measurement of how many of the key collision types were identified as a key issue on the corridor.

Table 8.1

Top Collision Corridors (2007 – 2012)

Source: ICBC Collision Data (2007-2012), Bicyclists' Injuries and the Cycling Environment (BICE) Study (May2008-Nov 2009)

High Collision Corridors	Collision Frequency	Collision Density	Collision Likelihood	Collision Types	Key Collision Types	Bicycle Facility
Main Street	●	◒	●	●	▪ Doorings ▪ Conflict Zones ▪ Bicycle Facilities ▪ High Collision Locations	Shared Use Lane
Burrard Street	●	●	●	●	▪ Conflict Zones ▪ Right Hooks ▪ High Collision Locations	Painted Bicycle Lane
10th Avenue	●	●	◒	◒	▪ Doorings ▪ Bicycle Facilities	Local Street Bikeway
Broadway	●	◒	◒	◒	▪ Doorings ▪ Bicycle Facilities	None
Pacific	○	●	●	○	▪ Right Hooks	Painted Bicycle lane
Clark Drive	◒	●	○	◒	▪ High Collision Location ▪ Sidewalk	None/ Protected Bikeway
Cypress Street	◒	●	◒	○		Local Street Bikeway
Commercial Drive	◒	●	○	●	▪ Doorings ▪ Bicycle Facilities	None

In addition to engineering treatments at high collision corridors and locations, there are a number of education and enforcement recommendations as described below:

Education

- **Doorings** including campaigns targeted to motor vehicle drivers and passengers to be sure to look out for bicycle users before opening their door;
- **Parking lot and driveway entrances and exits**, including education campaigns for both bicycle users and motor vehicle drivers; and
- **Passing**, including providing educational tools of the value of leaving space between bicycle users and vehicles when passing and waiting behind bicycle users as they are taking the lane to avoid doorings;
- Providing increased awareness of potential risk during the **afternoon commute and dark and rainy conditions;**
- Providing increased awareness of hazards at locations with **high proportion of right/left turning vehicles**;
- **Sidewalk cycling**, can also be addressed through education initiatives by informing bicycle users of the potential hazard of riding on the sidewalks and understanding collision potential, and enforcement of illegal sidewalk cycling; and
- A **joint education campaign** for pedestrian and cyclist safety, providing awareness of the number of collisions that occur when motor vehicles are turning left and right.

Enforcement

- Increased enforcement of vehicles **violating left turn and right turn regulations**; and **Table 8.2** below summarizes the engineering, education, and enforcement countermeasures that are available to address cycling safety issues, they have been broken down by key issue.

Table 8.2

Summary of Engineering, Education, and Enforcement Countermeasures to Address Cycling Safety Issues

Action	Typical Application	Doorings	Conflict Zones	Right Hooks	Left Crosses	Sidewalk Cycling	Two-Way Stop Signs	Non Motor Vehicle Collisions	High Collision Locations	Bikeways	PM Peak	Adverse Weather and Low Light
Engineering												
Corridor Treatments												
Protected Bicycle Lanes	▪ Streets with higher traffic speeds and volumes and with identified cycling safety issues to provide physical separation.	✓				✓		✓		✓	✓	
Parking Protected Bicycle Lanes	▪ Streets with higher traffic speeds and volumes and with on-street parking. Located adjacent to the curb with motor vehicle parking located between the bicycle lane and the moving vehicles	✓				✓		✓		✓	✓	
Buffered Bicycle Lanes	▪ Streets with higher traffic speeds and volumes and with identified cycling safety issues to provide increased shy distance between moving vehicles or parked cars and the bicycle lane	✓				✓		✓		✓	✓	
Painted Bicycle Lanes	▪ Streets with moderate traffic speeds and volumes. Avoid placing next to on-street parking on the driver side of parked motor vehicles unless buffer can be provided.					✓		✓		✓	✓	
Off-Street Bicycle and Pedestrian Pathways	▪ Off-street pathways that provide separated facilities for bicycle users and pedestrians	✓	✓			✓		✓		✓	✓	
Off-Street Multi-Use Pathways	▪ Consider off road pathways that bicycle users and pedestrians share the space	✓	✓			✓		✓		✓	✓	
Local Street Bikeways	▪ Shared facilities on lower volume streets. Consider designated local street bikeways to provide routes parallel to arterials that have lower traffic volumes and speeds					✓		✓		✓	✓	
Shared Use Lanes	▪ Streets with moderate traffic speeds and volumes. Avoid placing next to on-street parking on the driver side of parked motor vehicles unless buffer can be provided. Generally not recommended.											
Intersection Treatments												
Full Traffic Signal	▪ Install at half signal intersections with a high number of collisions						✓		✓		✓	
Dedicated Pedestrian and Bicycle Signal	▪ New dedicated bicycle signals at high collision intersections to allow bicycle users to clear the intersection separate from other vehicles.				✓		✓		✓		✓	
Bicycle Activated Signal	▪ Install at intersections where local roads and arterial roads intersect						✓		✓		✓	
Signal Timing	▪ Adjust signal timing to minimize cycling delay ▪ Coordinate signal timing to reduce vehicle speeds ▪ Provide separate phasing plans to provide additional cycling time at select intersections during the PM peak period			✓	✓		✓		✓		✓	
Coloured Conflict Zone Markings	▪ Use green coloured conflict zone markings that denote areas where conflict between vehicles and bicycle users		✓	✓	✓				✓		✓	
Bike Box/Advance Stop Lines	▪ Treat high collision intersections with bike boxes and advance stop lines that provided dedicated spaces for bicycle users to wait and have a head start at intersections			✓	✓				✓		✓	

Action	Typical Application	Doorings	Conflict Zones	Right Hooks	Left Crosses	Sidewalk Cycling	Two-Way Stop Signs	Non Motor Vehicle Collisions	High Collision Locations	Bikeways	PM Peak	Adverse Weather and Low Light
Launch Pad/ Two-Stage Left Turn	▪ Install facilities that allow bicycle users to make left turns from a protected bicycle lane to move through the intersection and compete the left turn more efficiently and safely				✓				✓		✓	
Median Refuge	▪ Providing a refuge space in the median that provides a space for bicycle users to wait for traffic to clear								✓		✓	
Protected Intersection	▪ Provides a protection for bicycle users riding on cycle tracks as they enter an intersection			✓	✓				✓		✓	
Raised Crossings	▪ Provide a raised speed hump that also functions as a crossing, slowing down vehicles as they approach the hump.			✓							✓	
Traffic Calming												
Median Barriers	▪ Consider installing median barriers to limit left turn movements particularly at locations where there are a high number of left turn movements into driveways.								✓		✓	
Diverters	▪ Consider to restrict vehicle assess while allowing travel by other road users								✓		✓	
Curb Extensions	▪ Consider to calm traffic and make road users more visible			✓					✓			
Road Closures	▪ Consider closing roads for motor vehicle traffic								✓			
Traffic Circles	▪ Install traffic circles instead of 2-way and 4 way stops to slow traffic while maintaining some flow						✓		✓			
2-Way Stop	▪ Consider converting a 4-way or traffic circle into a 2-way stop if the volume on one road is much higher than the other.								✓			
Parking Removal	▪ Consider removing on street parking on corridors where there is a high number of doorings and collisions resulting from entering and exiting on street parking spots	✓								✓		

Action	Typical Application	Doorings	Conflict Zones	Right Hooks	Left Crosses	Sidewalk Cycling	Two-Way Stop Signs	Non Motor Vehicle Collisions	High Collision Locations	Bikeways	PM Peak	Adverse Weather and Low Light
Education and Encouragement												
Road Safety Awareness Campaigns	▪ Consider the following targeted road safety awareness campaigns: ▪ High collision arterials ▪ Encourage bicycle users to be safe and cautious road users ▪ Remind road users that most cycling collisions occur at intersections ▪ Remind road users to practice safe road use at all times of day, emphasizing the end of the day commute during the PM peak ▪ Encourage slow speeds on local streets ▪ Target young bicycle users and male bicycle users to make safe traffic decisions ▪ Target distracted driving ▪ Focus on promoting and teaching proper use of traffic circles and how to safely enter and exit ▪ Campaigns targeted at ensuring vehicle drivers open their door with caution when parking on street (sticker campaigns & in car reminders) ▪ Safety in Numbers Campaigns	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Operations and Maintenance												
Pothole Reporting Program	▪ Consider developing a pot hole reporting program on bike routes					✓		✓				
Regular Street clearing	▪ Ensure to regularly clear bike routes of debris, leaves, snow and ice					✓		✓				
Enforcement												
Right Turn on Red Restrictions	▪ Consider prohibiting and enforcing right turns on red at intersections with high numbers of bicycle user collisions with right turning vehicles									✓		
30 km/h Speed Limit Areas/Slow Zones	▪ Consider reducing speed limits in areas on local routes with a high number of collisions					✓	✓		✓	✓	✓	
Three foot passing space requirement	▪ Implement and enforce laws that require drivers to leave three feet of passing width between bicycle users and motor vehicles					✓			✓		✓	

8.5 Multi-Agency Coordination and Cooperation

Similar to the findings from the pedestrian safety study, the improvement of cycling safety within the City of Vancouver will require the involvement and coordination of a number of agencies involved in cycling-related infrastructure, operations, services, and enforcement. Some of these agencies include the City of Vancouver, ICBC, Vancouver Police Department (VPD), Vancouver Coastal Health (VCH), TransLink, and the Vancouver School Board (VSB). In addition, other stakeholders, such as HUB, HASTe, the British Columbia Cycling Coalition, the Association of Pedestrian and Bicycle Professionals (APBP) recently formed local Vancouver chapter, and British Columbia Automobile Association (BCAA), could play a role in identifying needs, education and advocacy. Each of these agencies can contribute to cycling safety through four general areas:

1. **Provision of primary data and information;**
2. **Planning/engineering/operations;**
3. **Communication; and**
4. **Enforcement.**

Each of the agencies could take on either a leadership or supporting role in these areas, however, the key is that these agencies and any others work together in cooperation to plan, deliver, and evaluate strategies to improve cycling safety. **Table 8.3** provides a summary of the agencies and their potential roles.

