Bicycle Crash Analysis

Understanding and Reducing Bicycle & Motor Vehicle Crashes

Denver Public Works
Transportation & Mobility
FEBRUARY 2016

DENVER
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Acknowledgements

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Introduction

In 2011, Denver Public Works (DPW), in cooperation with Denver Parks and Recreation, released *Denver Moves*, the bicycle network plan for the city. This Plan envisions that every household will be within a five-minute bike ride or walk to a high ease-of-use, or low stress, bicycle facility. *Denver Moves* proposes 270 miles of new bicycle facilities to add to the then current network of 172 miles. These new facilities will support Denver's goal of achieving a 15 percent non-motorized commute mode share by 2020. Public Works is currently amending Denver Moves to include more protected bike lanes and buffered bike lanes in downtown and along strategic corridors throughout Denver.

An important objective of *Denver Moves* is to "Increase Safety, Visibility, and Usability [of city streets for bicyclists]." Not only is it important to analyze crash data to understand actual safety issues, it also helps to address perceptions of safety. Perceived safety is often reported as a major deterrent for bicycling.[1] Making changes to both improve safety for bicyclists and to improve public perception of safety will have a positive contribution to the City achieving its stated goals.

To comprehensively assess safety, Public Works conducted an initial analysis of crash reports from a five-year period to reveal trends in crash types and locations. This report builds on that initial analysis to document recent crash trends, discover major contributing factors for crashes, and provide next steps to address bicycle safety.

This report offers a baseline to understand and analyze future events and trends related to bicycle crashes. The analysis identifies the overall context for crash characteristics including street conditions, motorist and bicyclist ages, crash typologies, and circumstances related to the crashes as recorded by police crash reports. With this understanding of safety in Denver, the final sections of the report present next steps for Public Works to address engineering strategies, as well as recommended opportunities for inter-agency City collaboration.

DPW created this report for the purpose of improving street safety across the city, particularly for bicyclists. Public Works can use this report's findings as a guide for planning, and capital improvement projects that will best improve road safety for bicyclists.

As Denver's bicycle program evolves, Public Works staff can expand their data collection procedures to capture better details about crash types and contributing factors. This data will play a key role in measuring the effectiveness of programs and/or design solutions in addressing specific crash types or behaviors that contribute to crashes.

While this report is focused on bicycle crashes in Denver, bicycling is a relatively safe mode of transportation in the city. Of the many tens of thousands of trips that occur each year, Denver

1 Monsere, C.M., Dill, J., McNeil, N., et al. "Lessons from the Green Lanes: evaluating protected bike lanes in the U.S." (2014). National Institute for Transportation and Communities, report no. NITC-RR-583, Portland, OR.

averaged 265 bicycle crashes per year between 2008 and 2012, with four of those resulting in a fatality from all five years. While all modes of transportation present safety risks, research increasingly finds that health benefits of bicycling compared to driving far outweigh the relative risks of bicycling in urban environments.[2]

Methods

This section of the report describes both the City's police crash reporting process and the process used to analyze these crashes as part of this project.

Crash Reporting Process

The crashes described in this report include crashes that were reported by police between 2008 and 2012. The state of Colorado follows standard crash reporting procedures, outlined in the Investigating Officer's Traffic Accident Reporting Manual. A standard crash report form used for investigation is shown in Figure 1.

When a crash occurs and is reported or police arrive at the scene, the reporting officer completes the Investigator's Traffic Accident Report (Form DR2447),[3] which includes personal identification information, pre-crash maneuvers, location, environmental conditions, road description, contributing factors, and bicyclist / motorist conditions. On the form, the officer can illustrate the street and crash circumstances by indicating positions of the parties in the crash and a narrative section to describe conditions or information beyond the standard form. Original copies of the report are sent to the Colorado Department of Revenue, Motor Vehicle Division for archival and analysis purposes. The reports may be used for legal cases and investigations. Denver Public Works (DPW) receives the crash report (form DR 2447) from the Denver Police Department and transfers data to an internal database for archiving and analysis.

Unreported Crashes

The total number of bicycle crashes is likely higher than the number of crashes captured by police reports. Bicycle crashes may go unreported if there were no major injuries or less than $1,000 of property damage occurred, if one or more parties were not aware of the need to report the crash, or if one or more parties were afraid to contact law enforcement.[4] A study conducted by the Federal Highway Administration of bicyclist injuries in California, New York, and North Carolina found that 33 to 57.5 percent of all bicycle crashes potentially go unreported.[5]

A note about terminology: this report uses the term "crash" as opposed to "accident." The manual defines a traffic accident as unintentional damage or injury caused by the movement of a motor vehicle or its load. The term "crash" is becoming a widely used term to describe a traffic collision as a way to focus on the event itself. Although a traffic accident is not an intentional crash, it is important to recognize the influence of the contributing factors to the crash, which may be preventable.

2 de Hartog, Jeroen Johan, et. Al. "Do the Health Benefits of Cycling Outweigh the Risks?" Environmental Health Perspectives. 18 (2010).

3 A crash report is required if the crash results in injury, fatality, or more than $1,000 in damage.

4 Colorado State Traffic Records Advisory Committee. Investigating Officer's Traffic Accident Reporting Manual. 2006.

5 Federal Highway Administration. Injury to Pedestrians and Bicyclists: An Analysis based on Hospital Emergency Department Data. FHWARD-99-078. 1999.

DR 2447A (11/17/05)
COLORADO DEPARTMENT OF REVENUE

MAIL TO: STATE OF COLORADO
MOTOR VEHICLE
TRAFFIC RECORDS
DENVER, CO 80261-0016

STATE OF COLORADO TRAFFIC ACCIDENT REPORT

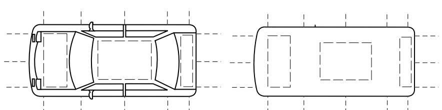
1 ☐ AMENDED/SUPPL. 2 ☐ UNDER $1,000 3 ☐ COUNTER REPORT 4 ☐ PRIVATE PROPERTY PAGE 5 OF ____ PAGES

CDOT Code 6	☐ INTERSTATE HWY ☐ STATE HWY ☐ CITY ST/CNTY RD 8	HWY NUMBER ☐ ☐ ☐ MILEPOINT ☐ ☐ ☐.☐ ☐	DOR Code 9
Case # 7			

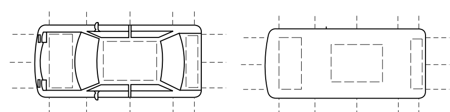
Date of Accident 10	City 11	Agency 12	County 13	County # 14	
Time (24 Hr.) 15	Officer Number 16	Officer Name 17	Signature 18	Detail 19	
Number Killed 20	Number Injured 21	Location Route, Street, Road 23 ____ Miles ____ Feet N ☐ S ☐ E ☐ W ☐ OF: ☐ At: ____ Latitude ____ Longitude ____			
Date of Report 22					

Agency Code 24	Investigated @ Scene 25 ☐	Total Vehicles 26	District Number 27	Public Property/ Employee 28 ☐	Photos Taken ☐ 29	Railroad Crossing Related ☐ 30	Const. Zone Related 31 ☐	Highway Interchg. 32 ☐	Bridge Related 33 ☐

Traffic Unit # 1 or 34 ☐ Veh. ☐ Parked ☐ Bicycle ☐ Pedestrian ☐ Non-Vehicle ☐ Non-Contact Veh.	Traffic Unit # 2 or 34a ☐ Veh. ☐ Parked ☐ Bicycle ☐ Pedestrian ☐ Non-Vehicle ☐ Non-Contact Veh.
Last Name 35 / First / MI	Last Name / First / MI
Street Address 36 / Personal Phone 38 ( )	Street Address / Personal Phone ( )
City 37 / State / ZIP / Bus. Phone 39 ( )	City / State / ZIP / Bus. Phone ( )
Driver License Number 40 / CDL 41 / State 42 / Sex 43 / DOB 44	Driver License Number / CDL / State / Sex / DOB
Primary Violation 45 ☐ DUI	Primary Violation ☐ DUI
Violation Code 46 / Citation Number 47 / Common Code 48	Violation Code / Citation Number / Common Code
Year 49 / Make 50 / Model 51 / Body Type 52	Year / Make / Model / Body Type
License Plate Number 53 / State or Country 54 / Color 55	License Plate Number / State or Country / Color
Vehicle Identification Number 56	Vehicle Identification Number
Vehicle Owner Last Name ☐ Same 57 / First / MI	Vehicle Owner Last Name ☐ Same / First / MI
Address ☐ Same 58 / City / State / ZIP	Address ☐ Same / City / State / ZIP
Towed Due to Damage ☐ By: To: 59	Towed Due to Damage ☐ By: To:
Trailer VIN#____ 60	Trailer VIN#____



____ Undercarriage ____ Undercarriage 1- Slight 2- Moderate 3- Severe



____ Undercarriage ____ Undercarriage 1- Slight 2- Moderate 3- Severe

Insurance Company ☐ None ☐ No Proof 61 / Exp. Date 62	Insurance Company ☐ None ☐ No Proof / Exp. Date
Policy Number 63	Policy Number

Owner Damaged Prop. Last Name 64	First	MI	Address 65	City	State	ZIP
Owner Damaged Prop. Last Name	First	MI	Address	City	State	ZIP

T.U. #	POS.	REST.	ENDO.	SAFETY EQUIP.	AIR BAG	EJECT	SUSPECTED ALCO	SUSPECTED DRUG	INJ. SEV.	AGE	SEX	NAME / ADDRESS
68	69	70	71	72 - 74	75	76	77	78	79	80	81	82	83

Approved By	I.D. #	Date

Figure 1: Colorado Traffic Accident Report Form, Page 1

Data and Study Process

Denver Public Works conducted an analysis of bicycle crashes in three phases.

Phase 1

All bicycle crash reports between 2008 and 2012 were compiled into a central database. Public Works staff then reviewed the narratives of each crash report to provide additional data to each. This additional analysis added more nuance about bicycle and motor vehicle behavior. For example, the crash report does not include a field or standard way to indicate that a bicyclist was riding on the sidewalk or riding against traffic on the sidewalk, even though these are among the most common actions associated with a crash. This level of detail is important to understand the unique and complex nature of each crash.

Public Works then used the information from the standard fields and the crash narrative to sort the crashes into initial typologies. These typologies included: *Broadside, Motorist Approaching Turn, Motorist Overtaking Turn, Bicycling Approaching Turn, Bicyclist Overtaking Turn, Rear End, Sideswipe, Dooring, and Unknown*. City staff then hired a consultant, Toole Design Group (TDG), to apply their expertise in multi-modal safety research to conduct further analyses.

The last part of Phase 1 included understanding why crashes occur by investigating the contributing factors, pre-crash maneuvers, and assignment of fault. Because the most reported contributing factor among motorists and bicyclists was "No Action,"[6] fields including pre-crash maneuver (the movement the vehicle or bicycle was making prior to the crash) were investigated. For instance, in crashes where the motorist was assumed to be at fault in the crash and "No Action" was listed as a contributing factor, the analysis lists the motorist pre-crash maneuver as a proxy for contributing factor.

Phase 2

The crash report narratives were carefully reviewed to determine the pre-crash location and riding direction of each bicyclist—e.g., sidewalk versus on street. For bicyclists riding on the sidewalk, the review also further categorized them as riding with traffic or against traffic. The crash analysis team then further sorted crashes into typologies based on direction of travel and pre-crash maneuvers (e.g., motorist driving straight into bicyclist turning left). These typologies were developed to identify the combination of pre-crash maneuvers leading to crashes. The typologies are detailed in their identification in order to best understand the complete nature of each crash to best address crash reduction strategies.

Phase 3

The team mapped the location of the most common crash types and developed a set of engineering crash reduction strategies to counteract the most common crashes in Denver.

Crash Reporting Definitions

Contributing Factors: The human factor which contributed to the accident. Common contributing factors include careless driving, failed to yield right of way, and improper turn.

Pre-crash Maneuvers: The movement that the vehicle or bicycle was making prior to the crash. These can include going straight, making a left or right turn, riding in the crosswalk/sidewalk, and other movements.

City and County of Denver, "Traffic Accident Reporting Manual." 2002.

