



Pedestrian Crash Analysis

Understanding and Reducing Pedestrian & Motor Vehicle Crashes

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Acknowledgements

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Introduction

Denver Public Works (DPW), in collaboration with Denver Parks and Recreation is in the process of developing *Denver Moves: Pedestrians & Trails*, which will identify opportunities to expand pedestrian amenities, increase access to transit and regional trails, and improve the safety and comfort of the pedestrian environment. Through the planning process for *Denver Moves: Pedestrians & Trails*, emphasis will be placed on pedestrian safety.

The City is undertaking numerous other initiatives to create safe streets for everyone. A Bicycle Crash Analysis report was released in February 2016, which reviewed crash findings for collisions between bicyclists and motor vehicles. The report helps DPW to identify trends and crash reduction strategies to counteract the most common crashes in Denver.

Also in February 2016, Mayor Michael B. Hancock announced Denver's commitment to eliminate all traffic-related deaths and serious injuries on the city's roadways. This goal, known as Vision Zero, has been adopted in cities around the world. In October 2017, the City released an Action Plan to outline efforts to reach this goal, directly engaging with community organizations and multiple government agencies. The Mayor has committed funding to planning, engineering and education in support of this goal in the 2016, 2017 and 2018 budgets.

This Pedestrian Crash Analysis expands upon Public Works' commitment to improve safety for all roadway users, specifically focusing on the most vulnerable users. This report is a continuation of a study conducted by a University of Colorado Denver graduate student, who analyzed pedestrian crash reports from 2011 to 2013. This report incorporates two more years of data (2014 and 2015), and continues to document recent crash trends, discover major contributing factors for crashes, and provide next steps to address pedestrian safety.

This report functions as a baseline to understand and analyze future events and trends related to pedestrian crashes. The analysis identifies the overall context for crash characteristics including crash typologies and circumstances related to the crashes as recorded in the crash reports. With this understanding of safety in Denver, the final sections of the report present next steps for DPW to address engineering strategies, as

well as recommended opportunities for interagency collaboration.

Denver Public Works can use this report's findings as a guide for planning and capital improvement projects that will best improve road safety for pedestrians. The findings in this report will supplement the findings and recommendations of the City's Vision Zero Action Plan.

As Denver's pedestrian program evolves, and as the Vision Zero Program grows, DPW staff can expand their data collection procedures to capture better details about crashes and contributing factors. These data will play a key role in measuring the effectiveness of programs or design solutions.

Finally, while this report is focused on pedestrian crashes in Denver, walking is a relatively safe mode of transportation in the city. While all modes of transportation present safety risks, research increasingly finds that health benefits of walking outweigh the relative risks of walking in urban environments.



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 study

Crash Reporting Process

The crashes described in this report include crashes that were reported by police between 2011 and 2015. 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 DR 2447), which includes personal identification information, pre-crash maneuvers, location, environmental conditions, road description, contributing factors, and pedestrian/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. Denver Public Works receives the crash report (form DR 2447)¹ from the Denver Police Department for crashes taking place on streets in Denver and transfers data to an internal database for archiving and analysis.

Unreported Crashes

The total number of pedestrian crashes is likely higher than the number of crashes captured by police reports. Pedestrian crashes may go unreported if one of the following is true:

- 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 chose not to contact law enforcement.²

A study conducted by the Federal Highway Administration

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

² Colorado State Traffic Records Advisory Committee. Investigating Officer's Traffic Accident Reporting Manual. 2006.

of pedestrian injuries in California, New York, and North Carolina found that 37.3 to 55.0 percent of all pedestrian crashes potentially go unreported.³

Data and Study Process

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

Phase 1

All pedestrian crash reports between 2011 and 2015 were compiled into a central database. The study team then reviewed the narratives of each crash report to provide additional data. This additional analysis added more nuance about pedestrian and motor vehicle behavior. For example, the crash report does not include a field or standard way to differentiate the crossing street (the street on which the crash took place) from the pedestrian corridor (the street on which the pedestrian was walking prior to the crash). Pedestrians do not have the same movement restrictions that motor vehicles do and thus, the standard report did not provide sufficient detail in the existing fields to determine crash location. "Pedestrian Corridor" and "Crossing Street" were added to the database to better understand mid-block crossings and other non-intersection crashes. This level of detail is important to understand the unique and complex nature of each crash.

The study team then used the information from the standard fields and the crash narrative to sort the crashes into one of thirty-four typologies, "other", or "N/A." These typologies noted the pedestrian and driver actions and location, as well as the signal phase, if applicable. Examples of crash typologies include: pedestrian mid-block, motorist straight; pedestrian in crosswalk with signal, motorist left turn; pedestrian in intersection with the right of way, motorist straight; and pedestrian on sidewalk, motorist exiting a driveway. These typologies are detailed in their identification in order to best understand the complete nature of each crash and recommend the appropriate crash reduction strategies.

³ Federal Highway Administration. Injury to Pedestrians and Bicyclists: An Analysis based on Hospital Emergency Department Data. FHWARD-99-078. 1999.

STATE OF COLORADO TRAFFIC ACCIDENT REPORT

1 ☐ AMENDED/SUPPL. 2 ☐ UNDER \$1,000 3 ☐ COUNTER REPORT 4 ☐ PRIVATE PROPERTY

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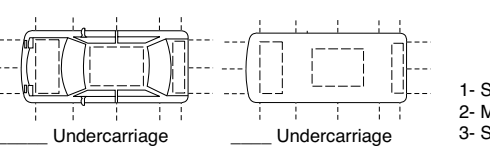
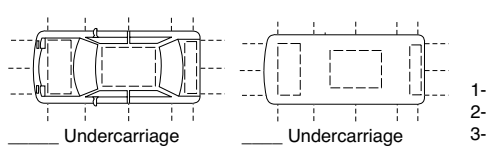
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Figure 1: Colorado Traffic Accident Report Form, Page 1

Phase 2

The project team conducted citywide analyses to identify pedestrian crash trends and better understand why crashes occur. High-crash corridors and high-crash intersections were identified. Crash types were analyzed based on overall count, injury rate, fatality rate, and location. Other fields such as contributing factor, circumstance, vehicle type, speed limit, age, and time of crash were investigated.

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.

Interpretations and Assumptions

While crash reports are the most reliable source of pedestrian/motorist crash information, the data have been used with caution. Some limitations of the data include:

- Data have undergone several rounds of interpretation (first by the victim, then by the officer) by the time it is included in crash reports. There is further room for error as crash reports are manually entered by Public Works staff and interpreted by the study team to determine the crash typology.
- Incomplete reports. Some of the fields, such as contributing factor, are geared toward driver behavior and cannot be accurately completed for a pedestrian. Other fields were blank or not descriptive for a variety of reasons.
- Lack of pedestrian count data at the time of this report. Lack of data limits the analyses on exposure and crash rates.
- Severity of injury in a pedestrian crash. While this data point is input by the responding officer at the crash, it does not appear in the central crash database. Furthermore, this rating is subjective and does not account for pedestrians who may have an injury later that day or week such as neck pain or dizziness.
- Unreported crashes. There are likely many pedestrian crashes that are not reported for a variety of reasons.
- Race and sex information.

These caveats do not discredit this analysis; 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 pedestrian traffic volumes, turning movements, intersection geometry, and Denver's streets.

Key Findings

Between 2011 and 2015, there were a total of 1,924 reported crashes that involved pedestrians. During the five year time frame, there was an average of 385 pedestrian crashes per year (see figure 2). While the number of pedestrian crashes increased in Denver, the crash rate has remain consistent. In order to identify a pedestrian crash rate, the annual mode share rate from the Census American Community Survey (ACS) 2010-2014 Commute to Work survey was reviewed as a proxy for the number of people walking in Denver. While this number fails to account for the fact that everyone is a pedestrian at some point in their trip whether they started on foot, on bike, on transit, or in a car, it is used as a way to understand the relative rate of exposure to crashes for pedestrians.