Table 8.3
Multi-Agency Cycling Safety Roles

	City of Vancouver	ICBC	VPD	VCH	TransLink	VSB	Stake-holders
Data and Information	Co-Lead	Co-Lead	Support	Co-Lead	Support	Support	Support
Planning, Engineering, Operations	Lead	Support	Support	Support	Support	Support	Support
Communication	Lead	Support	Support	Support	Support	Support	Support
Enforcement	Support	Support	Lead	Support	Support	Support	Support

A cooperative between agencies could be made through the Active Transportation Policy Council, or through another separate cooperative model. The scope of the cooperative could be the recommendation of plans and investments through the identification of issues and the development of business cases based on evidence and research of documented cycling safety improvements, new trends and successes.

The effectiveness of any monitoring program is dependent on the data and information being used to measure current conditions and identify trends which will take organization and commitment from all agencies and stakeholders involved.

8.6 Data Collection

The data used for this study and that is available to the City of Vancouver and other municipalities in British Columbia is extremely important and helpful to understand the collision patterns and trends. However, there are opportunities to develop a more robust dataset and to continue to consolidate study and review data as it is available. While current data is extremely helpful, there are limitations as noted previously in this study.

The availability of bicycle-related safety data is limited for any given location due to the relatively low number of reported incidents involving bicycle users In order to develop an evidence-based process that can be used to make crucial investment decisions it is extremely important to be sure that the data provided is current, accurate and has been compiled from a number of sources. A list of the types of data required to support a comprehensive cycling safety program include:

Collision / Injury Data Reported collision and injury data is the core of safety analyses. Collision data typically is reported when a vehicle is involved and is available through ICBC. Injuries can be reported through Vancouver Coastal Health, especially for non motor vehicle related incidents (i.e. bicycle user /pedestrian collisions, collisions on off-street paths). It is recommended that cycling collision and injury data be harmonized so that it can be more effectively and efficiently used in cycling safety analyses. Data is also required regarding injury severity to better understand how these injuries impacted the bicycle user in the short and long term. This would require an organized recording and sharing of cycling injury data between multiple organizations. In addition, collecting data on driver demographics would be helpful as well. They can help to determine if there are certain ages or genders that are more often involved in collisions and awareness and education campaigns can be targeted accordingly. As such, the recommended next step for getting this data is to bring relevant agencies and associations together to form a pilot program for collecting data, including working with health agencies including VCH and potentially paramedics and emergency responders.

Violations / Complaints Data Citation data for violations can be obtained by the VPD. These include violations made by both bicycle users and vehicles related to cyclist-related or cyclist-significant (i.e. speeding or red-light running from ICBC operated Intersection Safety Cameras) violations. Other cities have developed phone applications that allow bicycle users to provide real-time updates of near misses and any type of collision that has not been reported to the police or an insurance company.

Bicycle Travel Volumes Understanding bicycle rider volumes is important to have a better understanding of the proportion of collisions based on the number of bicycle users (the likelihood of a collision occurring). Bicycle volume data can help verify and speak to 'safety in numbers' research and help normalize the data. The City of Vancouver counts the number of bicycle users traveling on a number of their major bicycle routes. In addition, understanding where bicycle users are travelling within the city and being able to track routes with start and end locations would add significant detail to understanding collision trends and neighbourhood patterns. Strava and other mobile apps are an emerging source of data for bicycle travel volumes.

Weather and Light Conditions Data Information regarding weather and light conditions can play an important role in the evaluation of safety metrics related to cycling collisions and incidents. Furthermore, glare during sunrise and sunset can affect visibility. This data is provided by Environment Canada. Illumination can also vary by location as tall buildings and foliage can reduce lighting and visibility, therefore site specific assessment should consider such information (obtained both from site observations and City data).

Table 8.4 provides a summary of the types of cyclist-related data that can be assembled and their sources.

Table 8.4
Inter-Agency Cycling Safety Data Types and Sources

Data Source: Data Type	COV	ICBC	VPD	TransLink	Other Province	StatsCan	Other Federal
Collision / Injury		✓	✓				
Violations / Complaints		✓	✓				
Demographic	✓			✓	✓	✓	
Bicycle Count Volumes	✓			✓	✓		
Weather & Light Cond.	✓						✓

The use of data from a number of different sources can have its own challenges. It will be important to develop a consistent methodology for analyzing the data accurately and interpreting the results through the same set of assumptions. Despite some concerns of having too much data it is clear that having as much available information can help to understand the situation in as much detail as possible and allow a greater understanding of some of the more significant issues and trends in reference to cycling safety.

Appendix A

Detailed Characteristics of Peer Cities

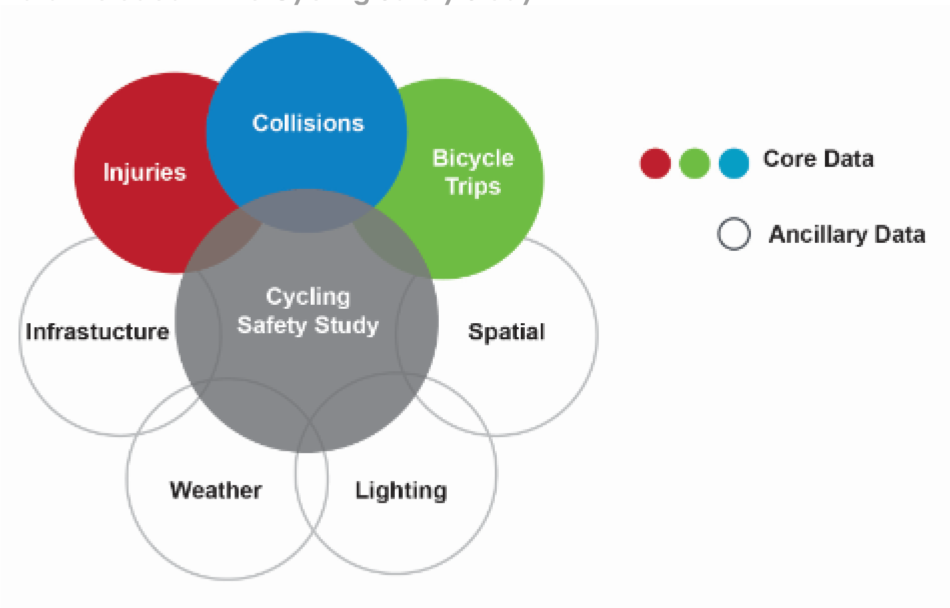
	Population		Population Density		City Mode Share					Fatality Data					
City Name	City	Employed Labour Force (2011)	City Land Area (sq. km)	City Population Density (ppl/km2)	Bicycle	Bike To Work Trips	Bike To Work Trips/1,000,000	Daily Bike Trips	Per 1,000,000 Daily Trips	Average Fatalities Per Year	Year	Average Fatalities Per Million Bike to Work Trips	Average Fatalities Per One Million Residents	Average Fatalities per Day	Average Fatalities Per One Million Daily Trips
Montreal	1,649,519	776,535	365.13	4517.6	3.2%	6,120,595.2	6.12	18,982,036.2	19.0	3.7	2007-2012	0.60	2.22	0.01	0.19
Vancouver	**603,502**	**324,375**	**114.97**	**5249.2**	**4.4%**	**3,536,280.6**	**3.54**	**9,605,741.9**	**9.6**	**0.7**	**2007-2012**	**0.19**	**1.10**	**0.00**	**0.07**
Ottawa	883,391	463,625	2790.22	316.6	2.5%	2,897,823.9	2.90	8,061,409.4	8.1	2.7	2007-2012	0.92	3.02	0.01	0.33
Calgary	1,096,833	617,040	825.29	1329.0	1.3%	1,972,702.5	1.97	5,119,666.0	5.1	1.0	2007-2012	0.51	0.91	0.00	0.20
Edmonton	812,201	451,395	684.37	1186.8	1.4%	1,562,442.4	1.56	4,104,532.1	4.1	2.0	2007-2012	1.28	2.46	0.01	0.49
Winnipeg	663,617	345,805	464.08	1430.0	2.1%	1,843,490.8	1.84	5,165,115.8	5.2	1.0	2007-2012	0.54	1.51	0.00	0.19
Copenhagen	734,829	367,415	77.20	9518.5	36.0%	33,067,305	33.07	96,556,530.6	96.6	4.3	2007-2012	0.13	5.80	0.01	0.04
Amsterdam	811,354	405,677	165.76	4894.8	38.0%	38,539,315	38.54	112,534,799.8	112.5	5.4	2007-2012	0.14	6.59	0.01	0.05
Melbourne	177632	88,816	3162.00	56.2	7.0%	34,999,843	35.00	102,199,540.1	102.2	6.8	2007-2012	0.20	1.71	0.02	0.07
Berlin	3,501,872	1,750,936	891.85	3926.5	13.0%	56,905,420	56.91	166,163,826.4	166.2	11.0	2011	0.19	3.14	0.03	0.07
London	8,332,400	4,166,200	8278.00	1006.6	2.0%	20,831,000	20.83	60,826,520.0	60.8	13.8	2007-2011	0.66	1.66	0.04	0.23
Austin	817,197	428,315	298.90	2734.0	1.28%	1,370,608	1.37	3,817,944.4	3.8	1.2	2007-2011	0.88	1.47	0.00	0.31
Boston	628,335	319,146	48.28	13014.4	1.51%	1,207,008	1.21	3,469,484.2	3.5	1.4	2007-2011	1.16	2.23	0.00	0.40
Chicago	2,705,248	1,245,137	227.63	11884.4	1.21%	3,769,474	3.77	11,957,036.3	12.0	5.2	2007-2011	1.38	1.92	0.01	0.43
Los Angeles	3,823,316	1,788,532	468.67	8157.8	0.90%	4,043,175	4.04	12,618,823.5	12.6	7.2	2007-2011	1.78	1.88	0.02	0.57
Minneapolis	388,227	207,205	53.97	139.78	3.86%	1,999,528	2.00	5,469,730.2	5.5	1.8	2007-2011	0.90	4.64	0.00	0.33
New York City	8,269,639	3,756,914	302.64	783.83	0.72%	6,725,119	6.73	21,612,655.6	21.6	19.8	2007-2011	2.94	2.39	0.05	0.92
Philadelphia	1,538,567	619,412	134.10	347.32	1.71%	2,646,270	2.65	9,596,741.5	9.6	3.2	2007-2011	1.21	2.08	0.01	0.33
Portland	593,893	301,504	133.43	345.58	5.81%	4,376,370	4.38	12,585,833.5	12.6	2.0	2007-2011	0.46	3.37	0.01	0.16
San Francisco	814,233	447,467	9.14	23.67	3.09%	3,461,890	3.46	9,197,161.9	9.2	1.8	2007-2011	0.52	2.21	0.00	0.20
Seattle	621,897	350,924	83.94	217.40	3.00%	2,634,416	2.63	6,816,204.0	6.8	1.8	2007-2011	0.68	2.89	0.00	0.26
Washington, DC	619,020	300,913	61.05	158.12	2.55%	1,919,555	1.92	5,765,235.8	5.8	1.0	2007-2011	0.52	1.62	0.00	0.17

Appendix B

Data Sources

The analysis required the assembly, documentation and manipulation of a number of datasets from a variety of sources as described below in **Figure C1**.