6 The contributing factor field on the Colorado Crash Report Form notes that the information is considered to be "officer judgment only." More detailed reporting or tailored reporting procedures may help understand the primary contributing factors for future crashes.

Interpretation and Assumptions

This report presents an analysis of available data on bicycle crashes in Denver. While crash reports are the most reliable source of bicyclist/motorist crash information, the data have been used with caution. Some limitations of the data include:

- Data has undergone several rounds of interpretation (first by the victim, then by the officer) by the time it is included in crash reports.
- Lack of exact location of crashes. All crashes are mapped at intersections, which can skew corridor analyses.
- Lack of bicycle count data at the time of the crashes review in this report. Public Works is developing its bicycle count program, which will enable fast and accurate calculation of crash rates in districts and corridors in Denver
- Severity of injury in a bicycle crash.
- Unreported crashes. There are likely many bicycle crashes that are not reported for a variety of reasons.
- Race and sex information.

These caveats do not discredit crash reports, rather they frame the complexity of the crash reporting process. A primary assumption with this analysis is that crash reports are accurate and while the precise details of every crash may deviate from the sequence of actual events, the overall findings in this report are consistent with anecdotal evidence, knowledge of bicyclist traffic volumes, turning movements, intersection geometry, and Denver's streets.

Key Findings

There were a total of 1,325 reported bicycle crashes in Denver between 2008 and 2012 (see Figure 2). Of all Denver crashes, bicycles are involved in about 2%. In the four year time frame, there was an average of 265 bicycle crashes per year (figure 2). While bicycle crashes

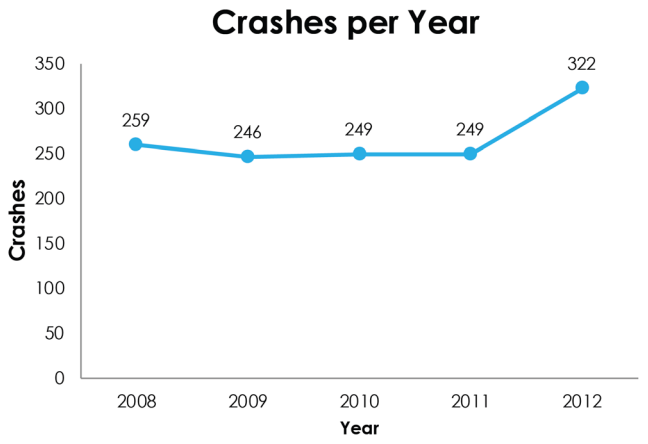


Figure 2: Bicycle Crashes per Year

have increased in Denver, the crash rate has declined.[7]

Injuries and Fatalities

A total of 52 percent of bicycle crashes in Denver resulted in at least one injury during the five-year period, though the reporting process does not distinguish between minor and serious injuries. There was a large increase in injury rate from 2009 to 2010 (see Figure 3), which may be linked to changes in the State of Colorado's reportable injury criteria as opposed to an increase in the actual number of injuries. The injury rate has been steadily declining since its peak in 2010: from 61 percent to 49 percent.

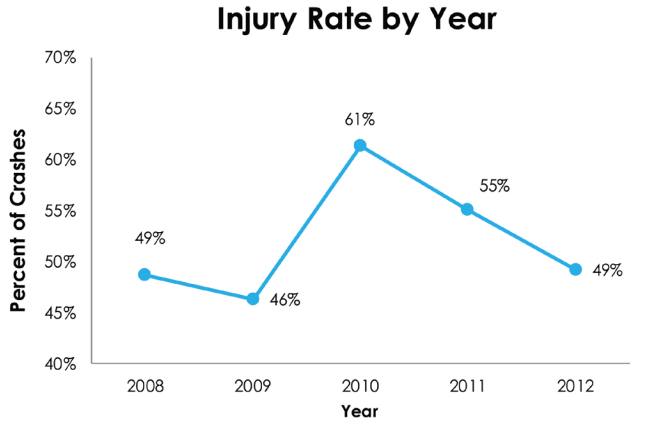


Figure 3: Injury Rate per Year

7 The crash rate, which is the percentage of bicycle trips that experience a crash, is intended to decline with implemented safety countermeasures, although the total number of crashes may not as rates of bicycling increase

Year	2008	2009	2010	2011	2012
Commute Mode Share	1.6%	1.8%	2.2%	2.4%	2.9%
Commute Trips	9,782	11,072	13,042	15,300	18,832
Crashes per Year	259	246	249	249	322

Table 1: Bicycle Crash Rates, 2008-2012

Between 2008 and 2012, four reported bicycle crashes resulted in fatalities. Two of these crashes involved heavy vehicles and two involved hit and run occurrences, where the motorist fled. With such a small number of fatal crashes, there was not enough data to determine trends. Although Denver has one of the lowest bicycle fatality rates among large cities in the nation, no fatality is acceptable.

Bicyclist Fatality Rates per 10,000 Bicycling Commuters

Omaha	0.0	**Denver**	**1.5**
San Francisco	0.9	Chicago	1.5
Portland, OR	0.9	Atlanta	1.5
Minneapolis	1.0	Albuquerque	2.9
Philadelphia	1.3	Indianapolis	4.9

2012 Benchmarking Report, Alliance for Biking & Walking. Rates based on 2007-2009 crash data from NHTSA's Fatality Analysis Reporting System.

Bicycle crash rates per trip decreased between 2008 and 2012 from 2.6 to 1.7 percent (see Table 1). This rate is based on crash data and estimates of commute trips from the American Community Survey (ACS).[8] Long-term bicycle count information was not available for this study, thus ACS commute numbers serve as a proxy to show rates over time. The actual crash rate may be lower, as the ACS does not consider non-work trips; however, crash numbers also do not consider unreported crashes.

A recent study from the University of Colorado Denver found an inverse correlation between the number of bicyclists on a road and the number of bicycle-vehicle collisions[9]. Increasing the number of bicyclists that use a transportation network improves their visibility on the street, which likely increases the awareness of bicyclists among motorists.[10] This phenomenon is known as 'safety n numbers' and is likely the case in Denver, as shown in the crash rates in Table 1.

8 American Commuter Survey 1-Year Estimates (2008-2012). Accessed June 2014. http://factfinder2.census.gov/

9 Krista Nordback, Wesley E. Marshall, Bruce N. Janson. Bicyclist safety performance functions for a U.S. city. Accident Analysis & Prevention, 2014; 65: 114.

10 Jacobson, Peter L. "Safety in numbers: more walkers and bicyclists, safer walking and bicycling." Injury Prevention. 2003; 9:205-209.

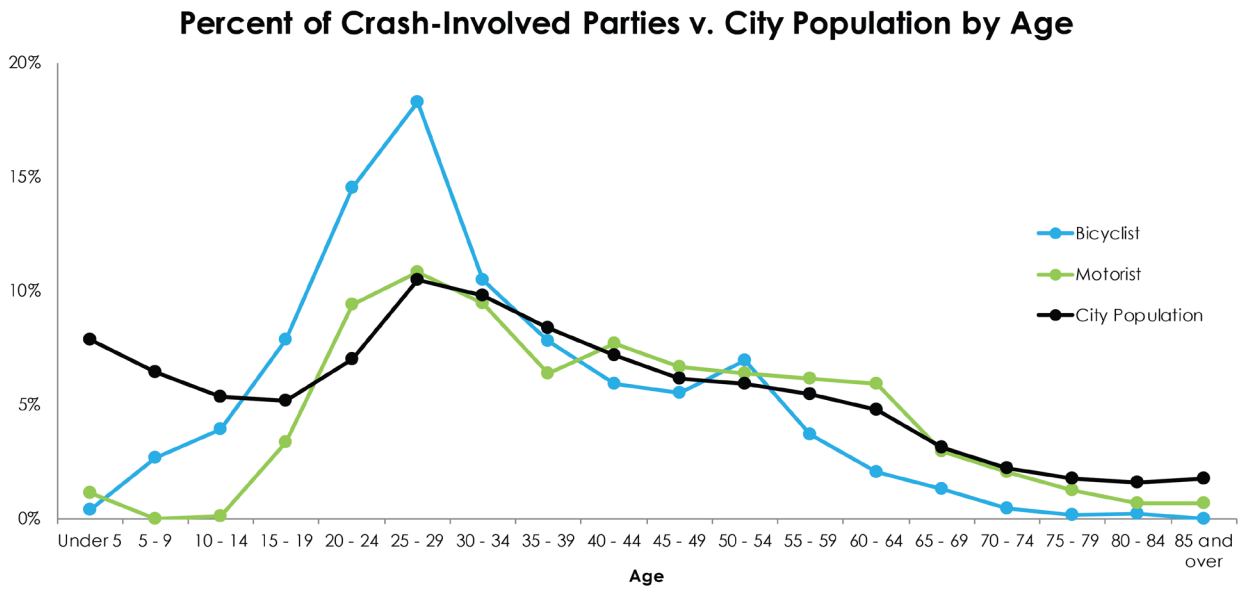


Figure 4: Ages of Those Involved in Bicyclist/Motor Vehicle Crashes Compared to Denver Population, 2008-2012

Crash Characteristics

Age

The majority of parties involved in bicycle/motorist crashes were between the ages of 24 and 35. Overall, bicyclists involved in crashes were younger than motorists and were mostly between the ages of 25 and 29. Motorists were also most-represented by the 25 to 29 age range, but were closely followed by ages 30 to 34. Nationally, the average age of bicyclists injured in a bicycle collision has increased steadily from 27 in 2003 to 32 in 2012. Following national trends, the average age of bicyclists involved in crashes in Denver is 32.4 (see Figure 4).[11]

Vehicle Type

Crashes involving SUVs and pickup trucks resulted in injuries at a higher percentage (57 percent) than crashes involving passenger cars (47 percent). Studies have shown that large vehicles cause injuries to pedestrians at higher rates than small vehicles when the vehicle is traveling at less than 30 mph. For speeds above 30 mph, the injury rates become similar.[12] Data on the severity of injury were not available for this study.

Time of Day/Month/Year

The majority of crashes occurred during the evening rush hours (between 4 and 6 PM) on weekdays in the summer months (May to October). While there are two peak crash periods that align with peak commuting periods, the majority of crashes occur during the afternoon rush hours.

Eleven percent of all crashes occurred during the 5:00 pm rush hour, the peak hour during the day, followed by the 4:00 pm hour with 9 percent (Figure 5). Chicago, Boston, and Minneapolis all report the highest number of bicycle crashes during the PM rush hour period, as well (Chicago – 3pm to 5pm,[13] Boston – 4pm to 6pm,[14] Minneapolis – 3pm to 6pm[15]). Nationally, the most bicycle fatalities occur between 4 pm and

11 "Bicyclists and Other Cyclists." Traffic Safety Facts 2012 Data. National Highway Traffic Safety Administration. April 2014.

12 Basem Y. Henary, Jeff Crandall, KaviBhalla, Charles N. Mock, Bahman S. Roudsari. Child and Adult Pedestrian Impact: The Influence of Vehicle Type on Injury Severity. AnnuProcAssocAdvAutomot Med. 2003; 47: 105–126.