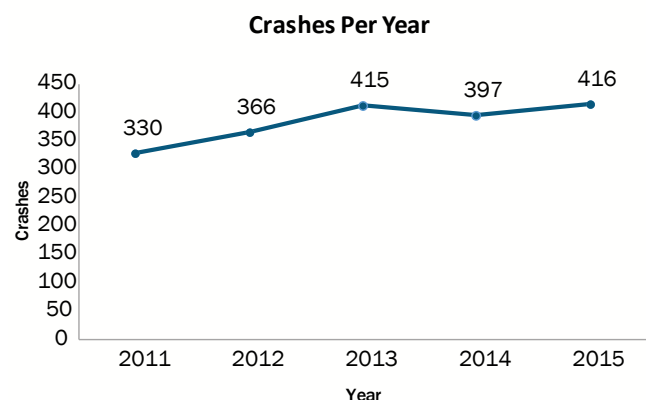


Figure 2: Pedestrian/ Motor Vehicle Crashes by Year, 2011-2015.

Injuries and Fatalities

During the five-year period, approximately 60 percent of reported pedestrian crashes in Denver resulted in an injury. There were 1,154 injuries resulting from pedestrian and vehicle crashes. The annual number of injuries ranged from 215 in 2012 to a to 243 in 2014. The injury rate for crashes has decreased by approximately 10 percent during the five-year time period. See Figure 5.

Between 2011 and 2015, eighty-eight reported crashes involving in pedestrians resulted in pedestrian fatalities. This results in a fatality rate of 4.6% during the five year period. While the number of commute trips taken on foot rose steadily from 2011 to 2015, the year-over year fatality rate remained relatively constant during the study period, with 2012 being an exception. Figure 3 shows how Denver compares to other Cities' pedestrian fatality rates.

Pedestrian Fatality Rates per 10,000 Pedestrian Commuters

Boston	0.9	Portland, OR	5.8
Seattle	2.7	Philadelphia	5.8
Washington, D.C.	3.3	Denver	7.6
San Francisco	4.0	Austin	14.0
New York City	4.0	Los Angeles	14.0
Minneapolis	4.5	Atlanta	14.6
Chicago	4.5	Albuquerque	19.1
Omaha	4.6	Indianapolis	19.9

2012 Benchmarking Report, Alliance for Biking & Walking. Rates based on 2009-2011 crash data from NHTSA's Fatality Analysis Reporting System.

Figure 3: Denver's Pedestrian Fatality Rate Compared to Peer Cities, per 10,000 Commuters.

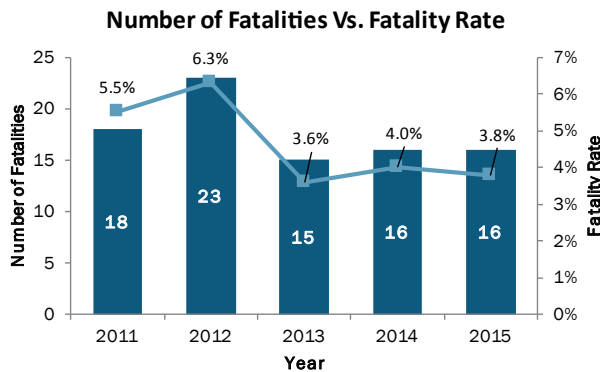


Figure 4: Number of Fatalities Vs. Fatality Rate

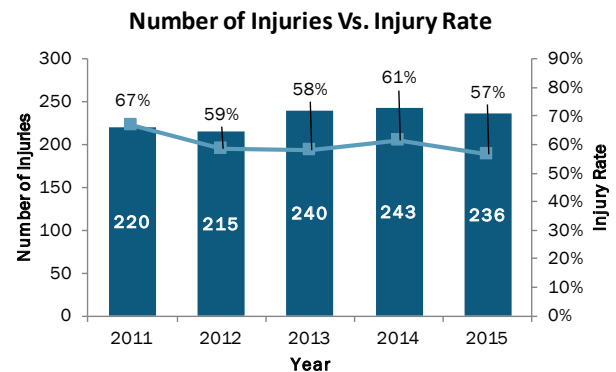


Figure 5: Number of Injuries Vs. Injury Rate

Year	2011	2012	2013	2014	2015	5- Year Total
Pedestrian Crashes	330	366	415	397	416	1,924
Injuries from Crashes	220	215	240	243	236	1,154
Fatalities from Crashes	18	23	15	16	16	88
% of Crashes Fatal	5.5%	6.3%	3.6%	4.0%	3.8%	4.6%

Table 1: Number of Injuries vs. Injury Rate

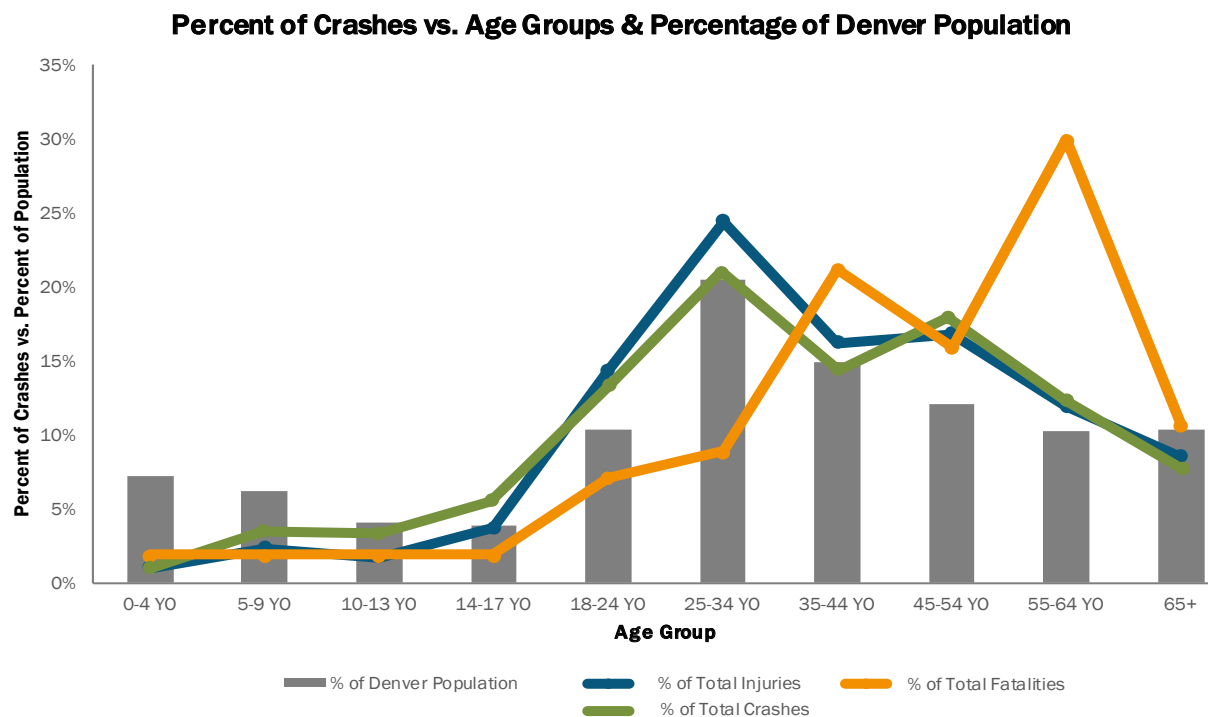


Figure 6: Ages of Those Involved in Pedestrian/ Motor Vehicle Crashes Compared to Denver Population, 2011-2015.

Crash Characteristics

Age

The age distribution of pedestrians involved in crashes generally follows the overall age distribution of the Denver population. Pedestrians between the ages of 25 and 34 years old were the most prevalent in pedestrian/motorist crashes (21 percent). This age group also represents the greatest proportion of the Denver population (20 percent). Pedestrians between the ages of 45 and 54 years old were the second most prevalent in pedestrian crashes (18 percent), accounting for 12 percent of the Denver population overall. These two age groups also represent the most injuries. The 55 to 64 age range represented a higher share of the total number of fatalities (30 percent) than the share of the Denver population. Fifteen percent of fatalities involved pedestrians ages 24 and younger. Figure 6 shows the distribution of pedestrian injuries and fatalities compared to the Denver population.

Vehicle Type

Passenger cars and vans represent 50 percent of all vehicles involved in pedestrian crashes. SUVs and pickup trucks or utility vans were the second most prevalent vehicle type involved in pedestrian crashes, and both result in injuries more frequently than passenger cars, likely due to the size and weight of these vehicle types. Crashes involving SUVs and Pickup trucks resulted in an injury rate of 66% and 67% respectively, compared to an injury rate of 61% for crashes involving passenger cars. There were 32 crashes (2%) involving transit vehicles. Sixteen of these crashes resulted in an injury, which is an injury rate of 50%. Two crashes involving transit buses resulted in a fatality. It should be noted that crashes involving light rail vehicles are not included in this data set.