Figure C1
Data Included in the Cycling Safety Study



1. Collision Data

- **ICBC Data.** The Insurance Corporation of British Columbia (ICBC) collects and maintains statistics for all reported collisions in British Columbia. The collision data classifies collisions based on the type of collision as follows: fatality, injury, or property damage only and also identifies collisions involving cyclists, motorcycles, and pedestrians. The City provided this dataset for all collisions reported to ICBC in the City of Vancouver between 1996 and 2012. This dataset included:
  - ICBC Incident Number
  - Incident Date and Time
  - Incident Location (Primary Street and Cross Street)
  - Incident Description
  - Intersection or Mid-Block Classification
  - Severity (Fatality, Injury, Property Damage Only)
  - Parking Lot Flag
  - Bicycle Flag
  - Pedestrian Flag
  - Motorcycle Flag

  Analysis was also conducted on ICBC data that provided the age and gender of the injured cyclist, although this data was not associated with an incident number or collision report.

- **VPD Data.** The Vancouver Police Department (VPD) also collects and maintains statistics for all collisions reported to the police. The City provided this dataset for all fatalities resulting from collisions between 1992 and 2012. This dataset included:
  - VPD Incident Number*
  - Incident Date
  - Incident Time (injuries only)
  - Fatality Date (fatalities only)
  - Incident Location
  - Gender of Victim
  - Age of Victim*
  - Victim Type (driver, passenger, pedestrian, bicyclist, or motorcyclist)

  * *Not included in 2012 data, 2012 data was presented in a different format.*

  It should be noted that the City considers the VPD dataset as the official record of all traffic-related fatalities, and the ICBC dataset as the official record of all other collisions. The ICBC and VPD datasets do not always correspond directly to each other, as not all incidents are reported both ICBC and the VPD.

2. Injury Data

- **Bicyclists' Injuries and the Cycling Environment (BICE)** The objective of this study was to better understand the link between bicyclists' injuries based on the type of route they took and the presence of variables that may have contributed to the injury in the Cities of Vancouver and Toronto (May 2008 – November 2009). Participants in this study were individuals who suffered an injury bicycling and attended a hospital emergency room due to their injuries. The data provided from this report includes but is not limited to:
  - Cyclist accidents that resulted in emergency room visits that were a result of:
    - Collisions with motorized vehicles
    - Falls that resulted from attempting to avoid a collisions
    - Collisions due to road surface maintenance or debris
    - Collisions with road infrastructure including curbs, bollards, posts etc.
    - Collisions with pedestrians, other cyclists or animals
    - Other types of falls (i.e. Loss of balance, breaking too hard, slip)
  - Presence of parked cars
  - Bicycle facility type
  - Road classification where injury occurred

  - Gender
  - Age
  - Trip purpose
  - Day of the week
  - Weather conditions
  - Trip distance

3. Bicycle Trip Data

- **Metro Vancouver Regional Trip Diary (2011).** This survey distributed and reviewed by TransLink provides a snapshot of travel behaviour in the Metro Vancouver Region. The benefits of the Metro Vancouver Regional Trip Diary are that it includes trips beyond those done for work and focuses on understanding travel patterns throughout the day. The information from the Metro Vancouver Trip Diary was used to better understand the proportion of bicycle trips within the City of Vancouver in reference to more detailed information including gender, age and home location and destination.
- **National Household Survey (2011).** The National Household Survey (NHS) is conducted by Canadian Census and provides information regarding transportation mode choice based on the employed population 15 years of age and older. The data provided in the NHS was used to determine the main mode of transportation of residents of the City of Vancouver between their home and their place of work. This data was used to understand bicycle travel patterns within the City of Vancouver and understand the proportion of bicycle trips within a year (2011) including the City's bicycle mode share.
- **City of Vancouver Bicycle Count Data** Provided by the City of Vancouver for four locations. This data was used to verify cycling volumes and trends. This count data was specifically used to look at seasonal patterns, by defining the facilities included, the time and the weather conditions. The findings were all summed up together to form a proxy for overall cycling patterns and trends. Count data was provided for the following locations:
  - Burrard Street Bridge (Southbound) - 2011
  - Hornby and Robson (Northbound and Southbound)- 2011
  - Dunsmuir Viaduct (Eastbound and Westbound) - 2011
  - Dunsmuir and Seymour (Eastbound and Westbound) - 2011

4. Infrastructure Data

- **Road Network.** This dataset was provided by the City of Vancouver and includes centreline data for public streets, alleyways, and non-public streets as well as intersections. The dataset includes road classification as Primary Arterial, Secondary Arterial, Collector, or Local roads and also identifies one-way streets.

- **Traffic Signals.** This dataset was provided by the City and contains the location and types of the City's traffic signals.
- **Traffic Circles.** This dataset was assembled based on the City's traffic circles dataset and was validated and updated using the Orthophoto data.
- **Bicycle routes.** This dataset was assembled based on the City's Bikeways dataset and published bicycle route map and includes the location and type of bicycle facility, including local street bikeways, painted bicycle lanes, painted shared use lanes, and separated bicycle lanes.

5. Spatial Data

- **Neighbourhoods.** This dataset was provided by the City and contains the boundaries, names, residential population, and employment for the City's 22 local areas.
- **Traffic Analysis Zones.** Boundaries were generated from the regional Emme transportation model.
- **Orthophoto.** This dataset was provided by the City and includes an orthophoto of the City capture in May 2011.

6. Other Data

- **Weather.** This dataset was obtained from the Environment Canada National Climate Data and Information Archive for the City of Vancouver for all days between January 1, 2007 and December 31, 2012. This data includes both hourly weather and daily weather. The hourly weather dataset includes the date and time, temperature, relative humidity, wind direction, wind speed, visibility, and weather description (i.e. cloudy, rain, snow), among other features. The daily weather dataset includes the date, maximum temperature, minimum temperature, mean temperature, daily rainfall, and daily snowfall, among other features.
- **Light Conditions.** This dataset was obtained from the National Research Council Canada Sunrise / Sunset Calculator for the City of Vancouver for all days between January 1, 2007 and December 31, 2012. This data includes nautical twilight start, civil twilight start, sunrise, local noon, sunset, civil twilight end, nautical twilight end, and total hours of illumination for each day.
- **Demographics.** Residential and employment data were provided for the year 2011 for each of the City's 22 local areas.

Appendix C

Detailed Collision Classification

No Collisions matching the description
Collisions that match the description were coded

Number	Classification Code	Location	Driver Movement	Cyclist Movement	Intersection (Signals)	Cyclist Action in Intersection	Collision Description
1	I1	Intersection			Traffic circle		Vehicle and cyclist collided in traffic circle
2	L1	Intersection	Left turn	Straight	2-Way Stop	Cross with right of way	Vehicle turns left at an intersection with a 2-Way Stop while the cyclist crossed with right of way
3	L2	Intersection	Left turn	Straight	2-Way Stop	Cross at crosswalk (permitted)	Vehicle turns left at an intersection with a 2-Way Stop while the cyclist crossed in crosswalk (permitted)
4	L3	Intersection	Left turn	Straight	2-Way Stop	Cross at crosswalk (not permitted)	Vehicle turns left at an intersection with a 2-Way Stop while the cyclist crossed in crosswalk (not permitted)
5	L4	Intersection	Left turn	Straight	2-Way Stop	Did not stop at stop sign	Vehicle turns left at an intersection with a 2-Way Stop while the cyclist did not stop at stop sign
6	L5	Intersection	Left turn	Straight	4-Way Stop	Cross with right of way	Vehicle turns left at an intersection with a 4-Way Stop while the cyclist crossed with right of way
7	L6	Intersection	Left turn	Straight	4-Way Stop	Cross at crosswalk (permitted)	Vehicle turns left at an intersection with a 4-Way Stop while the cyclist crossed in crosswalk (permitted)
8	L7	Intersection	Left turn	Straight	4-Way Stop	Cross at crosswalk (not permitted)	Vehicle turns left at an intersection with a 4-Way Stop while the cyclist crossed in crosswalk (not permitted)
9	L8	Intersection	Left turn	Straight	4-Way Stop	Did not stop at stop sign	Vehicle turns left at an intersection with a 4-Way Stop while the cyclist did not stop at stop sign
10	L9	Intersection	Left turn	Straight	4-Way Stop	Unknown	Vehicle turns left at an intersection with a 4-Way Stop, cyclist action in intersection is unclear
11	L10	Intersection	Left turn	Straight	Half Signal	Cross with signal	Vehicle turns left at an intersection with a Half-Signal while the cyclist crossed with right of way
12	L11	Intersection	Left turn	Straight	Half Signal	Cross at crosswalk (permitted)	Vehicle turns left at an intersection with a Half-Signal while the cyclist crossed in crosswalk (permitted)
13	L12	Intersection	Left turn	Straight	Half Signal	Cross at crosswalk (not permitted)	Vehicle turns left at an intersection with a Half-Signal while the cyclist crossed in crosswalk (not permitted)
14	L13	Intersection	Left turn	Straight	Half Signal	Cross against signal	Vehicle turns left at an intersection with a Half-Signal while the cyclist did not stop at red light
15	L14	Intersection	Left turn	Straight	Half Signal	Unknown	Vehicle turns left at an intersection with a Half-Signal, cyclist action in intersection is unclear
16	L15	Intersection	Left turn	Straight	Signal	Cross with signal	Vehicle turns left at an intersection with a Signal while the cyclist crossed with right-of-way
17	L16	Intersection	Left turn	Straight	Signal	Cross at crosswalk (permitted)	Vehicle turns left at an intersection with a Signal while the cyclist crossed in crosswalk (permitted)
18	L17	Intersection	Left turn	Straight	Signal	Cross at crosswalk (not permitted)	Vehicle turns left at an intersection with a Signal while the cyclist crossed in crosswalk (not permitted)
19	L18	Intersection	Left turn	Straight	Signal	Cross against signal	Vehicle turns left at an intersection with a Signal while the cyclist did not stop at red light
20	L19	Intersection	Left turn	Straight	Signal	Unknown	Vehicle turns left at an intersection with a Signal, cyclist action in intersection is unclear
21	L20	Intersection	Left turn	Left turn	Signal	Stopped waiting to turn left/Cross with signal	Vehicle and cyclist are both turning left and collide
22	L21	Intersection	Left turn		Unknown		Vehicle is turning left in intersection while cyclist action is unknown
23	L22	Intersection	Left turn	Right Turn		Cross with right of way	Vehicle is turning left in intersection while cyclist is turning right, head on collision
24	R1	Intersection	Right turn	Straight	2-Way Stop	Cross with right of way	Vehicle turns right at an intersection with a 2-Way Stop while the cyclist crossed with right of way
25	R2	Intersection	Right turn	Straight	2-Way Stop	Cross at crosswalk (permitted)	Vehicle turns right at an intersection with a 2-Way Stop while the cyclist crossed in crosswalk (permitted)
26	R3	Intersection	Right turn	Straight	2-Way Stop	Cross at crosswalk (not permitted)	Vehicle turns right at an intersection with a 2-Way Stop while the cyclist crossed in crosswalk (not permitted)
27	R4	Intersection	Right turn	Straight	2-Way Stop	Did not stop at stop sign	Vehicle turns right at an intersection with a 2-Way Stop while the cyclist did not stop at stop sign
28	R5	Intersection	Right turn	Straight	4-Way Stop	Cross with right of way	Vehicle turns right at an intersection with a 4-Way Stop while the cyclist crossed with right of way
29	R6	Intersection	Right turn	Straight	4-Way Stop	Cross at crosswalk (permitted)	Vehicle turns right at an intersection with a 4-Way Stop while the cyclist crossed in crosswalk (permitted)
30	R7	Intersection	Right turn	Straight	4-Way Stop	Cross at crosswalk (not permitted)	Vehicle turns right at an intersection with a 4-Way Stop while the cyclist crossed in crosswalk (not permitted)
31	R8	Intersection	Right turn	Straight	4-Way Stop	Did not stop at stop sign	Vehicle turns right at an intersection with a 4-Way Stop while the cyclist did not stop at stop sign
32	R9	Intersection	Right turn	Straight	4-Way Stop	Unknown	Vehicle turns right at an intersection with a 4-Way Stop, cyclist action in intersection is unclear