13 City of Chicago. 2012 Bicycle Crash Analysis Summary Report and Recommendations. 2013.

14 City of Boston. Boston Cyclist Safety Report. 2013.

15 City of Minneapolis. Understanding Bicyclist-Motorist Crashes in Minneapolis, Minnesota. January 2013.

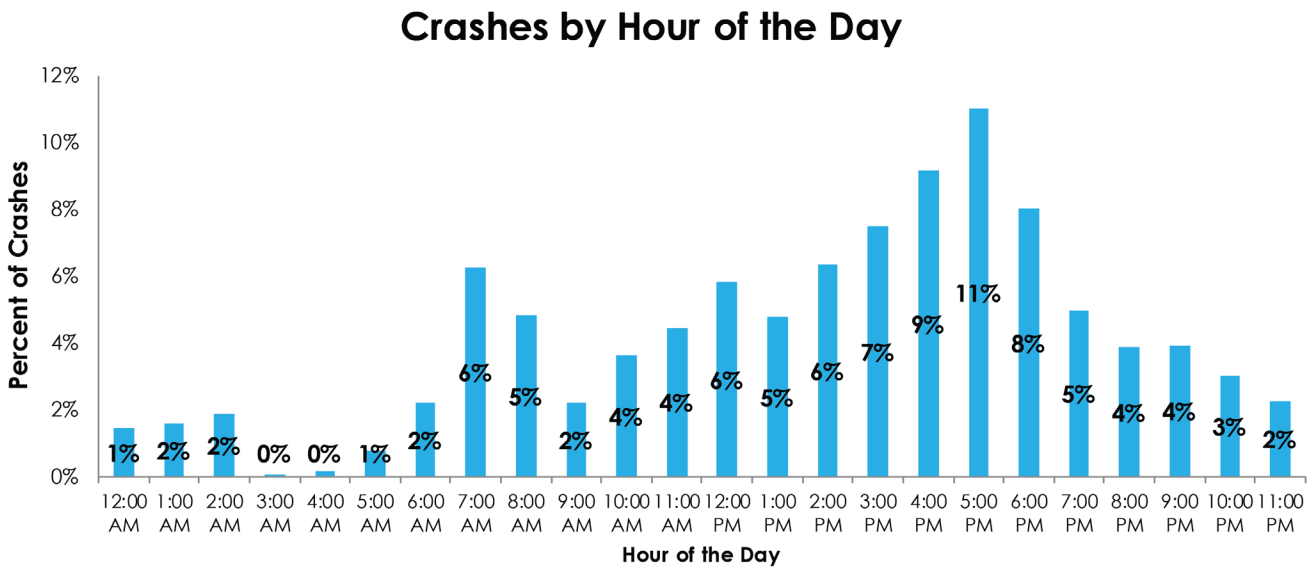


Figure 5: Bicycle/Motor Vehicle Crashes by Time of Day, 2008-2012

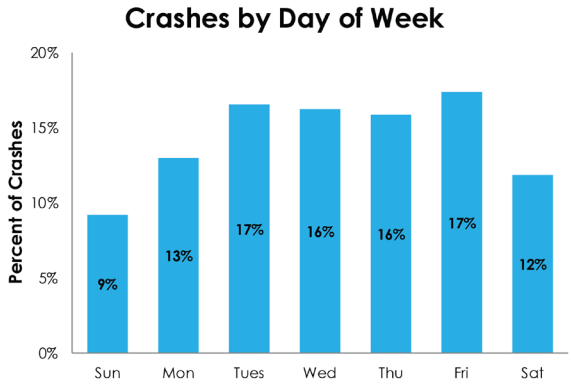


Figure 6: Bicycle/Motor Vehicle Crashes by Day of Week, 2008-2012

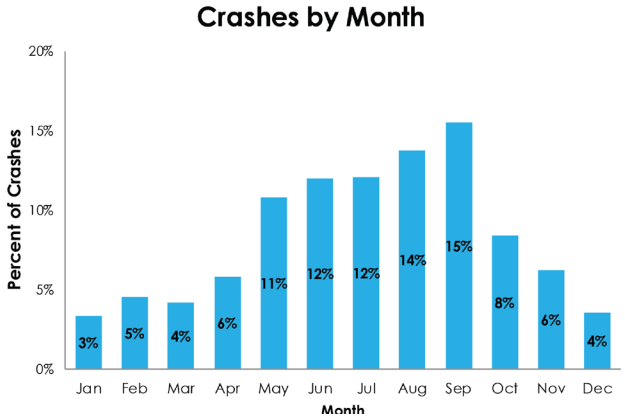


Figure 7: Bicycle/Motor Vehicle Crashes per Month, 2008-2012

8 pm.[16] This does not suggest that these are the most dangerous times to bicycle, rather, these peak periods likely align with the highest rate of bicycle trips.

There is less variation among days of the week. Tuesdays, Wednesdays, Thursdays and Fridays account for 14 percent to 18 percent of crashes each day. Mondays and Saturdays account for 13 percent and 12 percent of crashes, respectively. Sundays account for 9 percent of crashes, the lowest percent (see Figure 6).

Eleven percent of all crashes occurred during The six summer months represent 72 percent of all crashes, while winter months (November to April) represent 28 percent of all crashes (see Figure 7). Summer riding is not inherently more dangerous than winter riding, but higher bicycling rates likely leads to a greater frequency of crashes.

16 "Bicyclists and Other Cyclists." Traffic Safety Facts 2012 Data. National Highway Traffic Safety Administration. April 2014.

User Behavior

Understanding why crashes occur is important to implementing the right countermeasure. Several factors can play a role in a bicycle crash. Categories of information from the crash report form that were analyzed about why crashes occur include contributing factors, pre-crash maneuvers, and unsafe behavior.

The human factor is a contributing factor for crashes. The most reported contributing factor among motorists and bicyclists was "No Action;" it likely that "No Action" was coded because the reporting officer could not determine a clear contributing factor. "No Action" was listed as a contributing factor for both the bicyclists and motorists involved. Other common contributing factors include: careless driving, failed to yield ROW, improper turn, and other actions that may contribute to a crash.

Motorist Contributing Factors

The most common known contributing factors among motorists were failing to yield the ROW and careless driving (figure 8).

The most common contributing factors among motorists were failing to yield the right of way and careless driving.

As shown in Figure 9, going straight and making a turn were the most common pre-crash maneuvers for crashes where the contributing factor was listed as "No Action". Further analysis of the crash narratives is necessary to determine if other contributing factors were present.

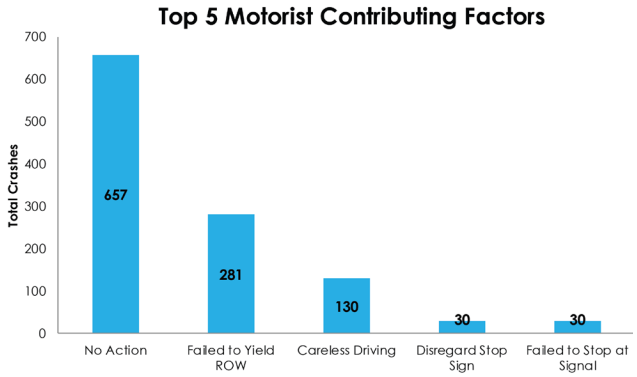


Figure 8: Motorist Contributing Factors, 2008-2012

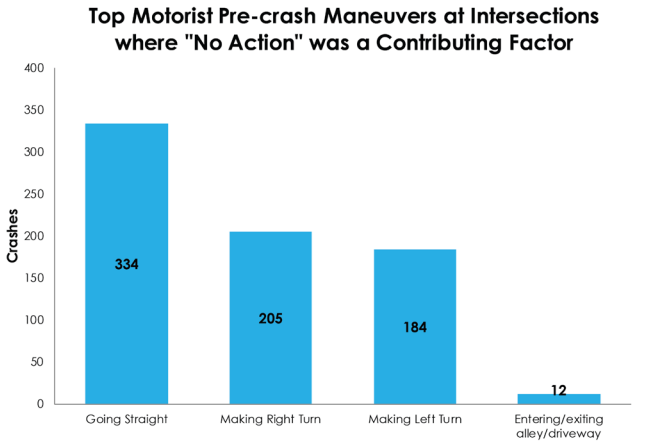


Figure 9: Motorist Pre-Crash Maneuvers, 2008-2012

Bicyclist Contributing Factors

The most common known contributing factors among bicyclists were failing to yield the ROW and failing to stop at a traffic signal or stop sign.

As shown in Figure 10, sidewalk and crosswalk riding are shown to be the most common pre-crash maneuver for bicyclist crashes with a "No Action" contributing factor. Of the 457 sidewalk crashes (34 percent of all crashes), 302 crashes (66 percent of all sidewalk crashes) bicyclists were riding against traffic. With such a large percentage of bicyclists riding in the crosswalk or on the sidewalk before the crash, strategies to address sidewalk riding are presented in the Crash Reduction Strategies section.

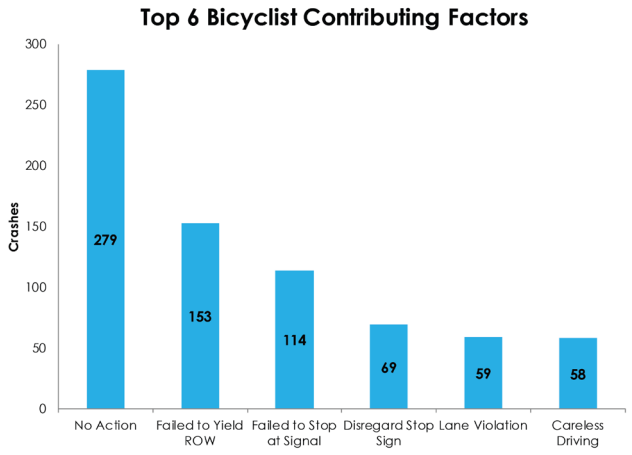


Figure 10: Bicyclist Contributing Factors, 2008-2012

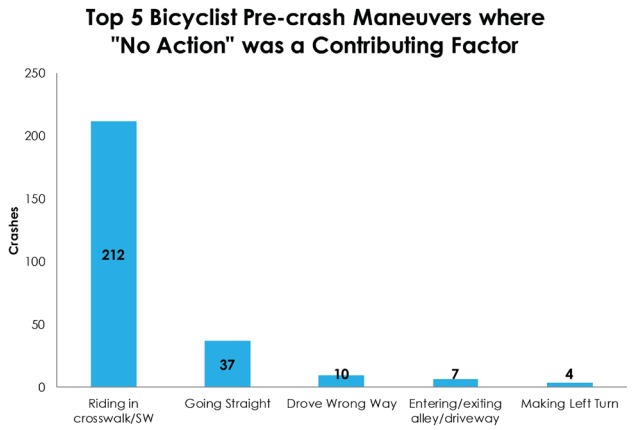


Figure 11: Bicyclist Pre-crash Maneuvers, 2008-2102

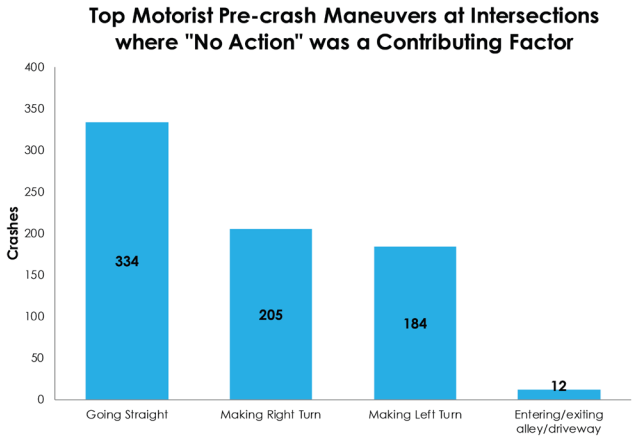


Figure 12: Motorist Pre-crash Maneuvers at Intersections, 2008-2012

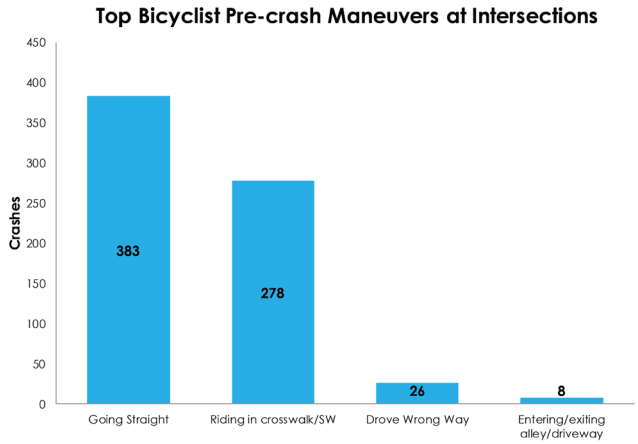


Figure 13: Bicyclist Pre-crash Maneuvers at Intersections, 2008-2012

Pre-crash Maneuvers

In the majority of crashes, bicyclists and motorists were traveling straight prior to the crash. In crashes at intersections, the bicyclist was most commonly reported traveling straight (either in the road or crosswalk) and the motorist was most likely making a turn. Figure 12 shows the motorists' pre-crash maneuvers at intersections while Figure 13 shows bicyclists' pre-crash maneuvers.