Time of Day/Month/Year

The peak crash period aligned with the PM rush hour from 4:00 PM to 6:00 PM, accounting for 17 percent of all crashes. While there are two peak crash periods that align with the peak commuting periods, the majority of crashes occur during the afternoon hours between 3:00 and 7:00.

There is less variation in the number of crashes among days of the week, though there is a slight increase in crashes between Monday and Friday. Sunday saw the fewest crashes at 11 percent.

Pedestrian crashes occurred most frequently in November, December, and January. Pedestrian crashes decrease significantly in the summer months, as seen in Figure 9. Fifty percent of the crashes in winter occur between 2:00 PM and 8:00 PM, whereas crashes in the summer are more evenly distributed throughout the day. Sixteen percent of crashes occurred between 8:00 PM and 10:00 PM in the summer months which is the most frequent time period for crashes that occur in summer.

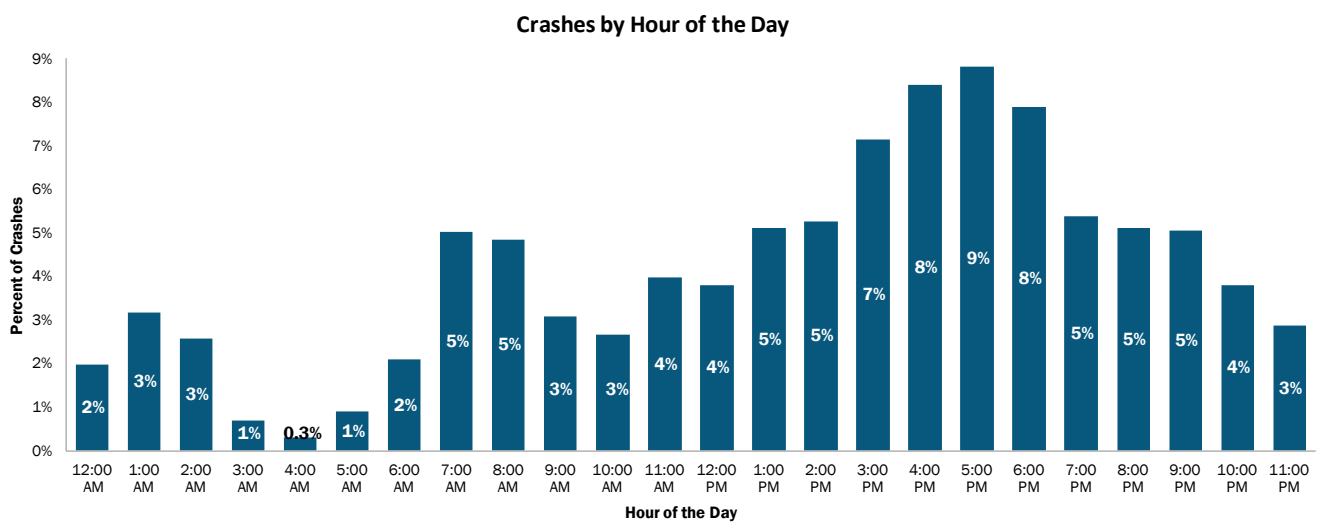


Figure 7: Pedestrian/ Motor Vehicle Crashes by Time of Day, 2011-2015

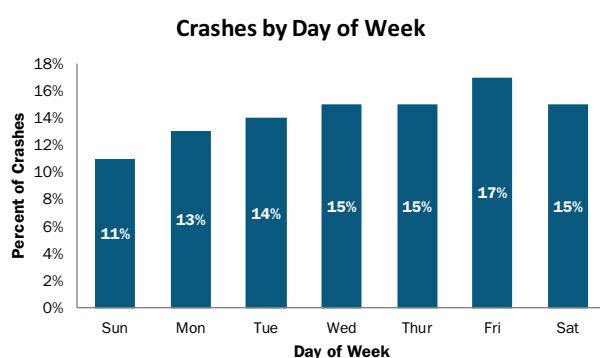


Figure 8: Pedestrian/ Motor Vehicle Crashes by Day of Week, 2011-2015.

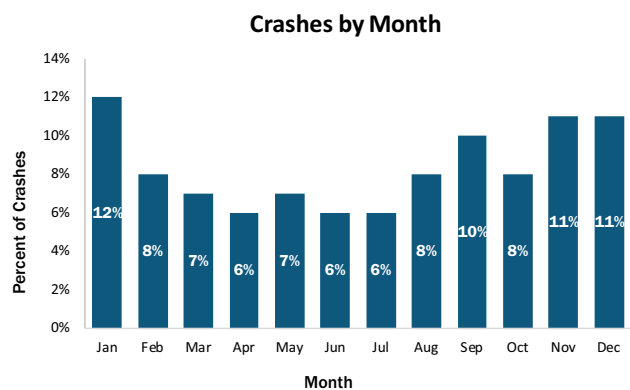


Figure 9: Pedestrian/Motor Vehicle Crashes per Month, 2011-2015.

Speed Limit

As many studies have found¹ both injury and fatality rates increase with vehicle speeds. Though the posted speed limit does not indicate the actual speed of a vehicle as it hits a pedestrian, there were zero fatalities on roadways with speed limits below 25 miles per hour. On roadways with speed limits of 30 miles per hour, there were 700 crashes with 14 fatalities for a fatality rate of 2.0 percent. The fatality rate continued to increase with the posted speed limit, ultimately with the highest fatality rate of 8.7 percent occurring on roadways with speed limits of 45 miles per hour (23 crashes with 2 fatalities). The injury rate largely follows this same trend, see table 2.

Speed Limit	Injury Rate	Fatality Rate
20 MPH or Lower	56%	0%
25 MPH	63%	1%
30 MPH	60%	2%
40 MPH	67%	7%
45 MPH	87%	9%

Table 2: Injury and Fatality Rate by Posted Speed Limit on Road where Crash Occurred in Denver.

Visibility of Driver



Figure 10: Fatality and Severe Injury Rate by Vehicle Speed. Source Data: Tefft, Brian C., 2013

User Behavior

Understanding why crashes occur is important to implementing the right countermeasure. Several factors can play a role in a pedestrian crash. The majority of crash reports do not list a specific contributing factor for the motorist. Either a blank field or “No Apparent Contributing Factor”, was listed for approximately 70% of the reports. This is likely coded because the reporting officer could not determine a clear contributing factor for both the motorists and pedestrians involved. “Other Factor” was listed for 11% of the crash reports, which is described in the crash narrative.

¹ Tefft, Brian C. Impact speed and a pedestrian’s risk of severe injury or death. Accident Analysis & Prevention. 50. 2013.

Motorist Contributing Factors

Among the remaining 19% of crashes with a listed contributing factor, distracted driving, aggressive driving, driver inexperience, and driving under the influence of drugs or alcohol were the most common contributing factors. See Table 3 on page 9. Fatality rates were particularly high in crashes where the driver was listed as being under the influence, distracted by a passenger, or evading law enforcement (12.2 percent, 12.5 percent, and 16.7 percent, respectively), compared to a citywide fatality rate of 3 percent for all crash types. The sample sizes in these categories were small, however, because of the infrequency of a listed contributing factor on crash reports.

Pedestrian Contributing Factors

Although officers may list a contributing factor for

Contributing Factor	% Attributed to Motorist
No Apparent Contributing Factor or None Listed	69.7%
Other Factor (Describe in Narrative)	11.4%
Distracted / Other i.e. Food, Objects, Pet, etc.	5.4%
Aggressive Driving	4.6%
Driver Inexperience	2.8%
DUI, DWAI, DUID	2.5%
Driver Unfamiliar With Area	1.1%
Distracted / Cell Phone	0.6%
Distracted / Passenger	0.4%
Driver Fatigue	0.3%
Driver Emotionally Upset	0.3%
Evading a Law Enforcement Officer	0.3%

Table 3: Top Motorists Contributing Factors for Pedestrian Crashes

pedestrians after a crash, 97.9 percent of crash reports listed “No Apparent Contributing Factor,” “Other Factor,” or a blank field for the pedestrian involved. This may be because many of the contributing factor options on the crash report do not apply to pedestrians.