Number	Classification Code	Location	Driver Movement	Cyclist Movement	Intersection (Signals)	Cyclist Action in Intersection	Collision Description
33	R10	Intersection	Right turn	Straight	Half Signal	Cross with signal	Vehicle turns right at an intersection with a Half-Signal while the cyclist crossed with right of way
34	R11	Intersection	Right turn	Straight	Half Signal	Cross at crosswalk (permitted)	Vehicle turns right at an intersection with a Half-Signal while the cyclist crossed in crosswalk (permitted)
35	R12	Intersection	Right turn	Straight	Half Signal	Cross at crosswalk (not permitted)	Vehicle turns right at an intersection with a Half-Signal while the cyclist crossed in crosswalk (not permitted)
36	R13	Intersection	Right turn	Straight	Half Signal	Cross against signal	Vehicle turns right at an intersection with a Half-Signal while the cyclist did not stop at red light
37	R14	Intersection	Right turn	Straight	Half Signal	Unknown	Vehicle turns right at an intersection with a Half-Signal, cyclist action in intersection is unclear
38	R15	Intersection	Right turn	Straight	Signal	Cross with signal	Vehicle turns right at an intersection with a Signal while the cyclist crossed with right-of-way
39	R16	Intersection	Right turn	Straight	Signal	Cross at crosswalk (permitted)	Vehicle turns right at an intersection with a Signal while the cyclist crossed in crosswalk (permitted)
40	R17	Intersection	Right turn	Straight	Signal	Cross at crosswalk (not permitted)	Vehicle turns right at an intersection with a Signal while the cyclist crossed in crosswalk (not permitted)
41	R18	Intersection	Right turn	Straight	Signal	Cross against signal	Vehicle turns right at an intersection with a Signal while the cyclist did not stop at red light
42	R19	Intersection	Right turn	Straight	Signal	Unknown	Vehicle turns right at an intersection with a Signal, cyclist action in intersection is unclear
43	R20	Intersection	Right turn	Straight	Unknown		Vehicle turns right at an unknown intersection, cyclist action in intersection is unclear
44	R21	Intersection	Right turn	Other			Vehicle turns right at an intersection cyclist action is other
45	S1	Intersection	Straight	Straight	2-Way Stop	Cross with right of way	Vehicle crosses intersection with a 2-Way Stop while the cyclist crossed with right of way
46	S2	Intersection	Straight	Straight	2-Way Stop	Cross at crosswalk (permitted)	Vehicle crosses intersection with a 2-Way Stop while the cyclist crossed in crosswalk (permitted)
47	S3	Intersection	Straight	Straight	2-Way Stop	Cross at crosswalk (not permitted)	Vehicle crosses intersection with a 2-Way Stop while the cyclist crossed in crosswalk (not permitted)
48	S4	Intersection	Straight	Straight	2-Way Stop	Did not stop at stop sign	Vehicle crosses intersection with a 2-Way Stop while the cyclist did not stop at stop sign
49	S5	Intersection	Straight	Straight	4-Way Stop	Cross with right of way	Vehicle crosses intersection with a 4-Way Stop while the cyclist crossed with right of way
50	S6	Intersection	Straight	Straight	4-Way Stop	Cross at crosswalk (permitted)	Vehicle crosses intersection with a 4-Way Stop while the cyclist crossed in crosswalk (permitted)
51	S7	Intersection	Straight	Straight	4-Way Stop	Cross at crosswalk (not permitted)	Vehicle crosses intersection with a 4-Way Stop while the cyclist crossed in crosswalk (not permitted)
52	S8	Intersection	Straight	Straight	4-Way Stop	Did not stop at stop sign	Vehicle crosses intersection with a 4-Way Stop while the cyclist did not stop at stop sign
53	S9	Intersection	Straight	Straight	4-Way Stop	Unknown	Vehicle crosses intersection with a 4-Way Stop, cyclist action in intersection is unclear
54	S10	Intersection	Straight	Straight	Half Signal	Cross with signal	Vehicle crosses intersection with a Half-Signal while the cyclist crossed with right of way
55	S11	Intersection	Straight	Straight	Half Signal	Cross at crosswalk (permitted)	Vehicle crosses intersection with a Half-Signal while the cyclist crossed in crosswalk (permitted)
56	S12	Intersection	Straight	Straight	Half Signal	Cross at crosswalk (not permitted)	Vehicle crosses intersection with a Half-Signal while the cyclist crossed in crosswalk (not permitted)
57	S13	Intersection	Straight	Straight	Half Signal	Cross against signal	Vehicle crosses intersection with a Half-Signal while the cyclist did not stop at red light
58	S14	Intersection	Straight	Straight	Half Signal	Unknown	Vehicle crosses intersection with a Half-Signal, cyclist action in intersection is unclear
59	S15	Intersection	Straight	Straight	Signal	Cross with signal	Vehicle crosses intersection with a Signal while the cyclist crossed with right-of-way
60	S16	Intersection	Straight	Straight	Signal	Cross at crosswalk (permitted)	Vehicle crosses intersection with a Signal while the cyclist crossed in crosswalk (permitted)
61	S17	Intersection	Straight	Straight	Signal	Cross at crosswalk (not permitted)	Vehicle crosses intersection with a Signal while the cyclist crossed in crosswalk (not permitted)
62	S18	Intersection	Straight	Straight	Signal	Cross against signal	Vehicle crosses intersection with a Signal while the cyclist did not stop at red light
63	S19	Intersection	Straight	Straight	Signal	Unknown	Vehicle crosses intersection with a Signal, cyclist action in intersection is unclear
64	S20	Intersection	Straight	Straight	Unknown		Vehicle and cyclist collide going straight in an unidentified intersection
65	S21	Intersection	Straight	Left turn			Vehicle crosses intersection while the cyclist turns left
66	S22	Intersection	Straight	Stopped			Vehicle collides with a cyclist that is not moving
67	S23	Intersection	U-turn				Vehicle and cyclist collide when vehicle is making a U-turn in an intersection

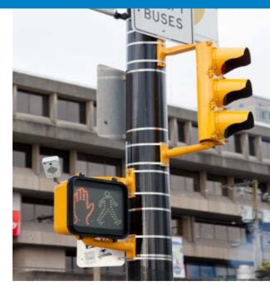
Number	Classification Code	Location	Driver Movement	Cyclist Movement	Intersection (Signals)	Cyclist Action in Intersection	Collision Description
68	S24	Intersection	Straight	Right Turn			Vehicle crosses intersection while the cyclist turns right
69	S25	Intersection	Lane Change	Straight			Vehicle hits cyclist while changing lanes in intersection
70	S26	Intersection	Passing				Vehicle and cyclist collide as a result of the vehicle passing the cyclist at the intersection
71	ST	Intersection	Stopped				Cyclist collides with stopped vehicle at intersection
72	STL	Intersection	Straight	Stopped - Left			Vehicle and cyclist collide when cyclist is stopped waiting to turn left
73	M1	Mid-Block	UTURN	Straight		Straight	Vehicle and cyclist collide mid block while doing a U-Turn
74	M2	Mid-Block	P- Leaving/ENTERING Parking Space			Straight	Vehicle and cyclist collide mid block as vehicle is leaving/entering an on street parking space
75	M3	Mid-Block	P- Opening Door			Straight	Vehicle and cyclist collide mid block as vehicle door is opening
76	M4	Mid-Block	ALLEY/PARKING LOT/GAS STATION			Straight	Vehicle and cyclist collide as entering/exiting an alley/parking lot/gas station mid block
77	M5	Mid-Block	PASSING			Straight	Vehicle and cyclist collide as a result of the vehicle passing the cyclist midblock
78	M6	Mid-Block	Lane Change			Straight	Vehicle hits a cyclist while changing lanes
79	M7	Mid-Block	Backing			Straight	Vehicle and cyclist collide as vehicle is backing up mid block
80	M8	Mid-Block	Parked			Straight	Cyclist collides with parked car mid block
81	M9	Mid-Block	Other			Straight	Other incident occurs mid block
82	D1	Parking Lot					Vehicle and cyclist collide in a parking lot
83	D2	ALLEY					Vehicle and cyclist collide in an alleyway
84	O1	Other					Other
85	O2	Unknown					Cyclist or vehicle action is not known