Driver/ Bicyclist Conditions

In the crash data, "condition" refers to the potentially unsafe behaviors that an involved party may exhibit. For the majority of crashes, neither the bicyclist nor the motorist exhibited unusual or unsafe conditions (such as intoxication, aggressive driving, inexperience, or distraction). Although bicyclists and motorists exhibiting unsafe conditions contributed to a minority of crashes, crashes where a motorist was driving unsafely resulted in a higher than average percentage of injuries.

Aggressive road use was more prevalent amongst bicyclists in crashes, 4.4 percent, than the 3.9 percent of motorists driving aggressively.

A total of 2.3 percent of crashes involved a bicyclist cited as driving under influence (DUI). Of these crashes, 74 percent resulted in an injury. Most crashes related to a specific bicyclist condition have a roughly even split between injury and non-injury related crashes, with the exception of DUI. This phenomenon is similar

among motorists: 1.9 percent of all crashes involved a motorist driving under the influence. Of these crashes, 68 percent resulted in at least one injury.

Hit and Run Crashes

Hit and run crashes, with one party fleeing the scene, represent 22 percent of bicycle crashes in Denver. Denver's hit and run crash rate is double the national average of 11 percent, though in line with other major cities'.[17] Denver's crash rate is below Chicago's whose hit and run rate for bicycle crashes is 25 percent (on average one hit and run bicycle crash per day)[18] and slightly above Minneapolis' rate at 21 percent.[19]

In Denver, similar to Minneapolis, bicyclists are disproportionately the victims of hit and run crashes, 82 percent of hit and run crashes involve a fleeing motorist, compared to 18 percent of fleeing bicyclists.[20] The percent of crashes involving a motorist hit and run occurrence has increased from 15 percent in 2008 to 20 percent in 2012. Bicyclist flight occurrence fluctuated from between 1 and 3 percent of all crashes in that time. Denver increased the penalty for hit and run crashes resulting in serious injury or fatality in both 2008 and 2012.[21]

Crash Location

Intersection/ Non-intersection Crashes

There is a greater number of bicycle/motor crashes at or in close proximity to the intersection of two or more streets (85% of crashes occurred at intersections and 15% at mid-block or alley locations (figure 14)). The location of all crashes is shown in Figure 15.

Crashes at non-intersection locations are shown in Figure 16. These crashes are concentrated in central Denver, which includes the Central Business District, Auraria, Lincoln Park, Civic Center, and Capitol Hill. Almost half (47 percent) of all crashes occurred at signal controlled intersections while 38 percent of crashes occurred at intersections with an all-way stop or two-way stop (stop signs on a one-way street). Figure 17 and Figure 18 show the locations of these crashes. Crashes at signalized intersections are concentrated in the central Denver while crashes at unsignalized intersections are more evenly distributed throughout the city.

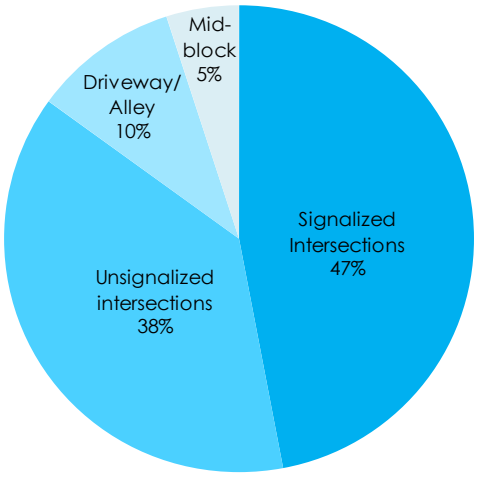


Figure 14: Crashes shown by location in the street network, 2008-2012

17 Hit And Run Drivers Kill Nearly 1500 People Annually With Pedestrians At Greatest Risk. American Automotive Association Foundation for Traffic Safety. 2004.

18 "City of Chicago 2012 Bicycle Crash Analysis Summary Report and Recommendations." CDOT. 2012.

19 "Understanding Bicyclist-Motorist Crashes in Minneapolis, Minnesota." City of Minneapolis Public Works Department. Jan. 2013

20 In Minneapolis, motorists fled 92.8 percent of the time and bicyclists fled 7.2 percent. (Ibid.)

21 "Less than half convicted in Colorado hit-and-run cases get prison time." Denver Post. August 30, 2013.