Driver/Pedestrian Conditions

61 percent of crashes occurred when the motorist was driving straight, 28 percent as a motorist was turning left, and 12 percent as a motorist was turning right. Figure 11 shows who was determined to be in the right-of-way for each of the vehicle movements that lead to a crash.

The right of way was mostly determined by the signal. Pedestrians had the right of way when they crossed with the signal. When a pedestrian crossed against the signal, it was assumed that the vehicle had the right of way. In mid-block crashes, the vehicle was assumed to have had the right of way. Pedestrians were assumed to have the right of way in any crash occurring at an unsignalized intersection and when the pedestrian was standing, lying, or playing in the street.² There were numerous crash types that did not lend themselves to determining right of way (such as crashes with conflicting reports), so these crashes were not included in this analysis.

In the majority of crashes where a vehicle was turning, the pedestrian had the right of way over the vehicle (93

percent versus 7 percent). Pedestrians were less likely to have the right of way in crashes where the motorist was driving straight.

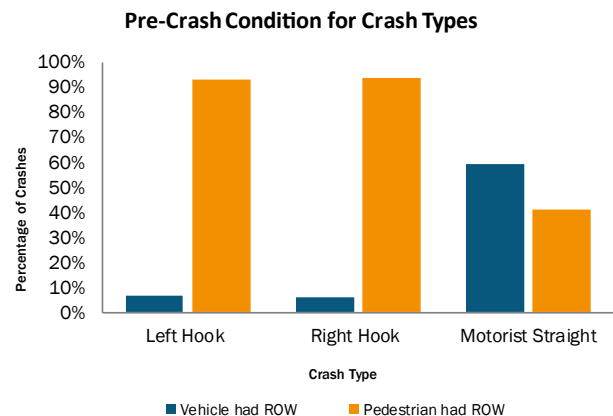


Figure 11: Pedestrian/ Motor Vehicle Crashes by Crash Type and Right of Way, 2011-2015.

Crash Typology Definitions

Right Hook: A vehicle strikes a pedestrian while turning right when a pedestrian is traveling straight.

Left Hook: A vehicle strikes a pedestrian while turning left when a pedestrian is traveling straight.

² National Committee on Uniform Traffic Laws and Ordinances. Uniform Vehicle Code and Model Ordinance. 1968.

Hit and Run Crashes

Hit and run crashes, where one party left the scene, accounted for 25.5% of crashes.

Four-hundred and thirty four (23 percent of all drivers who struck a pedestrian between 2011 and 2015) fled the scene following a crash. See Table 4.

Motorist hit and run crashes had slightly lower injury rates and slightly higher fatality rates than all pedestrian crashes (3 percent fatality rate and 60 percent injury rate citywide).

Circumstance	Distribution	Injury Rate	Fatality Rate
Motorist Hit & Run	23.1%	56%	4%
Not Hit & Run	74.5%	64%	3%
Pedestrian Left Scene	1.8%	6%	0%
All Parties Left Scene	0.5%	60%	0%

Table 4: Distribution of Hit & Run Crashes Involving Pedestrians.

Trail Proximity

There were 520 crashes (27 percent of all crashes) that occurred within 200 feet of a park or trail. Crash typologies for these crashes were similar to the entire city with left hooks representing the highest number of crashes, followed by mid-block crossings, pedestrians crossing against the signal, and right hooks. Many of these crash locations only had 1 crash, but a few were identified as high-crash locations with more than 1 crash at that location. These are shown in greater detail of page 17.

Proximity to Denver Public Schools

There were 111 crashes (6 percent of all crashes) that occurred within 200 feet of a Denver Public School. Mid-block crossings and left hooks were the most common crash types near schools, similar to the citywide trends. Seventy-five schools had 3 or fewer crashes within 200 feet. Crash locations around schools with four or more crashes are identified in Table 6. High-crash locations near schools are shown on page 18.

The following pages illustrate crashes in a map form through various analyses citywide.

Crash Locations

Around half of pedestrian crashes (54 percent) occurred at signalized intersections. Twenty-seven percent of crashes occurred mid block, 18 percent at unsignalized intersections. Two percent of crashes occurred as cars were entering or exiting driveways and alleys.