Appendix D

Cycling Safety Toolbox

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Separated Bicycle Lanes		Often referred to as a cycle track they are on street facilities physically separated from moving vehicles on road and separated from pedestrians on the sidewalk.	• Considered on streets with high traffic volumes and speeds • May be one-way or two-way • Can be located at street or sidewalk level • Designated by some form of physical separation (planters, curbs, parking or bollards) • Ideally located on streets with few driveways and alleyways	• Offer protection from moving vehicles • Increases feelings of safety and comfort • Encourages cyclists to use on-street facilities as opposed to sidewalks • Provide cyclists with a designated space on street but physically separated	High	High
Parking Protected Bicycle Lanes		The bicycle lane is located between the on-street parking and the curb. The parked vehicles act as a buffer for the cyclists from moving traffic. An added buffer between the parked vehicles and the bicycle lane protect cyclists from doorings.	• Considered on streets with moderate traffic volumes and speeds and on-street parking • Buffer denoted by an interior of diagonal cross hatching or chevron markings • Makes use of existing pavement and drainage • On routes where there is short term, metered parking	• Parked cars act as a barrier from moving vehicles • Offer increased protection from doorings • Increase feelings of route safety and comfort	Low	High
Buffered Bicycle Lane		A buffered bicycle lane is a conventional painted bicycle lane with a painted buffer between cyclists and moving vehicles or parked vehicles or both.	• Considered anywhere a bicycle lane is being constructed • On streets with high traffic speeds and volumes • Where road width permits • Buffer should be at least 0.6 metres in width[7]	• Can provide an increased sense of comfort • Offers more space for cyclists to manoeuver around other road users and parked vehicles • Provide space for bicyclists to pass other cyclists • Increase comfort for bicyclists of all ages and abilities	Low	Moderate
Painted Bicycle Lane		A space designated by a painted line and a bicycle symbol indicates that the space is designated for bicycles. Can be located on the left or right side of the lane.	• Considered on streets with moderate traffic volumes and speeds • On streets with transit vehicles • Ideal width >1.5 metres • Markings denoting that space is used for bicycles (bicycle symbol and arrow markings) • Marked by a solid white line [8]	• Indicate that the space is designated for cyclist use • Increase rider comfort and confidence • Increase cyclist visibility	Low	Moderate

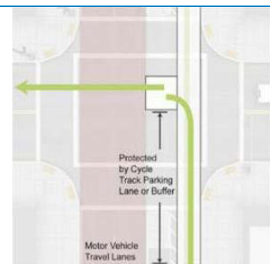
Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Separated Bicycle and Pedestrian Pathways		Off street pathways that provide separation between pedestrians and cyclists.	• Install on pathways that are used heavily by pedestrians and cyclists • Where space is available to provide facilities to accommodate both modes separately • If there is adequate space, for two direction use or one way only facilities	• Separated from the street and moving vehicles • Provide separated and designated spaces for pedestrians and cyclists • Safer for both pedestrians and cyclists, reduces conflict and interaction between the two modes • Is the facility that makes cyclists feel the most comfortable	High	High
Multi-Use Pathway		Off-street pathway where pedestrians and cyclists and other users use a shared travel space.	• Install where space is provided to allow for adequate two direction use or one way only facilities	• Separated from the street and moving vehicles • Provide separated and designated spaces for pedestrians and cyclists without interaction with motorized vehicles	High	Medium
Local Street Bikeways		Located on local streets with lower traffic volumes designated as routes for cyclists. Often have been traffic calmed and are located parallel to a major arterial route providing an alternative route for cyclists.	• Should still provide direct access to destinations • Easy to locate follow (signage) • Incorporate design features to slow vehicle speed and volumes • Provide safe and convenient crossings at intersections	• Traffic calming on local street bikeways reduces vehicle speeds, which allows vehicles more time to notice cyclists and reduces injury severity when crashes do occur. • Traffic calming and diversion reduces vehicle volumes on local street bikeways, reducing potential conflicts between motorists and cyclists.	Moderate	Moderate
Shared Use Lanes		Often denoted by the use of sharrow markings to indicate that this is a shared space. Bicycles and motorists have to share the lane.	• Often located on roads too narrow for bicycle lanes • Requires signage and street markings • Ideally located on streets with low traffic volumes and speeds	• Reinforce the legitimacy and position of cyclists on the street and within the lane • Makes motorists more aware of the presence of cyclists • Provides more guidance for cyclists to pass parked cars • Requires no additional street space	Low	Low

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Full Traffic Signal		Install a full traffic signal at high collision intersections and intersections with high cyclist volumes.	• Install at intersections with high volumes of vehicle travel • Where collisions are frequent with existing intersection control	• Provides better control of all vehicle movements	High	High
Dedicated Bicycle Signal		Bicycle signals provide cyclists with their own signal to indicate when it is safe to enter an intersection without conflict from other vehicles attempting to make movements in the intersection.	• Locate at intersections with high turning volumes where cyclist demand is high • Split signal phases at intersections where a frequent bicycle movement conflicts with a common vehicle movement • Use at complex intersections	• Separates bicycle movements from conflicting motor vehicles and pedestrians • Provides priority bicycle and bicycle only movements • Protects cyclists in intersections	Moderate	High
Cyclist and Pedestrian Activated Signals		Cyclist activated signals are used to assist cyclists in crossing major streets in areas where there is high cyclist demand, but where a full traffic signal is not warranted.	• Higher speed/volume roadways at mid-block locations or at unsignalized intersections where cyclist crossing demand is high and distant from an existing signalized crossing	• Provides a signal-protected cyclist crossing phase. • Possibly reduces the delay for vehicles travelling on the minor streets compared to a full signal • Improves cyclist safety	Moderate	High
Signal Timing		Adjusting the timing of signals for cyclists can reduce wait times for cyclists at intersections.	• Install at intersections with high volumes of vehicle travel	• Reduces cyclists from being tempted to cross against the signal due to long wait times • Allows for better trip flow for cyclists	Moderate	Moderate

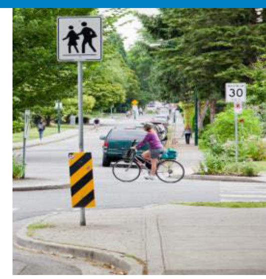
URBAN systems

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety

Protected Intersections		A combination of bicycle signal phases and design elements and space allocation that help protect cyclists from turning cars	• There are four main elements to protected intersection design
			  o A corner refuge island
			  o A forward stop bar for bicyclists
			  o A setback bike and pedestrian crossing
			• Bicycle friendly phasing
				• Makes cyclist more visible to turning vehicles
				• Provides protected space for cyclists at intersections
				• Changes to signal timing provide cyclists with the time to clear the intersection
					High	High

Launch Pad/ Two-Stage Left Turn		Allows cyclists to make a left turn from by continuing through the intersection to a location that sets them up to safely wait to cross the intersection.	• Use to ease left hand turns from separated bicycle lanes • Areas where there is heavy bicycle traffic and high volumes of left turn movements by cyclists	• Allows for efficient left turns from separated bicycle facilities as opposed to having to get off their bike and cross via a crosswalk • Provides safer options for cyclists • Reduces conflict between cyclists and pedestrians and motorists	Low	Moderate
Coloured Conflict Zone Markings		In the City of Vancouver Green marking have been used to designate conflict zones and areas where cyclists are travelling. They provide visual reminder of the presence of cyclists.	• Different types of material available including paint, Durable Liquid Pavement Markings (DLPM), Thermoplastic and coloured asphalt • Thermoplastic recommended by NACTO for spot improvements, DLPM for corridors	• Are used to identify conflict areas including intersections, driveways, and other areas where interaction between road users is high and conflict has or is likely to occur • Improve cyclist safety and driver awareness • Increase visibility of cyclists on the road	Low	Moderate
Bike Box and Advance Stop Lines		Provide a space for cyclists to wait to cross the intersection. They are often located in advance of the automobile stop line and provide the cyclists a "head start".	• Install at signalized intersections with high volumes of bicycle and motor vehicles • Where there are right or left hand turning conflicts • Where there are a lot of cyclists turning left • Pavement markings and signage required	• Helps reduce right hook conflicts • Facilitates transition from right side to left side of the bike lane • Often provide cyclists with a head start into the intersection • Allow the cyclist to make turning movements more obvious to other road users	Low	Low

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Median Refuge		Provides a space in the middle of the road (median) for cyclists to cross one direction of traffic and wait until there is a clearing to cross the intersection.	• Use on high speed and volume arterial routes where there is high cyclist crossing demand • Often used on roads with four or more lanes • Used near bus stops, schools, and other key destinations • Where local street bikeways cross arterial roads	• Cyclists can cross one direction of traffic at a time • Shortens the crossing distance	Moderate	Low
Grade Separated Crossing		Allows cyclists to cross major streets and intersections separated from other road users. Often via an underpass or overpass.	• Recommended over major roadways including highways and major arterials routes • Midblock crossings	• Provide a crossing of a major street or intersection • Cyclist and pedestrian crossings will have no delay on vehicle movements • Less wait times for cyclists	High	High
Median Barriers		Prevent vehicles from making certain movements, often used to limit turning and through movements of motorized vehicles. Median barriers are a form of traffic diversion.	• Install at intersections where an arterial and local road intersect • Use to lower traffic volumes on a local road • Often used at intersections where the local road is adjacent to a school, or other recreational facilities	• Limit turning movements of vehicles can increase the safety of cyclists traveling in the opposite direction • Reduces traffic volumes on certain local streets, such as those with a local street bikeway or destinations that encourage cycling	Moderate	Moderate
Diverters		Similar to median barriers noted above diverters prevent motorized vehicles from entering certain streets or restrict certain movements while permitting cyclists.	• Install on roads that are designated as bicycle routes, particularly local street bikeways • Use to lower traffic volumes on a local road	• Reduces vehicle volumes while still permitting cyclists to travel through • Reduces traffic volumes on certain local streets, such as those with a local street bikeway or destinations that encourage cycling	Moderate	Moderate