ALL CRASHES 2008-2012

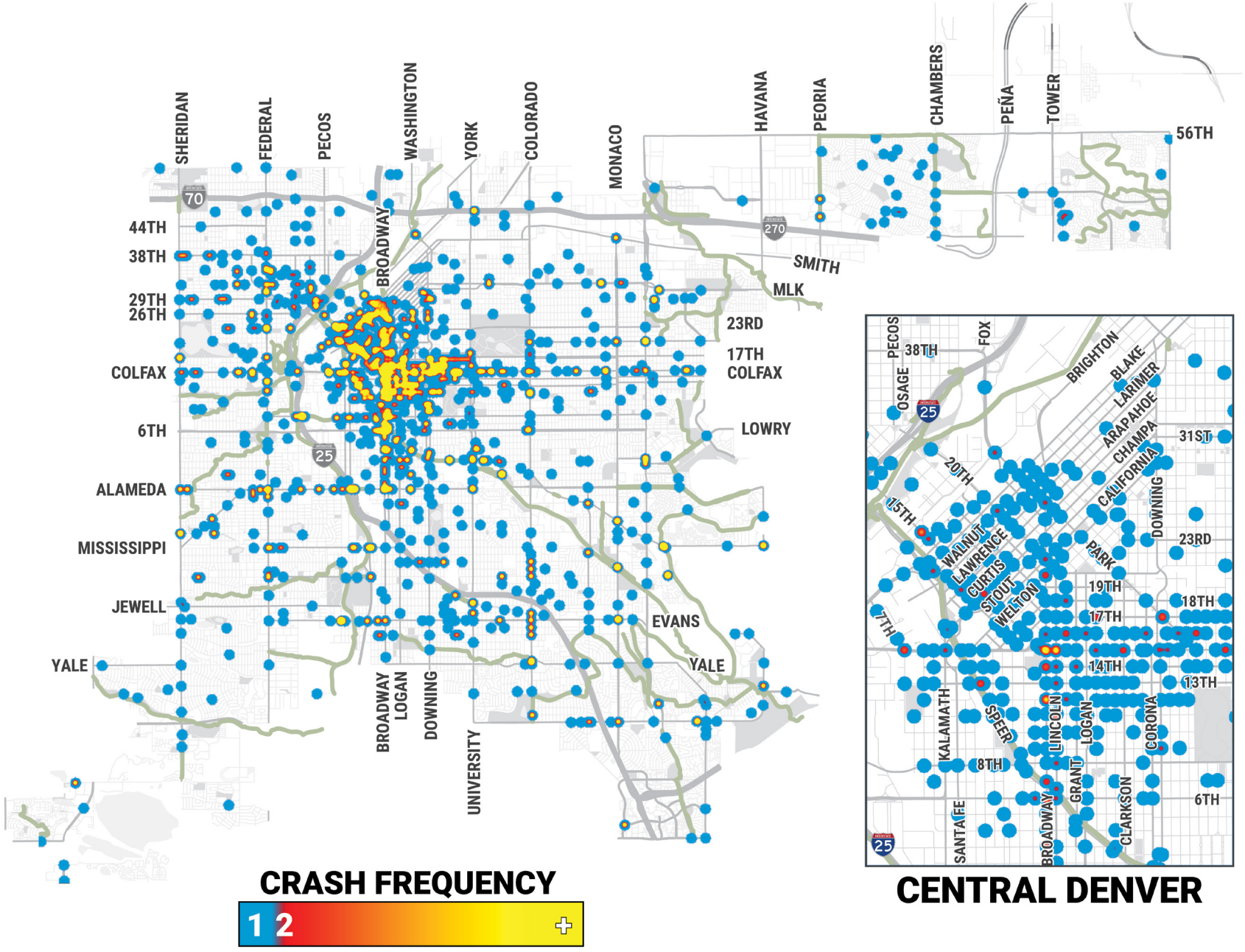


Figure 15: All Crashes, 2008-2012

NON-INTERSECTION CRASHES

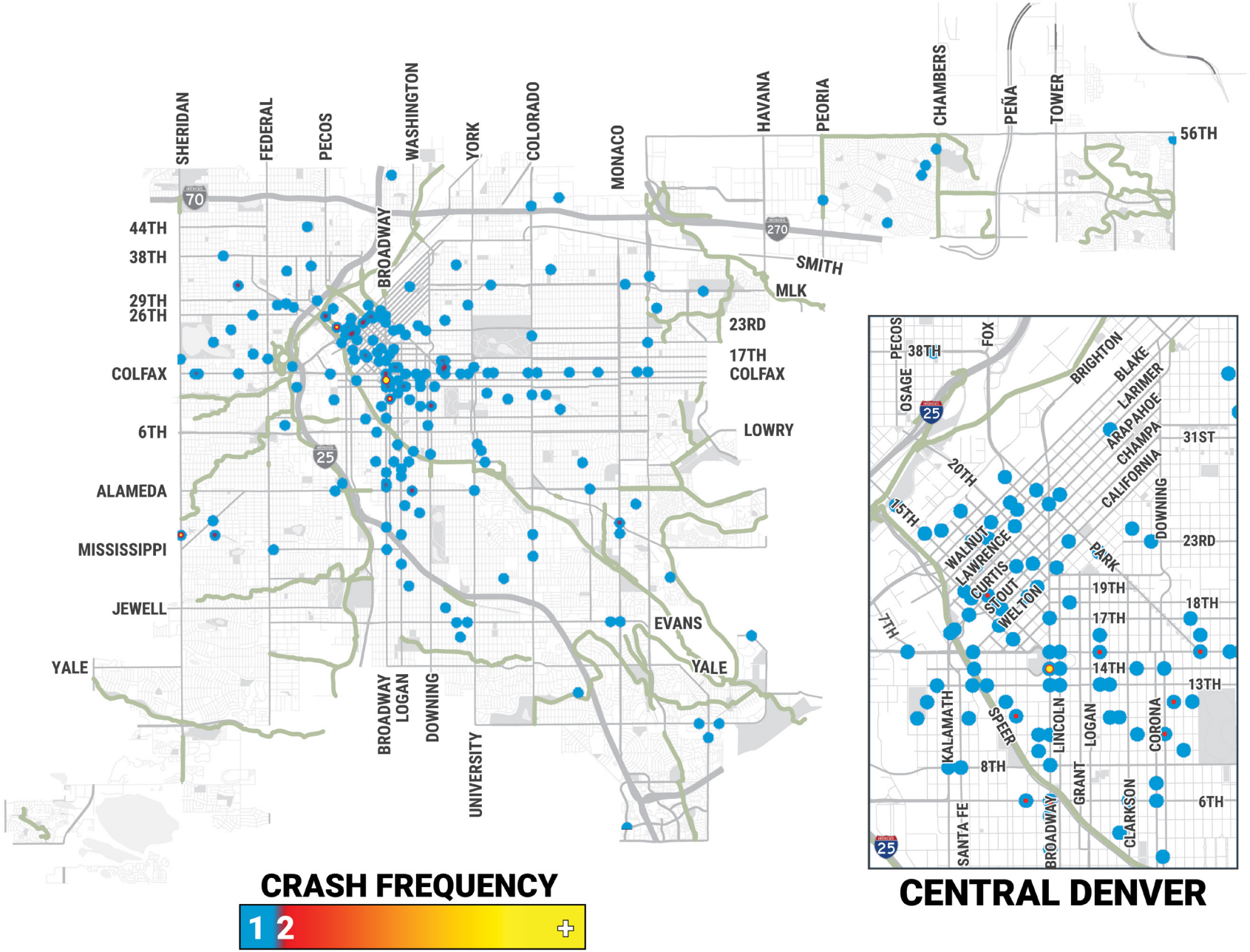


Figure 16: Non-Intersection Crashes, 2008-2012

CRASHES AT SIGNALIZED INTERSECTIONS

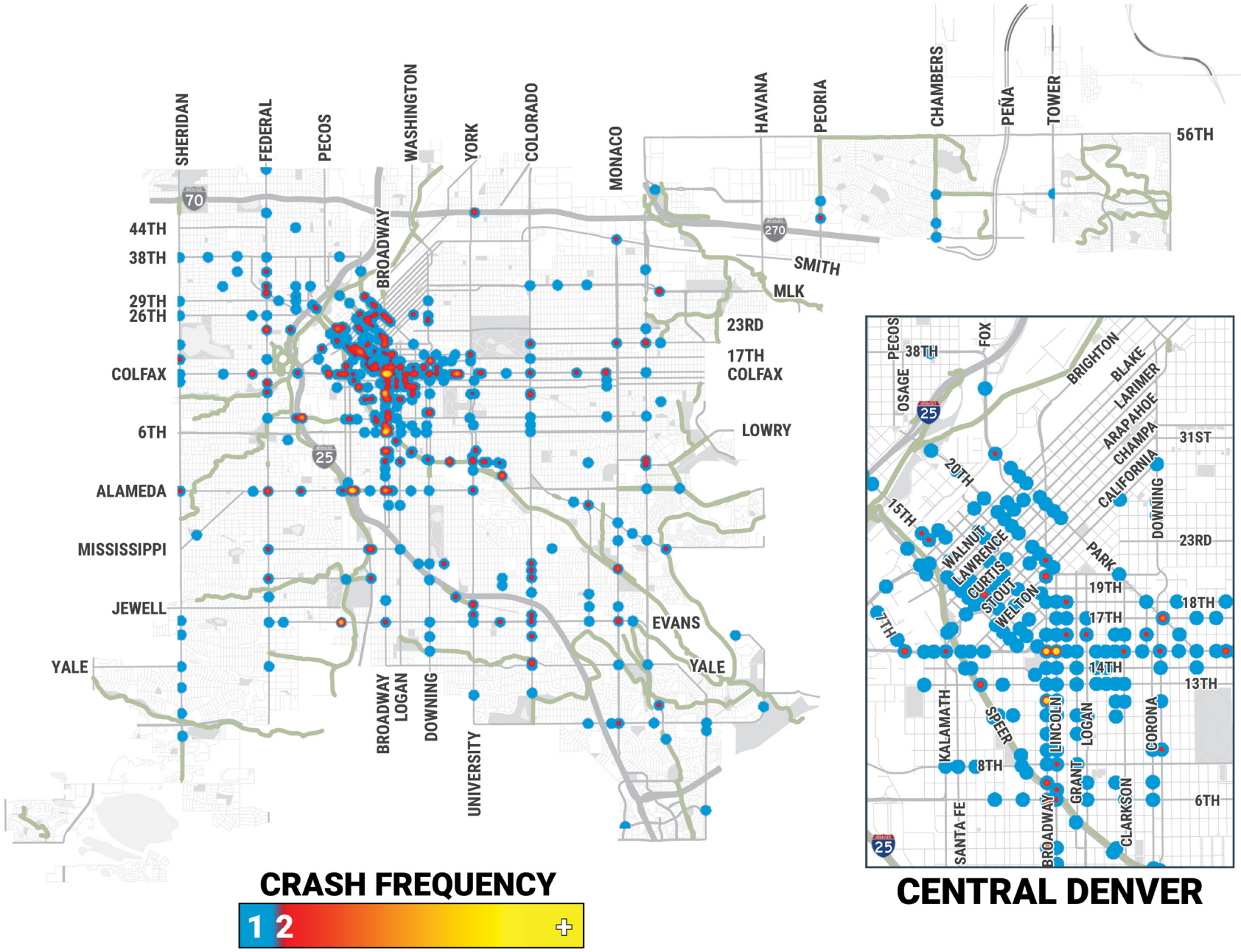


Figure 17: Crashes at Signalized Intersections, 2008-2012

CRASHES AT UNSIGNALIZED INTERSECTIONS

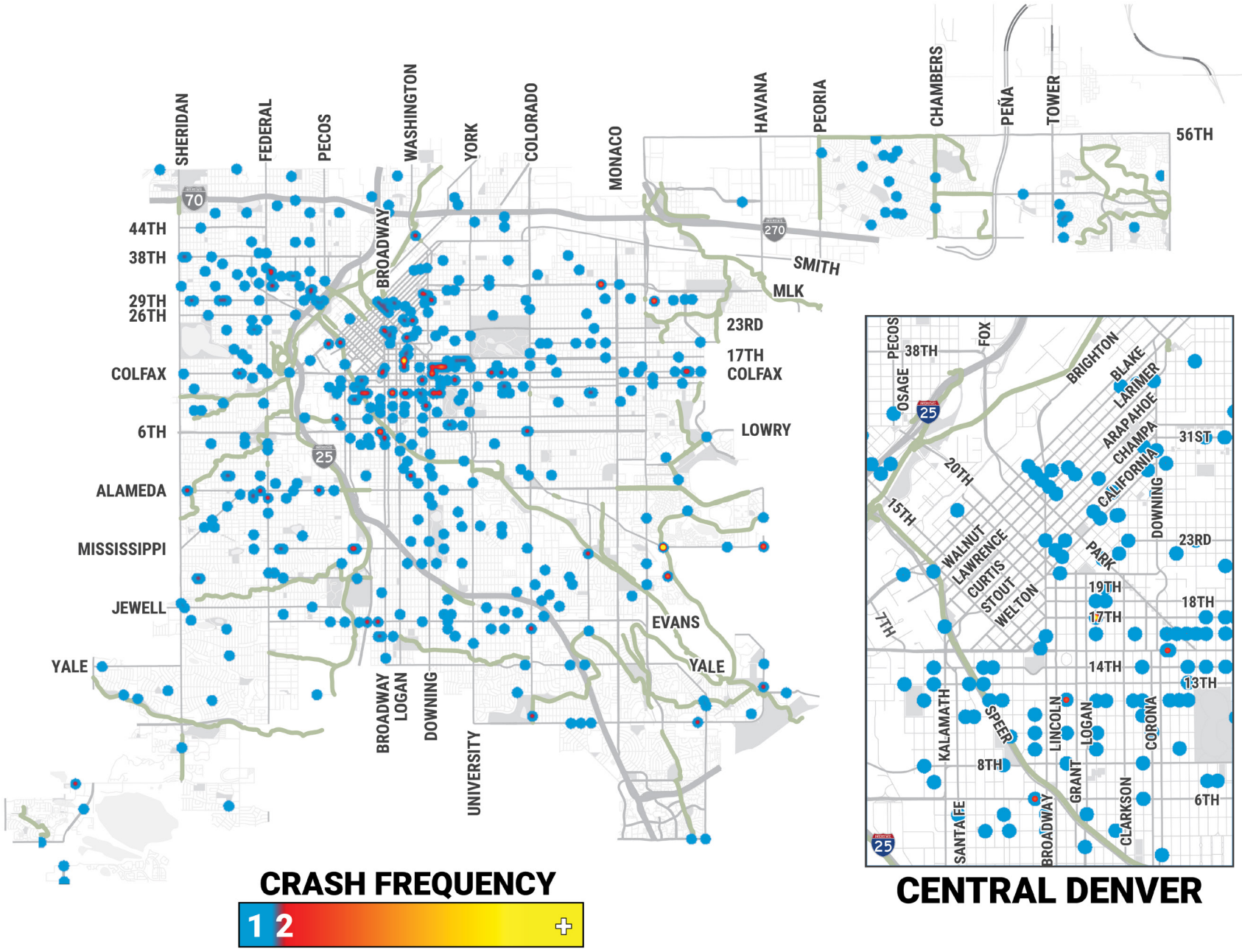


Figure 18: Crashes at Unsignalized Intersections, 2008-2012

Street Classification

Arterial streets provide the highest level of service for motor vehicles; these types of streets often carry high volumes of motor vehicles at relatively high speeds. A total of 24% of crashes reviewed between 2008 and 2012 involved arterial streets without a bike lane in which the person on the bike was riding in the street. Further, 18% of crashes involved an arterial street without a bike lane where the person was riding on the sidewalk. In terms of arterial streets with bike lanes, 9% of crashes involved these streets with the person on the bike riding in the street, and 2% involved arterial streets with the person riding on the sidewalk. The remaining 47% of crashes in Denver involved either a collector or local street (see Figure 19).

An important consideration about this data is that the aforementioned crashes may not have occurred on the arterial street, rather they may have involved an arterial street by occurring on a collector or local street that intersects an arterial. The data used in the crash analysis recorded crashes to the intersection and did not explicitly call out which street classification the bicyclist was riding on.

Street Types in Denver

Local: A neighborhood or minor street that provides access to adjacent properties only. Mobility on local streets is typically incidental and involves relatively short trips at lower speeds to and from collector streets.

Collector: A roadway that collects and distributes local traffic to and from arterial streets, and provides access to adjacent properties.

Arterial: Major roadway designed to provide a high degree of mobility and serve longer vehicle trips to, from, and within major activity centers in Denver and the region.

City and County of Denver, "Blueprint Denver: An Integrated Land Use and Transportation Plan." 2002.

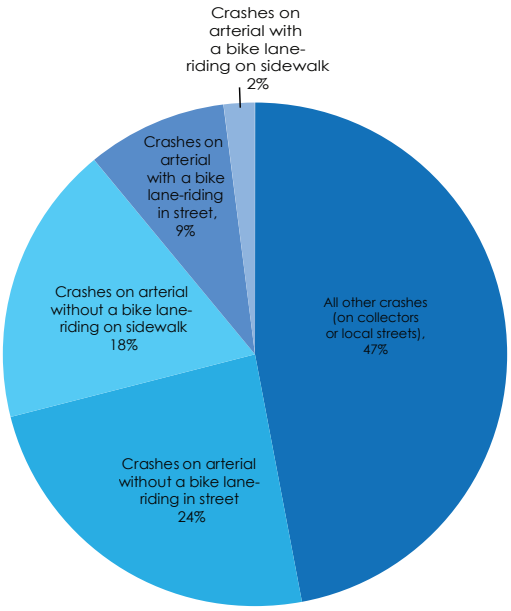


Figure 19: Crashes by Bicycle Presence in the Street.

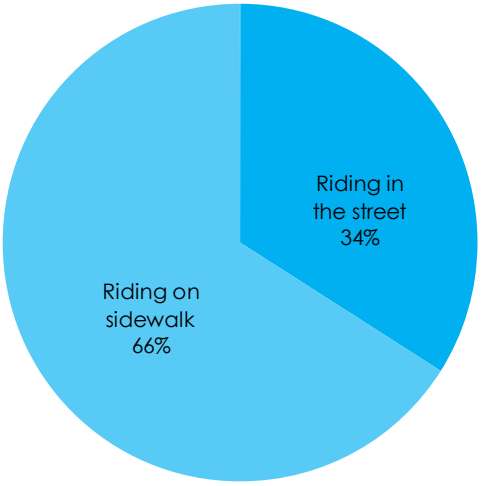


Figure 20: Crashes by Bicycle Presence in the Street or Sidewalk, 2008-2012.