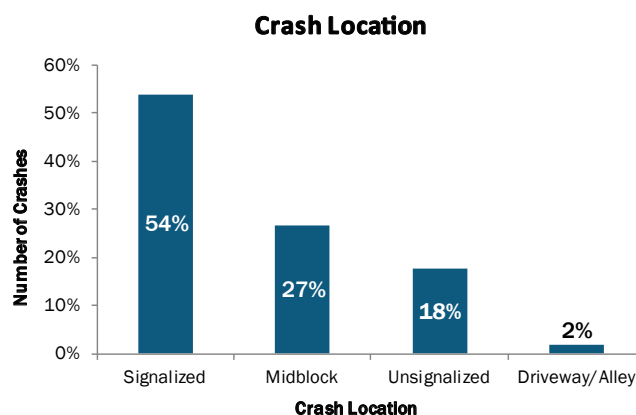


Figure 12: Roadway Locations of Crashes

ALL CRASHES 2011-2015

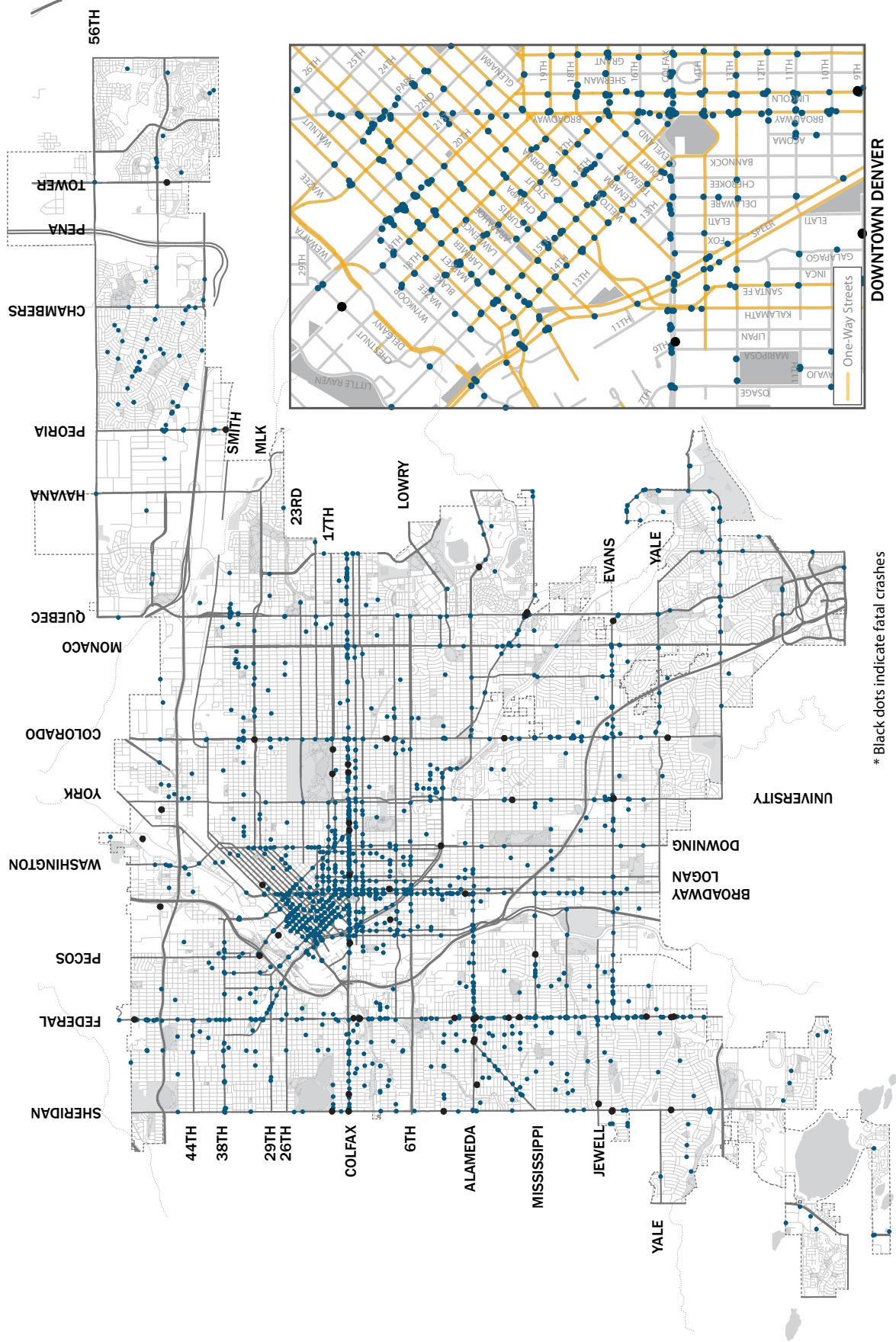


Figure 13: All Crashes 2011-2015

Mid-block Crashes

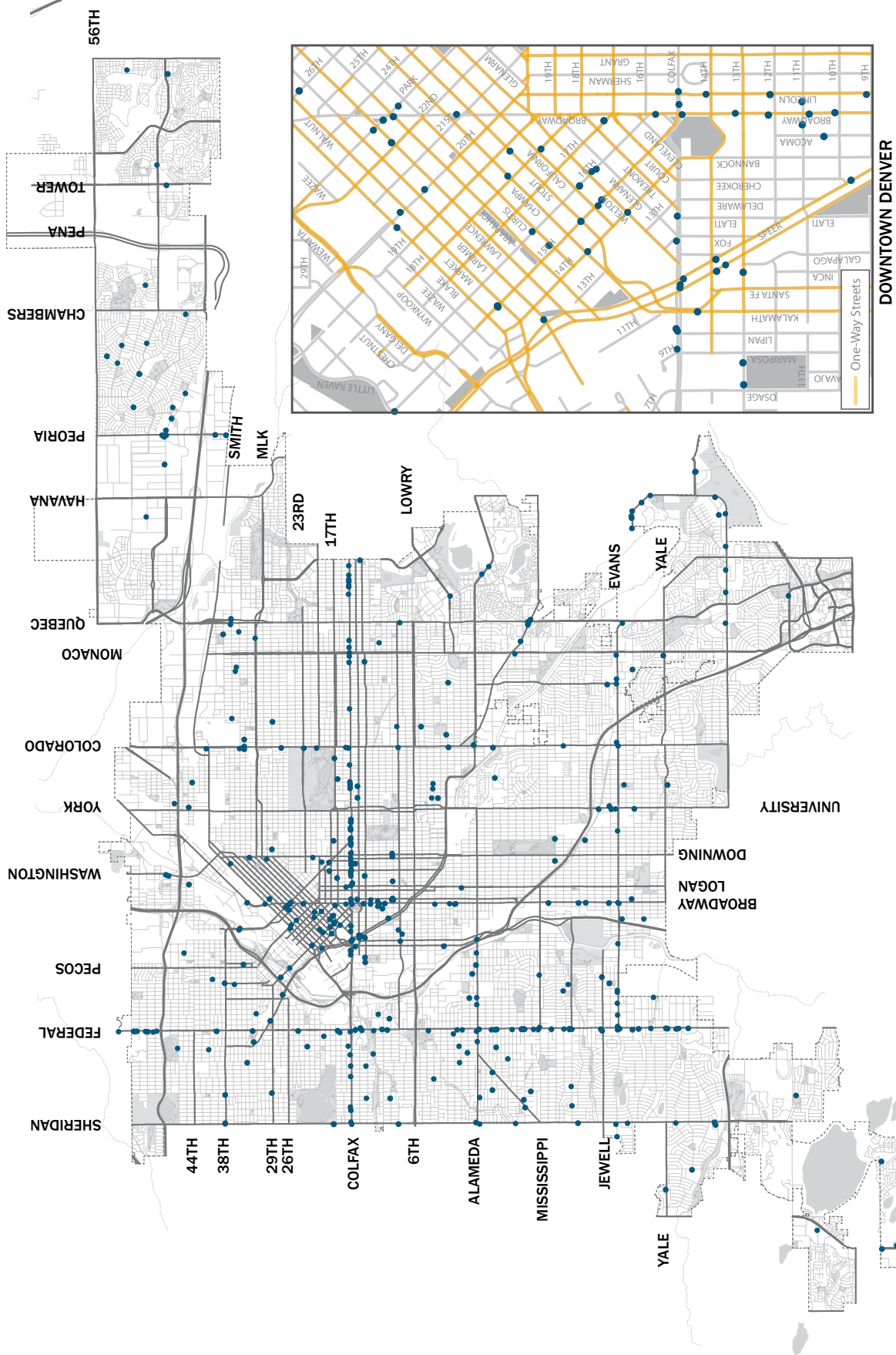


Figure 14: Mid Block Crashes 2011-2015

Left Hook Crashes - Signalized and Unsignalized

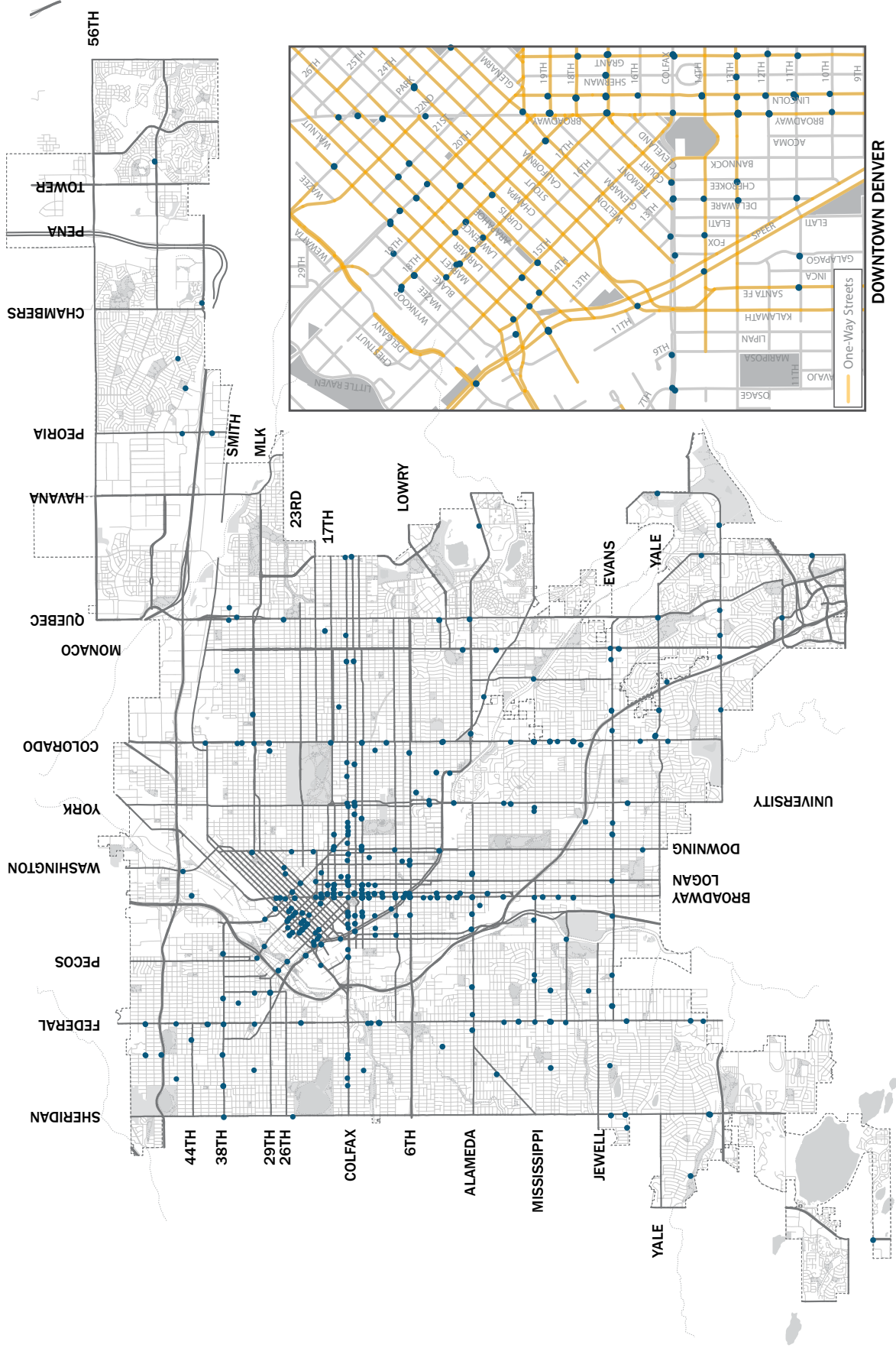


Figure 15: Left Hook Crashes- Signalized and Unsignalized 2011-2015

The map displays a detailed street grid of downtown Denver. Major streets are labeled, including 56TH, TOWER, PENNA, CHAMBERS, PEORIA, HAVANA, QUEBEC, MONACO, COLORADO, YORK, WASHINGTON, PECOS, FEDERAL, SHERIDAN, 44TH, 38TH, 29TH, 26TH, COLFAX, 6TH, ALAMEDA, MISSISSIPPI, JEWELL, YALE, BROADWAY, LOGAN, DOWNING, UNIVERSITY, and LOWRY. A grid of blue dots is overlaid on the map, representing data points. An inset map in the top right corner shows a larger area with orange lines indicating one-way streets and a legend for 'One-Way Streets'.