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Curb Extensions		Curb extensions are an extension of the curb into the parking lane at intersections to reduce speeds and increase the visibility of road users and shorten crossing distances.	• Where there is a full-time on-street parking lane • Where bicycles will travel outside of the curb edge for the length of the streets • Design should ensure adequate drainage	• Reduces speed of turning vehicles • Makes road users more visible	Moderate	Low
Traffic Circles		Often referred to as a roundabout, there is a raised island located in the centre of an intersection. Vehicles travel around the circle to complete turning movements.	• Use on local streets to help reduce vehicle speeds • Use in place of stops to give cyclists unimpeded travel •	• Can be used to slow traffic while allowing for better flow and traffic movement • Reduces possible conflict at intersections • Right of way is given to vehicles in the traffic circle	Moderate	Low
Road Closures		Closing a road to motorized vehicles can create routes that are designed specifically for cyclists and pedestrians. Can be a temporary or permanent option.	• Use on roads where there is a focus on increasing active transportation modes • Local or special roads with high pedestrian and cyclist volumes	• Reduces all conflict between cyclists and motorized vehicles • Creates a shared space with pedestrians	High	High
2-Way Stop		Two way stops at intersections give one road the right of way at all times and travelers on the other road must stop and wait for a break in traffic before they are able to cross.	• Use when one road that crosses the intersection has significantly higher traffic volumes (including cyclists) •	• Vehicles travelling on the street without the stop sign do not have to stop as frequently.	Low	Low
Parking Removal		Limit or remove on-street parking on streets with bicycle facilities or high volumes of bicycle travel.	• Consider removing parking on streets with high volumes of vehicle and bicycle traffic • Use on routes with a high occurrence of doorings	• Promotes cyclist safety by decreasing the chances of doorings and vehicles entering and exiting on street parking spaces	Low	High

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Separated vs. Mixed Modes		Roadways that mix modes allow for the shared use of space by motor vehicles, pedestrians, and bicyclists, without lane assignment. There generally are no sidewalks or other features to separate modes and these roadways usually have lower posted speed limits.	• Special consideration should be given to ensure there are cues that demarcate the travel way for visually impaired pedestrians. • Cyclists need to recognize that the space is shared and extra care should be taken to watch of other road users	• Reduces motor vehicle travel speeds and volumes. • Increases bicycle/pedestrian activity. • Improves attractiveness of street. • Increases social activity amongst neighbours and children.	Moderate to High	Moderate
New or Upgraded Intersection Lighting		Increases the visibility of the intersection for motorists to see Vulnerable Road Users	▪ All signalized intersections. ▪ Intersections where cyclist volumes are high, especially during the night time.	• Increases visibility of cyclists.	Moderate	High

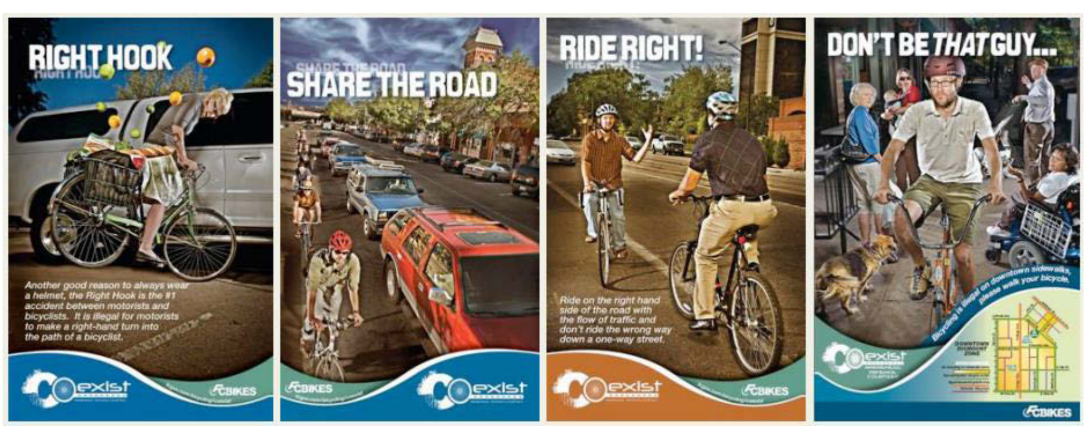
Appendix E

Cycling Safety Awareness Best Practices

Targeted public education campaigns have been identified as an effective means of bringing about behavioural change in the general population. Cycling safety campaigns can generally focus on increasing awareness of road safety strategies including changing behaviours, and providing information about road laws. However, they can also have more specific messages about specific types of collisions or safety hazards.

- **Road Safety Awareness Campaigns**

Educational outreach activities are an ongoing element of successful road safety strategies and continue to be utilized in places such as the Netherlands and Copenhagen where there are already high bicycle mode shares. Many road users lack information about the ways they can contribute to reducing the chances of a cyclist injury or fatality. Some drivers and cyclists are simply not aware that certain behaviors on their part put them at an increased risk of a collision. Numerous cities around the world report success with marketing campaigns aimed at particular roadway safety issues such as speeding, sharing the road with cyclists, cyclists not riding on the sidewalk, and specific safety concerns for both cyclists and drivers. Many of the current campaigns do not focus on singling blame for collisions but aim to educate all road users of their responsibility as a road user.



A sample of cities and programs are presented in **Table E.1** below. A variety of resources are available online to support the development of effective road safety awareness campaigns, some of which are included in the links found in below.

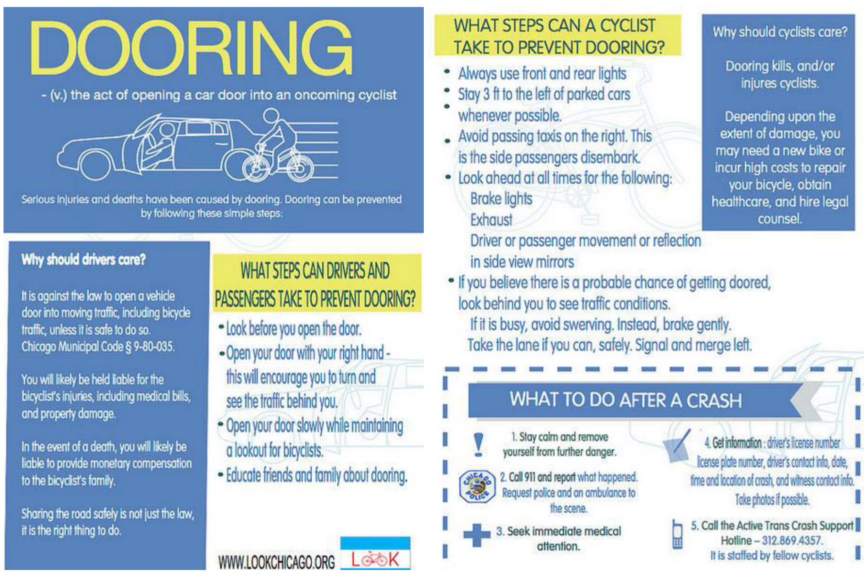
Table E.1
Example Road Safety Awareness Programs from Around the World

City/Agency	Campaign Messaging	Description
VicRoads	Bike Rider Safety Car Doors and Bike Riders Sharing the Road Places to Ride Wearing a Bicycle Helmet Keeping visible Learning to Ride	Various campaigns focused at promoting safe conditions for cyclists and motor vehicles.
Toronto	Cycling Education and Safety Pass Bikes Safely Please Don't Squeeze Sidewalks are for Pedestrians Watch for bikes	An extensive safety campaign that reinforces the theme that all road users need to have respect for each other as they make their way through Toronto. Includes a comprehensive website, ads on buses and at bus shelters.
Ontario	Young Cyclists Guide Riding Tips Learning the Rules of the Road Ride a Bike that Fits Important Bicycle Riding Skills Information for Parents	This site provides a guide for young cyclists on how to have fun cycling while staying safe during their cycling trip. Offers helpful tips and hints to make understanding the basic rules of the road more accessible for kids.
Think! Cycling (United Kingdom)	Look out for cyclists Watch when getting out Doorings Cyclists take their place on the road	Comprehensive website includes a wealth of information highlighting Think! campaigns as well as guidance for road safety professionals and educators. Provides information for both cyclists and drivers.
Germany	"Go Ahead" – School Competition	Focuses on accident prevention on school routes. Raises safety awareness among students. It is a competition to creatively work

City/Agency	Campaign Messaging	Description
		together to promote cycling safety.
Coexist (Fort Collins, San Francisco, and Capital District Transportation Committee)	Addresses key messages for cyclists and motorists: Educating cyclists to ride respectfully Educating motorists on how to drive cautiously Mutual awareness	Develop innovative and interesting posters and advertisements that are focused at both cyclists and drivers. Recognize the mutual responsibility for both parties and that both can play a part in making the road safer for all users.
FHWA	Pedestrian and Bicycle Safety Campaign	Extensive pedestrian safety campaign recently focusing more on cyclists. Developed Bicycle Road Safety Guidelines and Prompt Lists. Guidelines for conducting road safety audits specific to cyclists.
Geneva, Switzerland	PreDiRe Cyclistes	Police on bicycles are out on the street focusing on promoting bicycle safety and intercepting cyclists that are not following the rules of the road.
University of Washington	Why Can't We Be Friends	Focuses on reducing conflicts between bicycles and trucks
Seattle, Washington	Bike Smart	Focuses on two main goals, encouraging more people to ride their bikes and to promote a higher level of bicycle safety.
New York City	Don't Be a Jerk	Uses humour to point out some of the dos and don'ts of bicycling.

- **Doorings**

Doorings were identified as the most common cycling collision type in the City of Vancouver between the years 2007-2012. Vancouver is not alone. There are many other cities that have identified doorings as a significant safety concern and there are campaigns that focus specifically on these collision types. Toronto's "Watch for Bikes" campaign gave out 150,000 side mirror stickers that remind motor vehicle drivers to look for cyclists before opening their door. Car mirror stickers have also been distributed to cars and cabs in San Francisco, CA. In Cambridge, MA stickers are provided with every parking permit. Similar stickers are available through VicRoads in Australia and the "Look" Chicago campaign distributes flyers to motorist outlining how to prevent doorings.



- **Emotionally and Comedy Driven Campaigns**

Safety campaigns that personalize cyclists and focus on humour instead of evoking fear in cyclists and other road users have become the strategy of a number of cities. The Washington County Bicycle Transportation Coalition has a campaign called "And We Bike" which features life-sized cutouts of regular people and their bikes. They are designed to remind motorists that bicyclists are people you know including relatives, friends, coworkers and neighbours, ultimately trying to convey the message "Be careful; the cyclist could be someone you know." Similarly, the "Yield to Life" campaign focuses on humanizing and personalizing cyclists to help motorists to always be aware that all cyclists have a right to a safe space on the road.