Sidewalk Riding

In Denver, bicycling is not allowed on a sidewalk unless any of the following conditions are met: the sidewalk is part of a designated bike route,

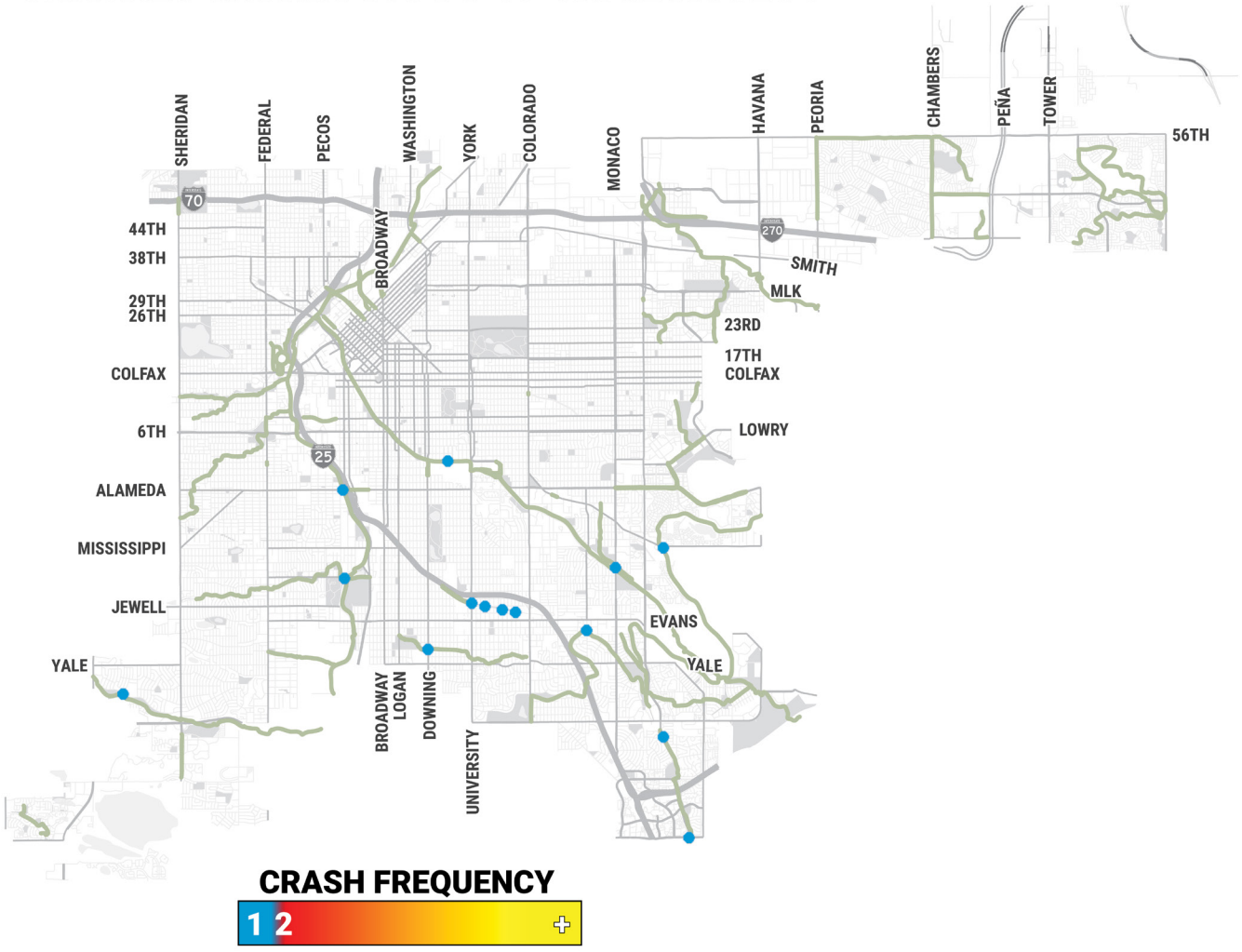


Figure 21: Crashes Near Trails, 2008-2012

if the bicyclist is within one block of preparing to dismount to park (maintaining a speed of less than 6 mph), or if the bicyclist is delivering newspapers. Bicyclists on the sidewalk or crosswalk are generally less visible to motorists compared to being on the street, they are traveling at higher speeds than pedestrians and are thus less predictable to other users of the street.[22] Bicycling on the sidewalk against the flow of adjacent motor vehicle traffic is particularly risky, as the direction of the bicyclist's movement is unexpected to others on the street and that much less visible.

Thirty-four percent of all crashes studied in this report involved a bicyclist riding in the sidewalk or crosswalk.[23] Eighty-five percent of bicyclists riding on the sidewalk were riding in the crosswalk at the time of the crash and 15 percent were riding at a driveway or alley. Of the bicyclists riding on the sidewalk or in the crosswalk, 66 percent were riding against traffic.

Trail Proximity

Denver's network of trails, including the Cherry Creek and South Platte, are highly-popular routes for both utility and leisure that provide

22 Wachtel, A. and Lewiston, D. Risk Factors for Bicycle-Motor Vehicle Collisions at Intersections. ITE Journal. Institute of Transportation Engineers. September 1994.

23 Bicyclists riding in the crosswalk are presumed to have been riding in the sidewalk prior to entering the roadway.

bicyclists facilities that are separate from motor vehicle traffic. A total of 2 percent of crashes occurred at a trail access point. The bicyclists in these crashes were originally described as riding on the sidewalk. However, a deeper analysis of sidewalk-riding bicycle crashes occurring within 100 feet of a trail access point suggests that these bicyclists most likely were riding on or adjacent to a trail prior to the crash. Although many of the same safety concerns apply with riding on the sidewalk (lack of visibility to motorists, possible interactions with pedestrians, etc.), it is important to understand these crash types and locations as riding on trails is an encouraged activity.

Top Crash Corridors & Intersections

In order to further understand where crashes are happening, the crash analysis team took an in depth look at both high crash corridors and high crash intersections. As can be seen in Figure 15, crashes are largely concentrated in central Denver. This is likely associated with higher bicycling rates, though the crash rate (percentage of crashes based on the total number of bicycle trips) may be lower than other areas, due to the greater numbers of bicyclists on the road. This supports the "safety in numbers" concept because even as the crash frequency increases due to a higher number of bicycle trips, the actual crash rate may fall, thereby indicating an overall increase in safety for bicyclists.

Corridor crashes include crashes along the roadway and crashes at intersections and driveways along the roadway. In Denver, the corridors with a high number of crashes vary from major arterials (Broadway, Lincoln Street, East Colfax Avenue, and 15th Street) to lower

Corridor	Crashes per Mile	No. of Crashes	Bike Facility	No. of Thru Lanes	Busses served
12th Ave	17	24	Sharrows	2	1
15th St	15	27	None	4, 3	11
E 16th Ave	14	23	Bike Lanes	2	0
E Colfax Ave	10	57	None	4	1
Lincoln St	10	22	None	4	18
Broadway	10	30	None	4	22

Table 2: High Crash Corridors, 2008-2012

Number of Crashes	Intersection Name
9	N BROADWAY & COLFAX AVE
8	N LINCOLN ST & E COLFAX AVE
7	S LIPAN ST & W EVANS AVE
7	N BROADWAY &12TH AVE
7	S KALAMATH ST &W ALAMEDA AVE/I-25

Table 3: High Crash Intersections, 2008–2012

* Average Daily Traffic (ADT) is shown, where data is available, to demonstrate automobile volumes along the corridor. Though ADT is not available, 12th Avenue is a roadway with low automobile volumes

** Volume indicated is Average Annual Weekday Traffic at 12th Avenue and Vine Street which is east of the location of interest.

volume and speed bicycle routes (East 16th Avenue and East 12th Avenue). Figure 22 shows each of these high crash corridors. Table 2 summarizes key characteristics of the high crash corridors.

The high crash intersections are shown in Figure 23 and Table 3. Three are located along high crash corridors (North Lincoln Street, East Colfax Avenue, and Broadway), two are located at highway ramp areas, and three are located near points of access for a trail. All of the high crash intersections involve at least one major arterial with a wide cross section and major turning movements.

Figure 22: High Crash Corridors, 2008-2012

Figure 23: High Crash Intersections, 2008-2012

Top Crash Types

This section of the report describes the most common crash types reported in Denver between 2008 and 2012. These types are based on position of the motorist and bicyclist relative to each other, travel movements, and occurrence of sidewalk riding. The top crash types each represent at least 5 percent of all reported crashes. Combined, these five crash types account for 61 percent of all crashes (Figure 24).

Crash Type 2 (same direction crashes) combines three sub-types of crashes. All crashes in this type involve a bicyclist and motorist traveling straight in the same direction, however, these crashes may take the form of a sideswipe, rear end, or dooring incident.

The top crash types presented describe common scenarios of bicyclist and motorist movements.

In this section, each top crash type is summarized by the major contributing factors causing the crash and other common crash characteristics.

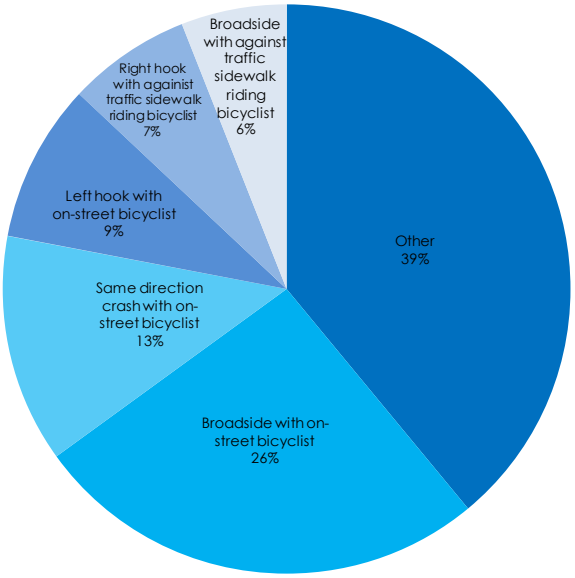


Figure 24: "All crashes", 2008-2012

1. Broadside with On-Street Bicyclist

The motorist, positioned to the left or right of the bicyclist, proceeds through the intersection and crashes with the bicyclist as the bicyclist enters the intersection from either the left or the right (or vice versa). This crash type is a result of a motorist colliding perpendicular to a bicyclist within the intersection.

The following are also typical behaviors or conditions which can contribute to this crash type:

- Where sight lines are obstructed by on-street parking, adjacent vegetation or some other object limiting the view between approaching motorists and bicyclists
- At all-way stop controlled intersections where bicyclists or motorists do not understand or follow the right-of-way rules
- At stop-controlled intersections where bicyclists or motorists disregard the stop sign, but fail to see each other.
- At one-way stop controlled intersections where the approach speed of the bicyclists or motorists is misjudged or disregarded by the user facing the stop control
- At locations where motorists and bicyclists are looking for gaps in crossing traffic from the left or right to cross through an intersection, failing to look for or anticipate approaching traffic

This type of crash accounts 26 percent of all reported bicycle crashes in Denver between 2008 and 2012.

- 348 of 1325 total crashes
- 57 percent of these 348 crashes resulted in an injury
- Majority of these crashes occurred at an unsignalized intersection

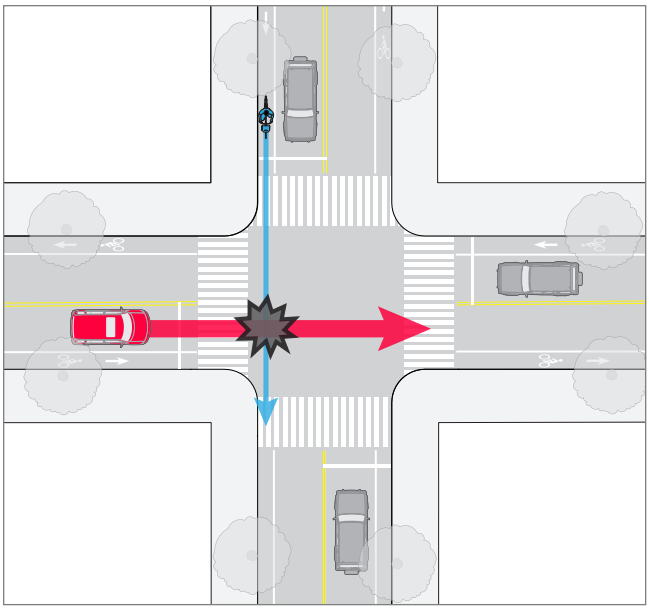


Figure 25: Crash Type 1 — Broadside

Major Contributing Factors

Bicyclists

- Failed to Stop at Signal – 20 percent
- Disregard Stop Sign – 17 percent
- Failed to Yield ROW – 16 percent

Motorists

- Failed to Yield ROW – 15 percent
- Careless Driving – 7 percent
- Disregard Stop Sign – 5 percent
- Failed to Stop at Signal – 5 percent

2. Same Direction Crashes with On-Street Bicyclist

A motorist and bicyclist crash with each other as both are traveling straight in the same direction.

This type of crash accounts for 13 percent of all reported bicycle crashes in Denver between 2008 and 2012.