Figure 16: Pedestrian Crossing Against Signal, Motorist Straight Crashes 2011-2015

Right Hook Crashes

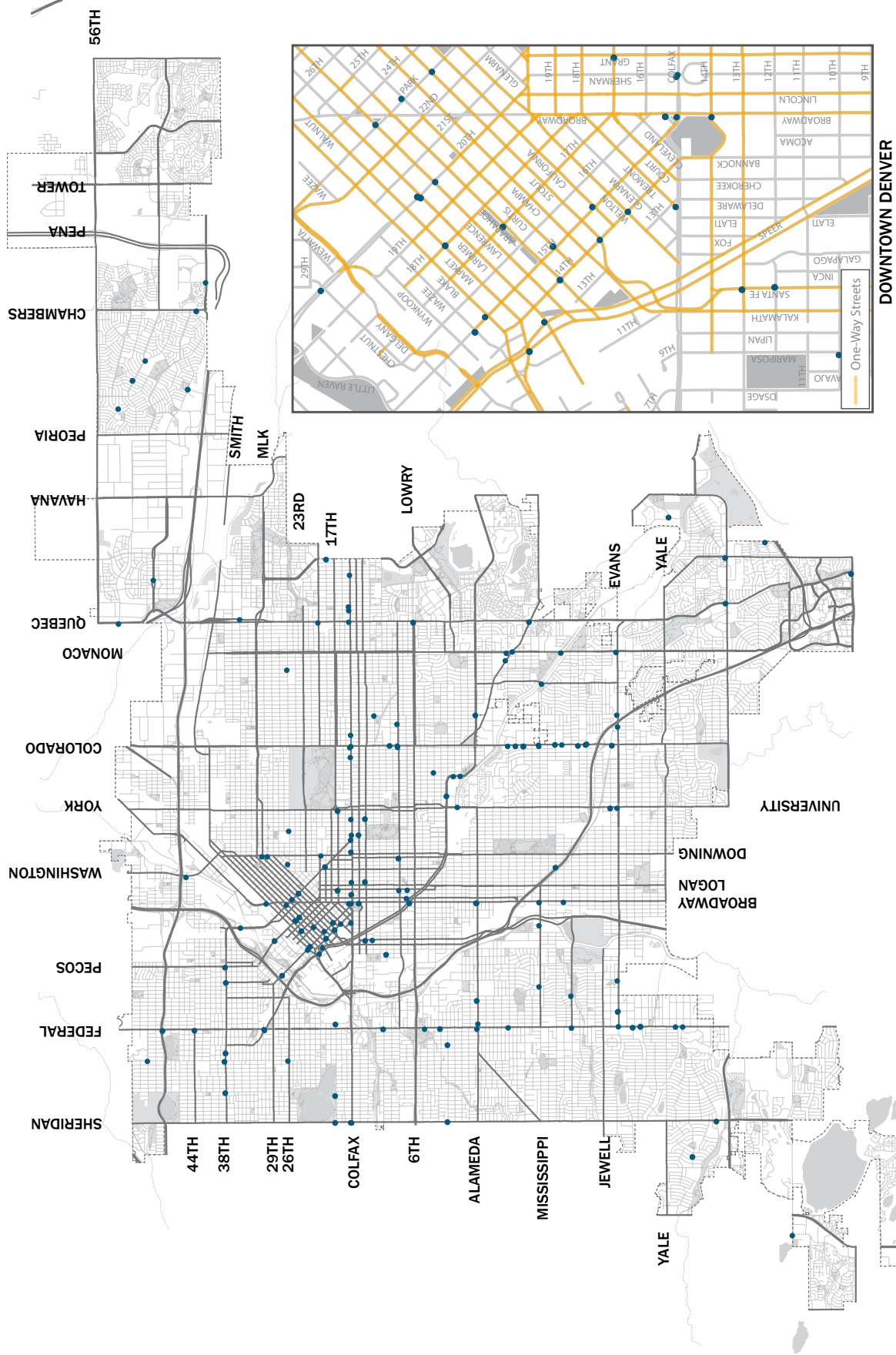


Figure 17: Right Hook Crashes 2011-2015

Figure 18: Pedestrian in Crosswalk with Signal, Motorist Straight Crashes 2011-2015