- **Youth Cycling Safety Education**

There are a number of reasons why focusing on cycling safety and skills is important for children and young people. Not only is it designed to help increase their safety and understanding how to be a courteous cyclist basic, traffic laws and safety rules, but also building cycling culture in youth and instilling confidence and knowledge in a new generation of cyclists. The Ontario Ministry of Transportation has developed an online guide for young cyclists that provides guidance, road rules, and key things to know before your trip for both parents and children. There is a curriculum for school-based training that has been developed within the Province of

British Columbia, the "Right to Bike" in conjunction with HUB and the BC Cycling Coalition. The initiative seeks to develop a framework for youth cycling education in BC.

Cycling training through school programs is a key component to many education programs throughout the world, particularly in the well-known cycling countries including Denmark, Germany and Netherlands. While not as well established in North America trained safety professionals can administer cycling safety in the classroom, perhaps in gym class, and teachers can add cycling safety components to the curriculum for students of all ages. This includes teaching specifically about being a cyclist but also general roadway safety. By teaching some basic dos and don'ts at a young age these lessons can be instilled at a young age and be carried through to adulthood.

- **Watch for Cyclist Campaigns**

While an assumption, some believe that collisions involving cyclists and motor vehicles is a result of other road users not seeing or looking for cyclists as they make a driving action. While touched on above in reference to doorings, collisions with cyclists have the potential to be reduced if all road users have a better awareness of their surroundings and the presence of each other. Transport for London has a very effective campaign "Do the Test" which is designed to demonstrate to all road users the importance of being aware of what is happening around them at all times. Other campaigns with similar messages include "Look" in cities such as New York and Chicago. Which recognize the importance of motorists being aware of the road space they share with cyclists.

There are also a number of important campaigns that focus on cyclists being more visible to other motorists through the use of bright clothing and lights. These campaigns focus on riding safely at night and in dark and cold winter months.

- **Safety in Numbers**

Safety in Numbers campaigns are based on the belief that the safest places to cycle are those with high cycle use. They indicate that the number of cyclists and cyclist safety go hand in hand. Possible explanations of the "safety in numbers" effect include the possibility that drivers are more aware of cyclists because they encounter them on a more regular bases, the drivers are more likely to be cyclists themselves.

City/Agency	Campaign Messaging	Description	References
VicRoads	Bike Rider Safety Car Doors and Bike Riders Sharing the Road Places to Ride Wearing a Bicycle Helmet Keeping visible Learning to Ride	Various campaigns focused at promoting safe conditions for cyclists and motor vehicles.	
Toronto	Cycling Education and Safety Pass Bikes Safely Please Don't Squeeze Sidewalks are for Pedestrians Watch for bikes	An extensive safety campaign that reinforces the theme that everyone needs to have respect for each other as they make their way through Toronto. Includes a comprehensive website, ads on buses and at bus shelters.	http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=c9e5970aa08c1410VgnVCM10000071d60f89RCRD
Ontario	Young Cyclists Guide Riding Tips Learning the Rules of the Road Ride a Bike that Fits Important Bicycle Riding Skills Information for Parents	This site provides a guide for young cyclists on how to have fun, while staying staff during their cycling trip. Offers helpful tips and hints to make understanding the basic rules of the road more accessible for kids.	http://www.mto.gov.on.ca/english/safety/cycling/young-cyclist-guide/index.shtml http://www.mto.gov.on.ca/english/safety/cycling/young-cyclist-guide/Young%20Cyclist's%20Guide_ENGL.pdf
Think! Cycling (United Kingdom)	Look out for cyclists Watch when getting out Doorings Cyclists take their place on the road	Comprehensive website includes a wealth of information highlighting Think! campaigns as well as guidance for road safety professionals and educators. Provides information for both cyclists and drivers.	http://think.direct.gov.uk/cycling.html

City/Agency	Campaign Messaging	Description	References
Germany	"Go Ahead" – School Competition	Focuses on accident prevention on school routes. Raises safety awareness among students. It is a completion to creatively work together to promote cycling safety.	http://www.verkehrssicherheitsprogramme.de/site/detail.aspx?id=121
Coexist (Fort Collins, San Francisco, and Capital District Transportation Committee)	Addresses key messages for cyclists and motorists: Educating cyclists to ride respectively Educating motorists on how to drive cautiously Mutual awareness	Develop innovative and interesting posters and advertisements that that are focused at both cyclists and drivers. Recognize the mutual responsibility for both parties and that both can play a part in making the road safer for all users.	http://www.fcgov.com/bicycling/coexist.php http://www.sfbike.org/?coexist
FHWA	Pedestrian and Bicycle Safety Campaign	Extensive pedestrian safety campaign recently focusing more on cyclists. Developed Bicycle Road Safety Guidelines and Prompt Lists. Guidelines for conducting road safety audits specific to cyclists.	http://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa12018/
Geneva, Switzerland	PreDiRe Cyclistes	Police on bicycles are out on the street focusing on promoting bicycle safety and intercepting cyclists that are not following the rules of the road.	http://www.romanvie.ch/canton-geneve/94-la-prochaine-campagne-predire-cyclistes-se-deroulera-du-lundi-20-au-vendredi-24-juin-2011
University of Washington	Why Can't We Be Friends	Focuses on reducing conflicts between bicycles and trucks	

City/Agency	Campaign Messaging	Description	References
Seattle, Washington	Bike Smart	Focuses on two main goals, encourage more people to ride their bike and to promote a higher level of bicycle safety.	http://www.seattle.gov/transportation/bikesmart.htm
Portland, Oregon	Be Seen Be Safe (TriMet) Be flashy Be Shiny Be Reflective	Outlines the importance of cyclist visibility. Focus on wearing highly visible clothing and equip bicycles with lights and reflectors.	http://trimet.org/beseen/

Appendix F

Annotated Bibliography

Beck, L., Dellinger, A.M., & O'Neil, M.E. (2007). Motor Vehicle Crash Injury Rates by Mode of Travel, United States: Using Exposure-Based Methods to Quantify Differences. American Journal of Epidemiology. Vol. 166 No.2: 212-218

The study used traffic exposure data to calculate fatal and nonfatal traffic injury rates in the United States. The 2001 National Household Survey was used to estimate traffic exposure. Fatal and nonfatal injury rates per 100 million person-trips were calculated by mode of travel, sex and age group. The overall fatal traffic injury rate was 10.4 per 100 million person trips. Fatal injury rates were highest for motorcyclists, pedestrians and **bicyclists (21.0 per 100 million person trips)**. The nonfatal traffic injury rate was 754.6 per 100 million person-trips. Nonfatal injury rates were highest for motorcyclists and bicyclists. Exposure-based traffic injury rates varied by mode of travel, sex and age group. Motorcyclists, pedestrians, and bicyclists faced increased injury risks. Male, adolescents and the elderly were also at increased risk.

Bíl, M., Bílová, M. & Müller, I. (2010). Critical Factors in Fatal Collisions of Adult Cyclists with Automobiles. Accident Analysis and Prevention. 42: 1632-1636

This article evaluates the critical factors influencing the collisions of motor vehicles with adult (over 17 years) cyclists that resulted in fatal injury of cyclists. (Czech Republic). The most consequential factors for collisions involving cyclists include:

Drivers

- Inappropriate driving speed of automobiles
- Head on crashes
- Night time traffic in places without streetlights

Cyclists

- When they enter an intersection without right of way
- Males are more likely to suffer a fatal injury due to collision with a car than females
- A cyclist fatality is more often the drivers fault than the cyclists

In order to reduce fatal risk for cyclists it is recommended to separate the road traffic of motor vehicles from bicyclists in critical road-sections; or to at least reduce speed limits there.

Duthie, J., Brady, J.F., Mills, A.F., & Machemehl, R.B. 2010. Effects of On-Street Bicycle Facility Configuration on Bicyclists and Motorist Behaviour. Transportation Research Record: Journal of the Transportation Research Board. No. 2190: 37-44

This research examines the impact of design elements including the type and width of the bicycle facility, the presence of adjacent motor vehicle traffic, parking turnover rate, land use, and the type of motorist-bicyclist interaction. Observational studies were conducted at 48 sites in three large Texas cities

Results found that bicycle lanes create a safer and more predicable riding environment relative to wide outside lanes, and that the provision of a buffer between parked cars and bicycle lanes is the only reliable method for ensuring that bicyclist do not put themselves at risk of being hit by opening car doors.

Key results

1. Bicycle lanes are operationally superior to wide outside lanes. They increase the lateral position of bicyclists, leading to not only a safer position but also one that indicates a greater sense of comfort, they also reduce the difference in the lateral position of motorists during nonpassing and passing events. They reduce the probability of a passing motor vehicle encroaching on the adjacent lane
2. The addition of a buffer space between the outer edge of the bicycle lane and the driver side of a parked car is the most effective way to ensure that bicyclists are removed from the door zone of parked motor vehicles
3. Bicyclists felt more confident that they could better predict the opening of a car door in a discrete (or intermittent) parking environment, or that they were more willing to take a gamble on passing by the door of a signal car as opposed to a row of cars.

Goodno, M., McNeil, N., Parks, J., & Dock, S. (2013). Evaluation of Innovative Bicycle Facilities in Washington D.C. Transportation Research Record: Journal of the Transportation Research Board.

Two innovative bicycle facilities were installed in Washington D.C. during 2010 by the District Department of Transportation: buffered center median bicycle lanes on Pennsylvania Avenue, NW and a two-way cycle track on 15th Street. This paper presents the results of a comprehensive study that evaluated the facilities to understand how well they worked for cyclists, motorists and pedestrians in terms of safety and level of service (LOS) and how they affected behaviour and attitudes.

The study found that bicycle LOS improved and that bicycle volume on those corridors nearly quadrupled, well above the rate of citywide bicycle use. Motor vehicle LOS was largely unaffected. Although bicycle crashes increased on both facilities, the crash rate remained similar on 15th Street to what it had been previously. Pennsylvania Avenue saw a higher crash rate, mainly as a result of illegal U-turns across the bike lanes. The perception of the lanes in general was positive for all users and the lanes were seen as a positive addition to the community.