- 167 of 1325 total crashes
- 57 percent of the 167 crashes resulted in an injury
- Majority of the 167 crashes occurred at a non-intersection location

As this category of crashes is complex, they have been divided into three sub-categories. These sub-categories are based upon an assignment of basic crash type. The City analyzed narratives from each crash report and estimated the following percentages of crashes:

- **Type 2A**: Sideswipe. Motorist crashes with bicyclist as motorist OR bicyclist is weaving or changing lanes (54% of crash type 2 and 6.8% of all crashes) (Figure 26).
- **Type 2B**: Rear End. Bicyclist rear ends motorist OR motorist rear ends bicyclist (18% of crash type 2 and 2.3% of all crashes) (Figure 27).
- **Type 2C**: Dooring. Bicyclist crashes into open door of vehicle (14% of crash type 2 and 1.7% of all crashes) (Figure 28).

The majority of the remaining crashes classified as Type 2 crashes were described in crash reports as a bicyclist or motorist "overtaking a turn" (speeding up and trying to turn in front of the other party which is unable to stop), or unreported or unknown movements.

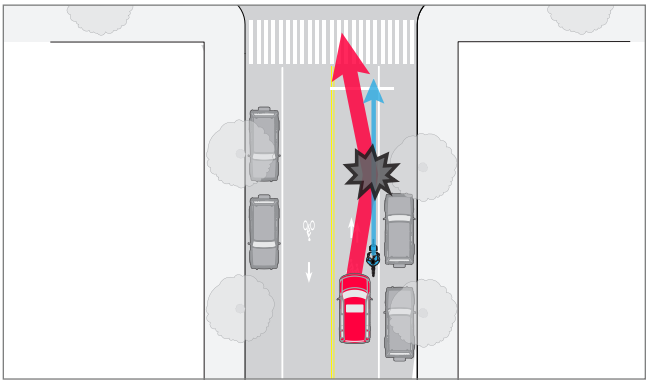


Figure 26: Crash Type 2A — Sideswipe

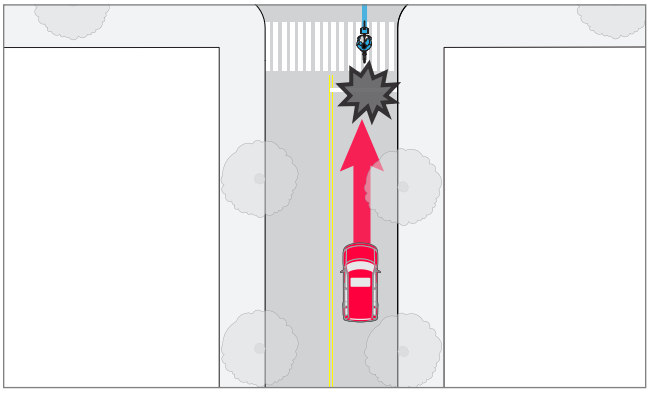


Figure 27: Crash Type 2B — Rear End

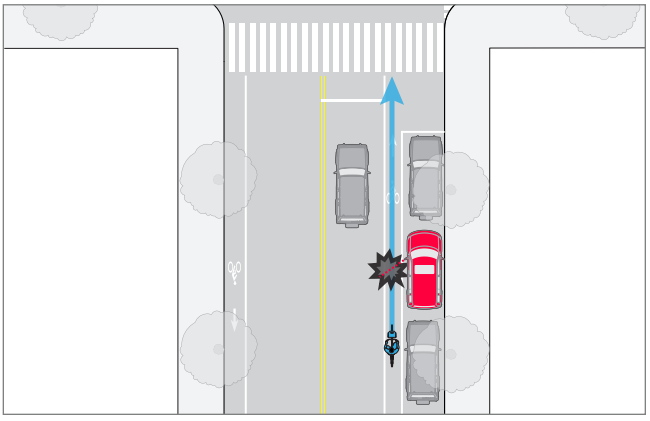


Figure 28: Crash Type 2C — Dooring

3. Left Hook with On-Street Bicyclist

A motorist and bicyclist approach an intersection from opposite directions. The motorist turns left into the path of the bicyclist. These crashes can occur at locations where motorists are looking for gaps in approaching traffic to make left turns, thereby failing to look for approaching bicyclists. At signalized intersections, these are typically permissive left turn conditions due to a lack of a separate turn lane and/or protected phasing. Permissive left turn conditions allow left-turning drivers to make that movement during the green phase, whereas protected phasing can restrict left-turning vehicles to a separate phase indicated by a green arrow.

Left hook crashes account for 9 percent of all reported bicycle crashes in Denver between 2008 and 2012.

- 115 total crashes of 1325 total crashes
- 60 percent of these 115 crashes resulted in an injury
- The occurrence of this crash type is closely between signalized and unsignalized intersections.

Major Contributing Factors

Bicyclists

- None – 5 percent

Motorists

- Failed to Yield ROW – 73 percent
- Careless Driving – 7 percent

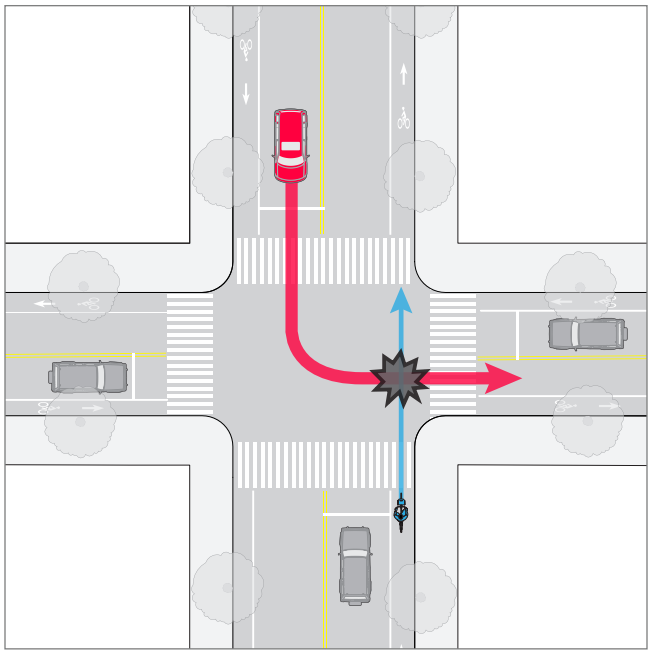


Figure 29: Crash Type 3 — Left Hook with On-Street Bicyclist

4. Right Hook with Bicyclist Riding on the Sidewalk Against Traffic

A motorist and bicyclist approach an intersection from a perpendicular position. The bicyclist, positioned to the right of the vehicle, proceeds straight into the intersection riding on the sidewalk in the opposite direction of traffic. The motorist approaches the intersection and makes a right turn into the path of the bicyclist. These crashes can occur at locations where motorists are looking for gaps in approaching traffic from the left to make a right turn, failing to look for approaching bicyclists from the right. At signalized intersections, these are typically locations where a right turn on red is allowed.

This type of crash accounts for 7 percent of all reported bicycle crashes in Denver between 2008 and 2012.

- 98 of 1325 total crashes.
- 42 percent of these 98 crashes resulted in an injury
- Majority of these crashes occurred at a signalized intersection

Major Contributing Factors

Bicyclists

- Failed to Yield ROW – 19 percent
- Lane Violation – 9 percent
- Careless Driving – 6 percent

Motorists

- Failed to Yield ROW – 17 percent
- Careless Driving – 5 percent
- Disregard Stop Sign – 5 percent

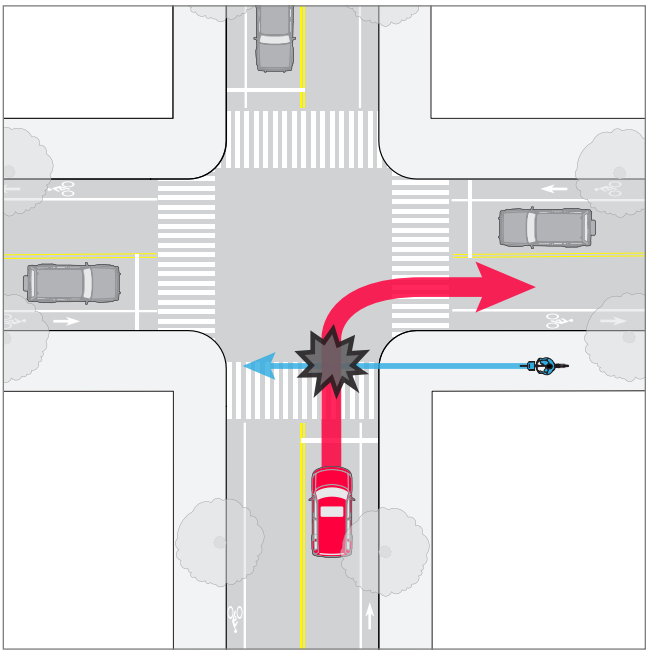


Figure 30: Crash Type 4 — Right Hook with Bicyclist Riding on the Sidewalk Against Traffic

5. Broadside into Bicyclist Riding on the Sidewalk Against Traffic

A motorist and bicyclist approach an intersection perpendicular to each other. The bicyclist, positioned to the left of the vehicle, proceeds straight into the intersection riding on the sidewalk in the opposite direction of traffic. The motorist approaches the intersection and crashes with the bicycle. These crashes can occur at locations where motorists are looking for gaps in crossing traffic from the left or right to cross through an intersection, failing to expect or look for bicyclists approaching on the sidewalk from the right, on the far side of the intersection.

- 85 of 1325 total crashes
- 41 percent of these 85 crashes resulted in an injury
- Split between signalized and unsignalized intersections

Dooring accounts for 1.7 percent of total crashes in Denver between 2008 and 2012.

Major Contributing Factors

Bicyclists

- Failed to Yield ROW – 20 percent
- Lane Violation – 7 percent
- Careless Driving – 7 percent
- Failed to Stop at Signal – 5 percent

Motorists

- Failed to Yield ROW – 13 percent
- Careless Driving – 6 percent

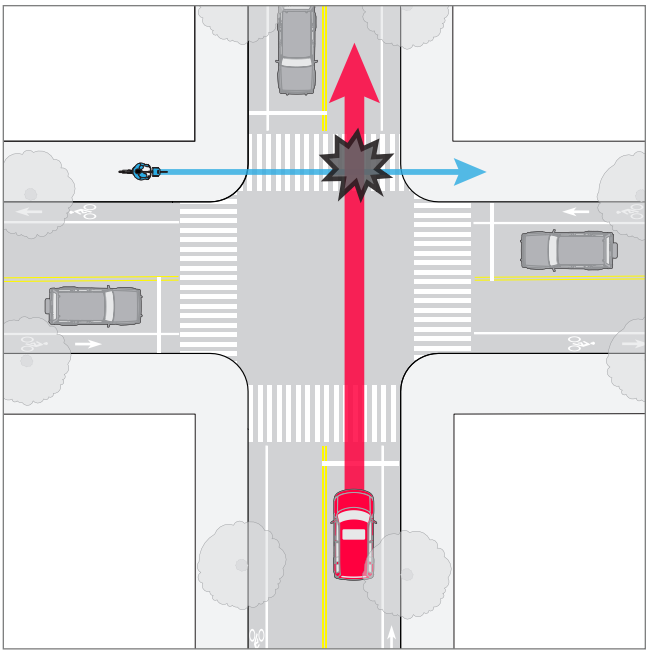


Figure 31: Crash Type 5 — Broadside into Bicyclist Riding on the Sidewalk Against Traffic

Next Steps

Denver Public Works created this report to better understand bicycle safety in Denver. It provides a baseline for trends and crash characteristics to inform future planning for bicycle-related projects and programs. Using this data, the next steps in addressing bicycle safety include an in-depth analysis of the high crash locations and top crash types to understand how issues may be addressed with engineering strategies and which treatments are appropriate. The information is also helpful in coordinating with partner agencies and community organizations that affect people on bicycles in Denver.

Bikeway Design

Denver Public Works is responsible for the planning, design, and implementation of the on-street bicycle network and the bicycle amenities, such as wayfinding or bicycle parking, which support the physical street environment. There are various planning/engineering tools that Denver Public Works uses to address bicycle safety through bikeway design. The following describes the toolbox of design treatments that Denver utilizes to improve safety, comfort and convenience for people on bicycles. Each of these design treatments have been proven to be successful in improving bicycle safety.