CRASHES WITHIN 200 FT OF TRAIL ACCESS

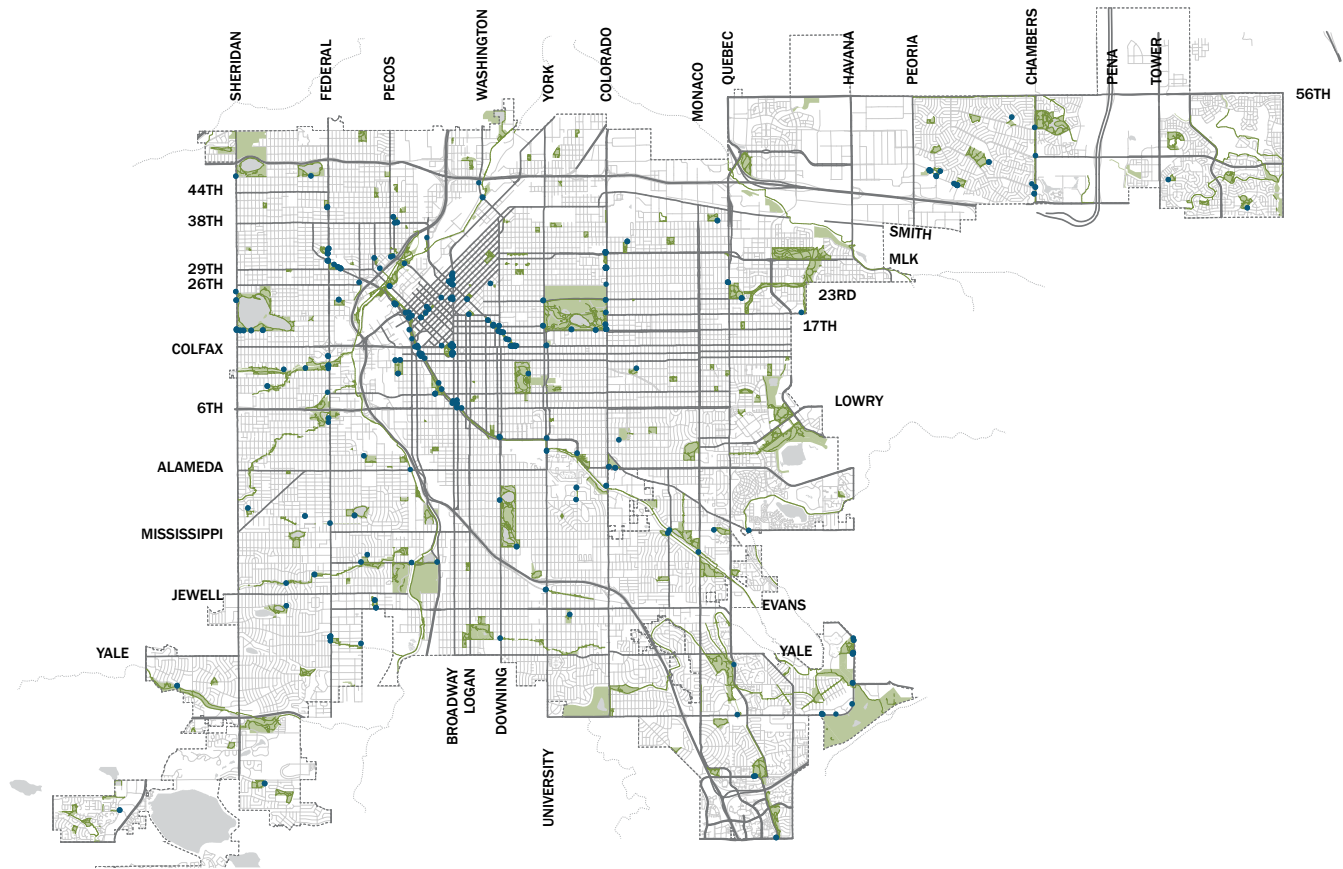


Figure 19: Crashes within 200 Feet of Trail Access 2011-2015

Park or Trail	Location	Count
Highland Park	32nd/33rd Avenues and Federal Boulevard	6
J. Langston Boyd Park	29th Avenue and Colorado Boulevard	6
Montbello Civic Center Park	46th Avenue and Albrook Drive	5
Harvard Gulch Trail	Federal Boulevard and Harvard/Vassar/Hillside Avenues	5
Sloan's Lake Park	17th Avenue near Sloan's Lake	4
J. Langston Boyd Park	Martin Luther King, Jr. Boulevard and Colorado Boulevard	4
Cherry Creek Trail	Speer Boulevard and Lincoln Street	3
Sunken Gardens Park	8th Avenue and Delaware Street	3
Sloan's Lake Park	17th Avenue and Sheridan Boulevard	3
Cherry Creek Trail	15th Street and Little Raven Street	3
Fred Thomas Park	26th Avenue and Quebec Street	3
City Park	17th Avenue and Colorado Boulevard	3

Table 5: High Crash Locations Near Trail Access

CRASHES WITHIN 200 FT OF DENVER PUBLIC SCHOOLS

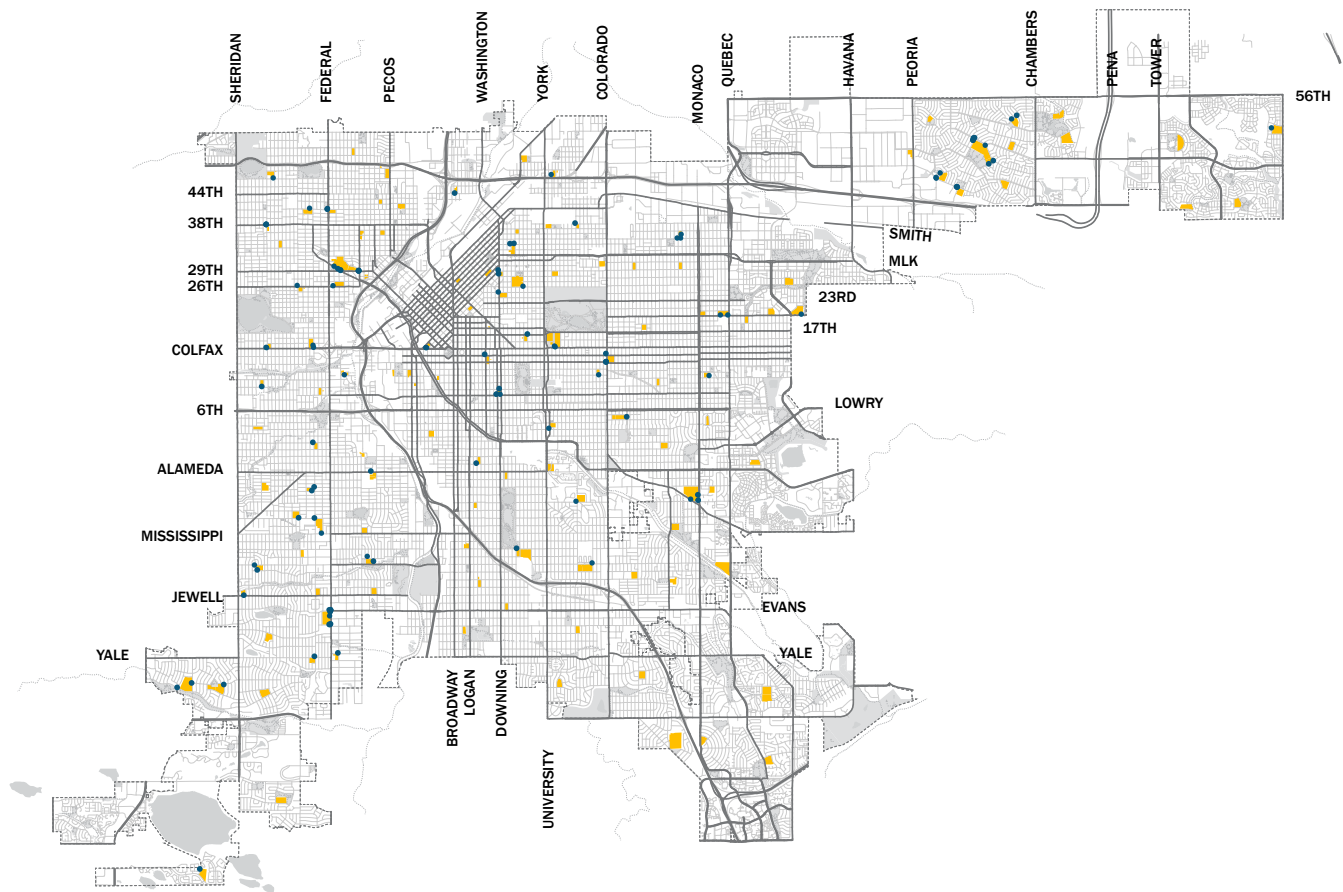


Figure 20: Crashes within 200 feet of Denver Public Schools 2011-2015

School	Location	Count
Abraham Lincoln High School	Federal Boulevard & Evans/Warren Avenues	11
Montbello High School*	51st Avenue & Crown Boulevard	5
North High School	Federal Boulevard & Speer Boulevard	4
George Washington High School	Monaco Parkway & Exposition Avenue	4
Dora Moore Elementary School	9th Avenue & Corona Street	4
Academy of Urban Learning	29th Avenue & Zuni Street	4

*Montbello High School closed in 2014, and the building now houses Noel Community Arts School and STRIVE Preparatory School.

Table 6: Highest Crash Intersections/ Areas within 200 Feet of a Denver Public School

Top Crash Intersections

20th Street and Market Street near Coors Field had the most pedestrian crashes of any intersection in the city, followed closely by Colfax Avenue and Broadway. Table 7 shows the 6 intersections with the highest number of crashes. A total of 1,070 intersections had at least one pedestrian crash between 2011 and 2015.

The map on the next page (Figure 21) shows the top 14 crash intersections, with the markers weighted proportionally by crash count, and the top crash corridors found in Figure 22.

Top Crash Corridors

East Colfax Avenue had the most pedestrian crashes of any corridor in the city. Between 2011 and 2015, there were 195 crashes on the corridor, equivalent to 7.1 crashes per mile per year. Federal Boulevard, Colorado Boulevard, Broadway, Lincoln Street, 20th Street, and Speer Boulevard also had a high prevalence of pedestrian crashes. Table 8 shows the streets with the highest number of pedestrian crashes and their respective annual average daily traffic (ADT) counts, speed limits, and other roadway characteristics.