Harris, M.A., Reynolds, C.C.O., Winters, M., Cripton, P.A., Shen, H., Chipman, M.L., Cusimano, M.D., Babul, S., Brubacher, J.R., Friedman, S.M., Hunte, G., Monro, M., Vernich, L., & Teschke, K. Comparing the Effects of Infrastructure on Bicycling Injury at Intersections and Non-Intersections using a Case Cross-Over Design. Published First Online February 14, 2013 as 10.1136/injuryprev-2012-040561

This study examined the impact of transportation infrastructure at intersections and non-intersection locations on bicycle risk. This was done through a study of adult cyclists who were treated at the hospital emergency department. A case-crossover design compared the infrastructure of injury and control sites within each injured bicyclist's route. Results found that intersections where two local streets (no demarcated traffic lanes) met had approximately one-fifth the risk of intersections of two major streets (more than two traffic lanes). Motor vehicle speeds less than 30km/h reduced risk, and traffic circles on local streets increased the risk. At non intersection locations there was very low risk associated with cycle tracks and local streets with diverters that reduced motor vehicle traffic. Downhill grades increased risk at both intersection and non-intersection locations.

Kim, J-K., Kim, S., Ulfarsson, G.F., & Porrello, L.A. (2007). *Bicyclist Injury Severities in Bicycle-Motor Vehicle Accidents*. Accident Analysis and Prevention. 39:238-251

This research explores the factors contributing to the injury severity of bicyclists in bicycle – motor-vehicle accidents. The multinomial logit model predicts the probability of four injury severity outcomes: fatal, incapacitating, non-incapacitating, and possible or no injury. The results show that there are several factors which more than double the probability of bicyclist suffering a fatal injury in an accident. Notable variables include inclement weather, darkness with no streetlights, a.m. peak (6:00 am to 9:59 am), head on collision, speeding-involved, vehicle speeds above 48.3 km/h (36mph), truck involved, intoxicated driver, bicyclist aged 55 and over, and intoxicated bicyclist. The largest effect is caused when estimated vehicle speed prior to impact is greater than 80.5 km/h (50mph), where the probability of fatality is more than 16-fold. The results also imply that bicyclist fault is more closely correlated with greater bicycle injury severity than driver fault.

Lusk, A.C., Morency, P., Miranda-Moreno, L.F., Willett, W.C., & Dennerlein, J.T. (2013*)*. *Bicycle Guidelines and Crash Rates on Cycle Tracks in the United Sates*. American Journal of Public Health. Vol.103 No.7: 1240-1248

This study looked at state - adopted bicycle guidelines to determine whether cycle tracks were recommended, whether they were built, and their crash rate. The study identified 19 cycle tracks in the US and collected extensive data on cycle track design, usage, and crash history from local communities. Used bicycle counts and crash data to estimate crash rates. For the 19 US cycle tracks studied the overall crash rate was 2.3 per 1 million bicycle kilometers. Showing that the risk of bicycle-vehicle crashes is lower on US cycle tracks than published crashes rates on roadways, these findings support the installation of cycle tracks. Furthermore, recent research shows bicyclists' preference for cycle tracks.

Nabors, D., Goughnour, E., Thomas, L., DeSantis, W., & Sawyer, M. *Bicycle Road Safety Audit Guidelines and Prompt Lists*. Report No. FHWA-SA-12-018. May 2012

- Typically, severe crashing causing fatality are reported; however, less serious cyclist crashes are more frequent and underreported
- Typically, reported crashes only represent a fraction of the total number of cycling crashes occurring on public roadways.
- For many jurisdictions, official crash reporting does not include bicycle-only crashes that occur on the roadway, bicycles striking fixed objects, or crashes between cyclists and pedestrians.
- Studies have found that state crash databases, even with high rate of reporting, may only capture about one-fourth of the crases serious enough to require treatment at a hospital emergency department and less than half of the crashes on the roadway that resulted in serious cyclist injuries.
- Cycling crashes on **sidewalks**, parking area, or off-roadway paths are also unlikely to be included in most State and local reported crash databases. At least one-fourth of the significant injuries in the hospital study resulted from crashes in non-roadway areas; about half of these were on sidewalks

Factors that contribute to bicycle crashes:

- Approximately one-half (51 percent) of the bicycle crashes occurred at intersections or were related to intersections, 22 percent occurred at junctions with commercial and private driveways or alleys and the remaining 27 percent occurred on roadway segments.
- In compact urban areas the percentage of intersection is even greater, 68 percent of collisions occurred at intersection locations (39 percent un-signalized and 29 percent signalized)
- The severity of a crash involving a cyclist and motorist increase exponentially with speed
- Top bicycle crash type groups:

  Crossing Paths

  - Motorist failure to yield – intersection
  - Bicyclist failure to yield – intersection
  - Bicyclist failure to yield – midblock
  - Motorist failure to yield – midblock (driveway/alley)
  - Turing errors – bicyclist and motorists
  - Bicyclist failure to clear intersection
  - Crossing Path Total

Parallel Paths

- Motorist turned/merged into path of bicyclist
- Motorist overtaking bicyclist
- Bicyclist turned/merged into path of motorist
- Bicyclist overtaking motorist
- Operator wrong side/head on (motorist or bicyclist)
- Operator wrong side/head-on (motorist or bicyclist)
- Motorist loss of control
- Bicyclist loss of control

Human factors and behaviour are a contributing factor in most crashes involving motor vehicles. Crashes involving cyclists are no different. Behaviours exhibited by motorists, pedestrians and cyclists should be observed and investigated to understand the reasons those behaviours are practiced. Cyclist, pedestrian or driver behavior should be accessed to determine if it is increasing the risk of collision.

OCED (2013). *Cycling Health and Safety*. OECD Publishing http://dx.doi.org/10.1787/9789282105955-en

This documents provides the following recommendations for improving cyclist safety:

1. Where it does not reduce the quality of the cycling networks, **bicycle facilities should be located away from road traffic** when feasible – especially for sections where cars are accelerating (hills, long straightaways)
2. **Insufficient evidence supports causality for the "safety in numbers" phenomenon** – policies increasing the number of cyclists should be accompanied by risk reduction actions
3. Efforts must be made to **harmonize definitions of terminology** so as to be able to make reliable international comparison of cyclist safety
4. National authorities should set standards for a collect or otherwise **facilitate the collection of data on non-fatal cycling crashes** based on police reports linked, in either a systematic or periodic way, to hospital records.
5. National authorities should set standards for and collect or otherwise facilitate the collection of accurate frequent and comparable **data on bicycle usage**
6. Authorities seeking to improve cyclists' safety should adopt **the Safe System approach** – policy should focus on improving the inherent safety of the traffic system, not simply on securing marginal improvement for cyclists in an inherently unsafe system
7. Authorities should establish top-level plans for cycling and cycling safety and should ensure **high-level coordination** among relevant government

agencies to ensure that cycling grows without aggravating safety performance

8. Authorities **should ensure that all road users receive cycling training** covering riding skills and use of both road and bicycle-specific facilities. This training can be part of a broader safety training program that many authorities have put in place targeting children and young adults.
9. **Speed management** acts as "hidden infrastructure" protecting cyclists and should be included as an integral part of cycling safety strategies.
10. Safety policy should target crashes between **Heavy Goods Vehicle and Bicycle crashes** due to the especially serious consequences of these crashes and their (relative) frequency.
11. Cyclists should not be the only target of cycling safety policies – motorists are at least as important to target
12. Cycle safety policies should play close attention to junction design – visibility, predictability and speed reduction should be incorporated as key design principles
13. Authorities should match investments in cycle safety to local contexts, including levels of bicycle usage
14. Cycle safety plans should address safety improvement and the improvement of *perceived* safety
15. The deployment of cycling infrastructure should be accompanied by adequate levels of maintenance and enforcement of access rules
16. Where appropriate, **traffic speeds should be limited** to less than 30km/hr where bicycles and motorized traffic mix but care should be taken so that speed control devices do not create hazards for cyclists
17. Where speed cannot be lowered, or where justified by traffic densities, authorities should seek to **separate bicycle and motor traffic wherever feasible**
18. Authorities must critically examine **bicycle facility junction design** and deploy known safety-improving measures to decrease crash risks

Reynolds, C., Harris, M.A., Teschke, K., Cripton, P.A. & Winters, M. (2009). The Impact of Transportation Infrastructure on Bicycling Injuries and Crashes: a review of the literature. Environmental Health. 8:47.

This study reviewed previous studies on the impact of transportation infrastructure on bicyclist safety. The results were tabulated in two categories of infrastructure 1. Intersection infrastructure (e.g. Roundabouts and traffic lights) and 2. Intersections on straightaways (e.g. bike lanes or paths). To access safety, studies examining the following outcomes were included: injuries; injury severity; and crashes (collisions and/or falls).

The results based on the study of 23 studies found that infrastructure influences injury and crash risk, intersection studies focused mainly on roundabouts and found that multi-lane roundabouts can significantly increase risk to bicyclist unless a separated cycle track is included in the design. The results of studies that looked at straightaways suggest that sidewalks and multi-use trails pose the highest risk, major roads are more hazardous than minor roads, and the presence of bicycle facilities (e.g. on-road bicycle routes, on-road marked bicycle lanes, and off road bicycle paths) was associated with the lowest risk. Street lighting, paved surfaces, and low-angled grades are additional factors that appear to improve cyclist safety.

Schepers, J.P., Kroeze, P.A., Sweers, W., & Wüst, J.C. (2011). *Road factors and bicycle-motor vehicle crashes at unsignalized priority intersections*. Accident Analysis and Prevention. 43: 853-861

In this study, the safety of cyclists at unsignalized priority intersections within built-up areas was investigated. The study focuses on the link between the characteristics of priority intersection design and bicycle-motor vehicle (BMV) crashes. Across 540 intersections that are involved in the study the police recorded 399 failure-to-yield crashes with cyclists in four years. The crashes were broken down into two groups.

Type I: through bicycle related collisions where the cyclist has the right of way

Type II: through motor vehicle related collisions where the motorist has the right of way

The probability of each crash type was related to its relative flow and to independent variables using negative binomial regression. The results show that more type I crashes occur at intersection with two way bicycle tracks, well-marked, and reddish colour bicycle crossings. Type I crashes are negatively related to the presence of raised bicycle crossings and other speed reducing measures. The accident probability is also decreased at intersections where the cycle track approaches are deflected between 2 and 5 metres away from the main carriageway.

Appendix G

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