Bicycle Network Implementation

With 34 percent of all crashes involving a bicyclist riding on the sidewalk or crosswalk and 66 percent of all sidewalk crashes associated with bicyclists riding the wrong way, it is important to provide safe, intuitive bicycle facilities throughout Denver. Sidewalk riding and increased compliance can be addressed through the introduction of dedicated bikeways.[24] Denver Public Works is currently working to build a connected bicycle network through the implementation of Denver Moves: Bicycles. This plan identifies dedicated bikeways and also includes design guidelines for continued implementation of the bicycle network. As all locations—corridors or intersections—are unique, a thorough understanding of contextual conditions is needed to make specific recommendations for engineering treatments; thus these tools may be applied after site-specific study and analysis.

Neighborhood Bikeways

Neighborhood bikeways can reduce the likelihood of broadside and same-direction crashes, which include three of the top five crash types in Denver. Neighborhood bikeways are low- speed, local streets that have been optimized for bicycle traffic. They are designed to give priority to bicyclists, and they offer a method to improve bicycle efficiency, comfort, and safety. Neighborhood bikeways are designed to allow comfortable and safe crossings of arterials through provision of median refuge islands, traffic signals, or other yield-inducing engineering treatments that provide complementary pedestrian safety benefits. The streets may have traffic calming or diversion elements to manage the volume and speed of motor vehicles along the route. Where these exist parallel to and near arterials without bicycle facilities, they can become an attractive alternative route for bicyclists.

Shared Lane Markings

Shared lane markings, more commonly known as sharrows, are pavement markings that are typically located on neighborhood bikeways or streets with the following characteristics: low speeds (<35mph), lower automobile volumes. Sharrows remind motorists that bicycles are present, they serve as a route finding tool, and they also indicate to bicyclists where to position themselves in the lane so as to avoid the door zone. Sharrows can potentially contribute to mitigating to sideswiping and dooring. As such, sharrows are a tool and not necessarily a facility type.

24 Denver Pubic Works, 15th Street: 62% reduction in sidewalk riding.

Bicycle Lanes

Bicycle lanes are typically located to the right of traffic, either between the travel lane and the curb or between the travel lane and parked cars. Bicycle lanes can reduce sidewalk bicycle riding by providing an on-street facility and same direction vehicle crashes with on-street bicyclists by separating bicyclists from motorists.

Buffered Bicycle Lanes

Buffered bicycle lanes are bicycle lanes that are separated from moving traffic or parked cars by a painted buffer providing increased comfort for bicyclists. Similar to the provision of bicycle lanes, buffered lanes reduce sidewalk bicycle riding by providing an on-street facility and same direction vehicle crashes with on-street bicyclists by separating bicyclists from motorists. Buffered bicycle lanes also have the potential to reduce or eliminate dooring type crashes.

Protected Bicycle Lanes

Creating a separate protected bike lane will help reduce crashes at mid-block locations and may provide a high degree of comfort for riders. Protected bicycle are effective on high volume roadways that have a high concentration of origins and destinations for bicyclists. Protected bicycle lanes also have the potential to reduce or eliminate dooring type crashes, same direction crashes (sideswipes, dooring or rear end), and directly affect sidewalk riding.

Intersection Treatments

With the high percentage of intersection related crashes in Denver (85% occurred at or near the intersection from 2008 – 2012), engineering treatments at intersections are valuable tools to consider in the reduction of crashes.

Improve Sight Lines

Restricted sight lines can contribute to all crashes, but especially broadside and left hook crashes. Broadside crashes often involve a failure to yield ROW on either the bicyclist's or driver's part. Maintaining low vegetation or modifying the placement of on-street parking spaces can improve visibility at intersections and, in turn, improve safety. While, at times, cars are currently allowed to park close to intersections, they create a visual barrier. Instituting no-parking zones within 50 feet of the intersection, on a contextual basis, is one strategy to improve sight lines and decrease broadside and left hook crashes.

Another strategy to improve sight lines that may be considered is the installation of below the curb bike parking corrals. The installation of curb extensions can also prevent illegal stopping or parking in no parking zones, thereby eliminating the need for enforcement.

Tighten Corner Radii

Tightening corner radii may reduce the prevalence of right hook crashes by reducing turning speeds of motorists. Projects that reduce curb radii sometimes create opportunities for the installation of a curb extension. These create space to allow for the posting of signs that are within the line of sight of approaching motorists.

Develop Separate Right Turn Lane

Developing separate right-turn lanes with short merging areas at locations with persistent conflicts with right-turning motorists may decrease the rate of right hook crashes. The merge area should be highlighted as a conflict zone and kept as short as practical with the addition of a "Right Turn Yield to Bicyclist" sign (MUTCD R4-4 sign) to communicate the bicyclist priority to reduce the potential for merging or sideswipe crashes with the new design.

Call Attention to Conflict Zones

The extension of bicycle lane markings through merging zones improves both motorist and bicyclist awareness of the potential conflict area. These merging zones are typically found as one approaches an intersection, where motorists must weave or merge across a bicycle lane. The conflict zone can be further accentuated with the use of green colored pavement markings.

This strategy can reduce the frequency of turning or merging crashes.

Extend Bicycle Facility through Intersection

To improve motorist and bicyclist awareness of intersection conflict zones, bicycle lane markings should be evaluated to extend through intersections. This conflict zone can be further accentuated with the use of green colored pavement markings. This strategy can reduce the frequency of broadside and turning (left hook, and right hook) crashes.

Install a Modified MUTCD R10-15

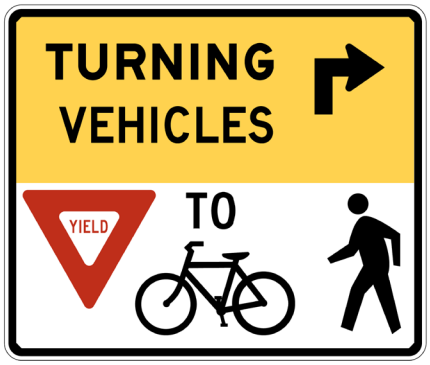


Figure 32: Modified R10-15 Sign Indicating Turning Vehicles to Yield

At high crash locations where left turns are not protected, the City may consider installing the modified R10-15 signs (with bicycle and pedestrian symbol, see Figure 32. A modified R10-15 sign that includes a bicyclist figure may help to remind motorists of the presence of oncoming bicyclists and reduce left hook crashes due to motorists failing to yield the right-of-way to bicyclists

Prohibit Right Turn on Red

Prohibiting right turns on red lights may address motorists' failure to yield at signalized intersections, which is a contributing factor in right hook crashes. It also has the potential to improve sight lines. Prohibiting right turns on red are appropriate at locations where bicyclists are travelling on a sidepath or shared use sidewalk perpendicular to the vehicular direction of travel, or where a bike box has been installed.

Install Bicycle Signals

Installing bicycle signals has been found to improve bicyclist compliance with traffic control signals. Dedicated signals for bicycle travel clarify for the bicycle when to enter an intersection and also can be coordinated with other signals at the intersection to restrict conflicting vehicle movements.

Optimize Signal Progression for Bicycle Travel

Optimizing signal progression for a bicyclist's speed of travel can increase compliance because bicyclists may be less likely to disregard traffic signals when they are guaranteed a green signal that allows them to maintain momentum.

Improve Detection at Actuated Intersections

Bicyclists are likely to run red lights at locations where they have difficulty triggering a traffic signal. Improvements in detection technology and the placement of detector pavement markings may reduce red light running.

High Crash Locations/Intersections

The analysis of high crash corridors/intersections provided in this report revealed the top five corridors and intersections for bicycle and motor vehicle crashes. In all of the corridor locations, Denver Public Works is actively working on planning studies or implementation of engineering treatments discussed in the following section. With regards to the high crash intersections, individual analyses of these locations will be undertaken to evaluate crash characteristics and to evaluate appropriate engineering treatments.

15th Street

In August 2013, the Denver Public Works installed a buffered bike lane on 15th Street, and in 2014, installed vertical separation on the street. Denver Public Works conducted a before/after study on 15th St, and has found a 30% increase in the number of bicyclists using the facility, and a 62% reduction in sidewalk riding. In addition, since the installation of the bikeway, there has been a decrease in the bicycle crash rate on the corridor.

E 16th Avenue & E 12th Avenue

E 16th and 12th Avenues are very popular bicycle route east of downtown. To facilitate travel on these corridors for bicycle travel, Denver Public Works has used the "optimize bicycle travel" engineering strategy to try and address bicycle crashes. Traffic lights have been retimed on these streets, paying particular attention to the opportunity to optimize bicycle travel. By allowing efficient travel for the bicycle user, the City hopes to reduce the number of crashes that involve a bicycle user disregarding traffic control devices that is associated with several different top crash types. Crash data will be studied over the next two years to understand any improvement that has occurred.

Additionally, in 2015, Denver Public Works will be installing a bicycle lane on 11th Avenue. This will provide a higher comfort facility connecting downtown with other areas of the City, and may be an alternate route to 12th Avenue. 11th Avenue also connects across Speer Blvd and provides direct connections to retail and restaurant destinations. Crash data will be studied to understand how this network improvement will affect crashes on 12th Ave.

Broadway & Lincoln

The Broadway/Lincoln corridor was identified in Denver Moves as a Phase III improvement that "needs further study" based on complexity of multi-modal needs. However, given the increasing bicycle demand on the corridor, prevalence of sidewalk riding noted by businesses, and the crash data, Denver Public Works has initiated the Broadway/Lincoln Corridor Study. The study will evaluate the crash characteristics, among other factors raised through the planning and public involvement process, to determine a solution to best accommodate bicycle travel on the major arterials.

East Colfax Ave

The Colfax corridor is currently under consideration for major transit and pedestrian improvements. As part of the Colfax Connections project, bicycle mobility in the corridor area is being reviewed for possible enhancements. The project is using the bicycle crash data to inform recommendations for engineering, but also other types of treatments.

Major Crash Types

To address the five major crash types included in the report, further study is needed into determine appropriate mitigation measures. This includes a deeper understanding of recurring trends, patterns, and behaviors at the specific locations. While engineering treatments may address some of the issues associated with the top five crash types, other strategies such as education and enforcement may be required for ultimate success.

Bicycle Safety Action Plan

A holistic approach to improving bicycle safety and increasing bicycle ridership in Denver would be successful, and includes the 'five E's'. While originally developed by the League of American Bicyclists[25] as a checklist for increasing bicycling, the five E's can be applied to improving safety through crash reduction.

1. Engineering: Create safe and convenient places to ride and park a bicycle;

2. Education: Give people of all ages and ability levels the skills and confidence to ride;

3. Encouragement: Create a strong bicycle culture that welcomes and celebrates bicycling;

4. Enforcement: Ensure safe roads for all users; and

5. Evaluation and Planning: Plan for bicycling as a safe and viable transportation option.

25 The League of American Bicyclists,

Not one single agency or organization can accomplish the five E's. Work within the five areas must involve partnerships and coordination across disciplines. For instance, engineering must be coupled with education and encouragement to teach and encourage the public about utilizing bicycle facilities. These partnerships are crucial to overcoming these bicycle crashes and to making a safer Denver.

In 2015, the Mayor's Office of Sustainability initiated the Bicycle Safety Action Plan. The purpose of this Plan was to bring agencies and organizations together to determine priority actions towards improve bicycle safety in Denver. The process and data examined in this report informed the development of the Safety Action Plan. In addition, members of the Action Plan Task Force identified issues, opportunities and goals related to bicycle safety. Members then refined and prioritized these issues into action items. The Action Plan will provide strategies to reducing bicycle crashes across the five E's, and will be released in coordination with this report.

Vision Zero

In early 2016, the City and County of Denver will be kicking off their Vision Zero program. Vision Zero works towards goals of reducing fatalities and serious injuries on city streets. The City will begin development of Denver's Vision Zero Action Plan in the spring of 2016. Vision Zero will address the safety of all modes of transportation on Denver streets, including bicycles. The Vision Zero Action Plan will build upon the findings and recommendations in this report and will identify a citywide approach to reducing preventable and unacceptable injuries and fatalities on Denver's streets.

Bicycle Crash Analysis

Understanding and Reducing Bicycle & Motor Vehicle Crashes

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