Intersection	# of Crashes
20th Street & Market Street	17
Colfax Avenue & Broadway	15
13th Avenue & Broadway	13
Federal Boulevard & Kentucky Avenue	11
Colfax Avenue, Park Avenue & Franklin Street	11
Colfax Avenue & Colorado Boulevard	10

Table 7: Highest Crash Intersections

Corridor	# of Crashes	ADT	Speed Limit	# of Lanes	Length (Miles)	Crashes per Mile
E Colfax Ave	195	34,512	30 MPH	4	5.5	7.1
N Broadway	95	23,080	30 MPH	5	3.0	6.3
S Federal Blvd	90	37,806	40 MPH	5	4.1	4.4
N Federal Blvd	69	38,110	35 MPH	4	5.1	2.7
W Colfax Ave	61	29,449	30 MPH	5	3.5	3.5

Table 8: Highest Crash Corridors

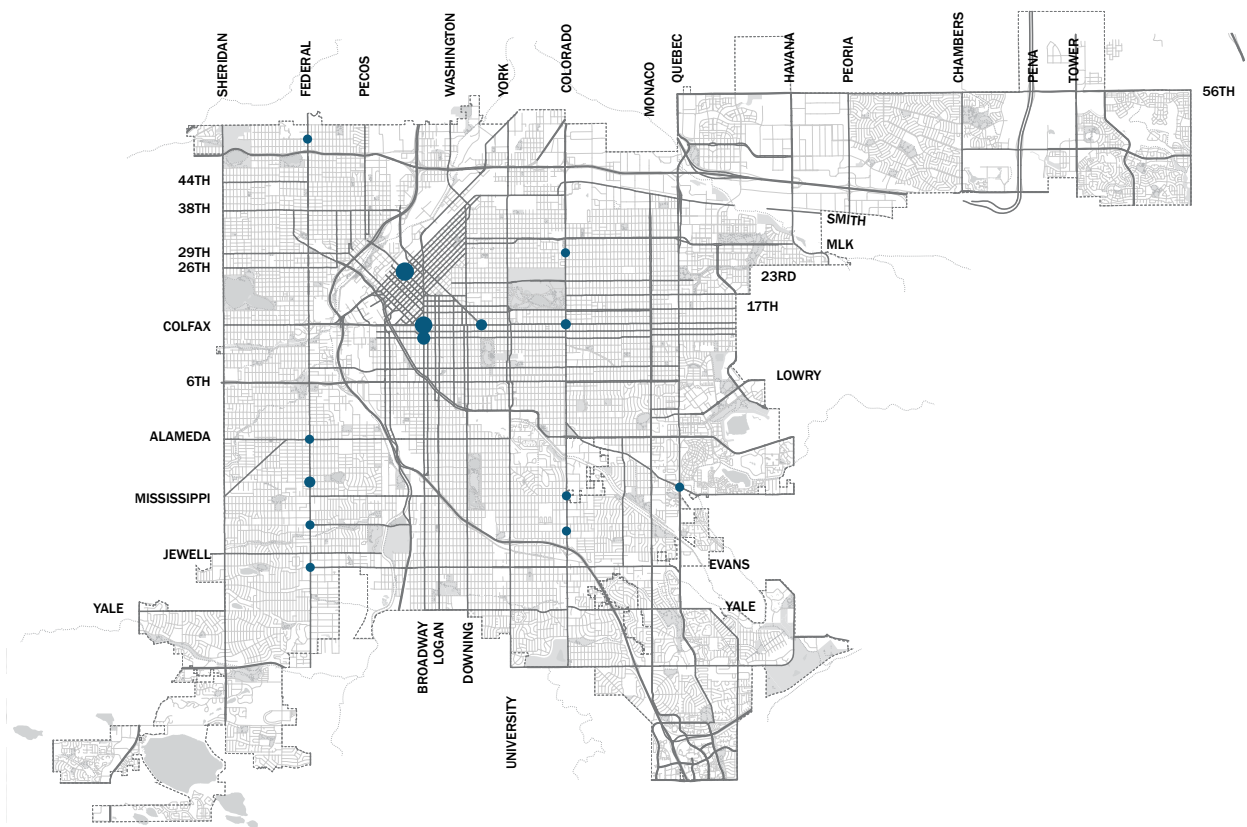


Figure 21: High Crash Intersections 2011-2015

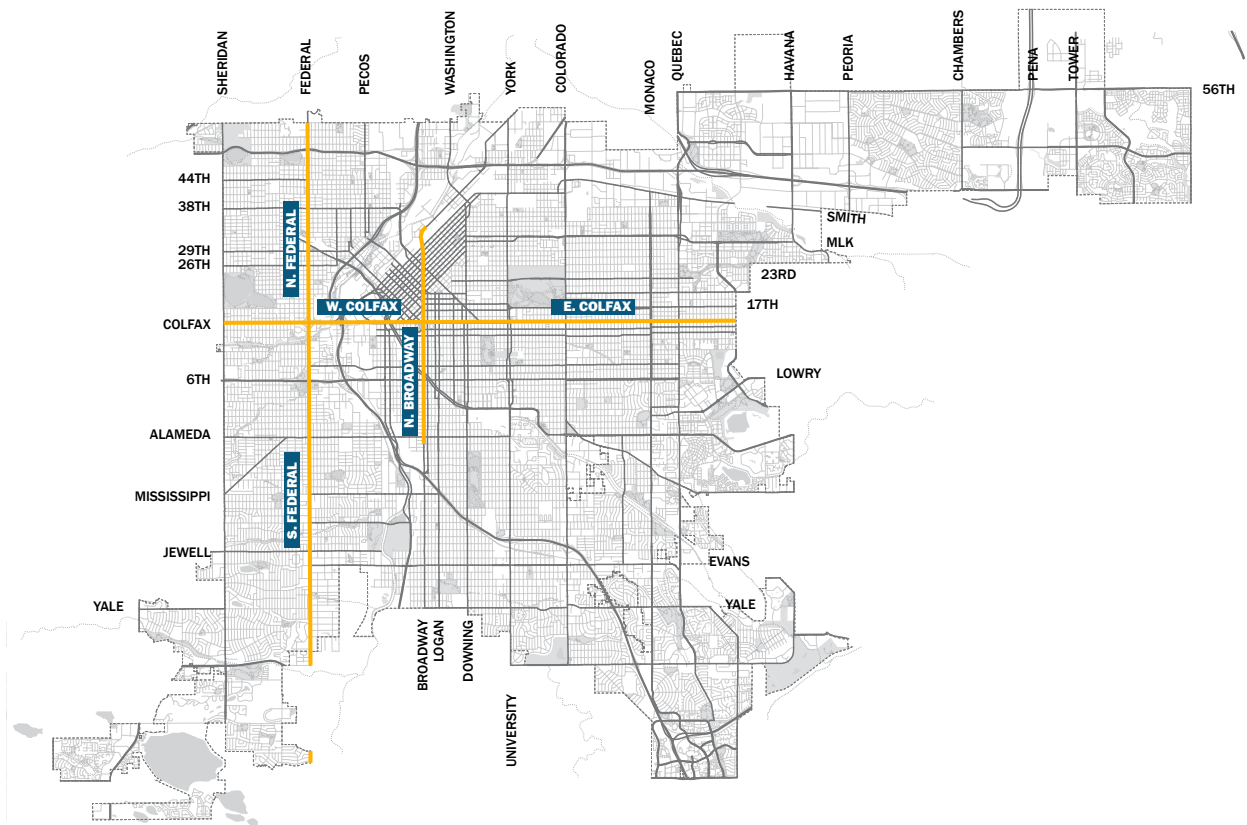


Figure 22: High Crash Corridors 2011-2015

Top Crash Types

Figure 23 shows the top 5 crash types, accounting for 62 percent of crashes citywide. Diagrams and descriptions of the top 5 crash types can be found on the following pages. Maps of these crash types can be found on pages 12-16.

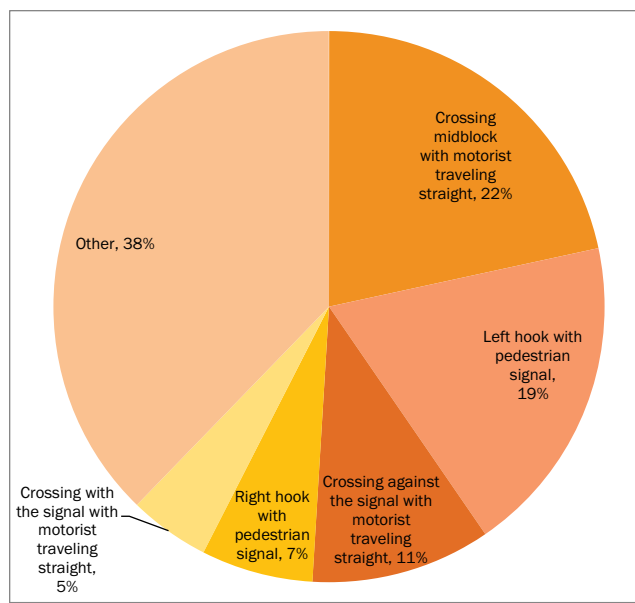


Figure 23: "All Crashes"- 2011-2015.

1. Pedestrian Mid-block, Motorist Straight

A pedestrian crosses the street at a mid-block, unsignalized location and the motorist continues straight into the pedestrian's path. See Figure 24. Mid-block is defined as more than 20 feet from the nearest permitted crossing location.

These crashes typically occur in locations with high pedestrian activity, such as downtown or along a commercial corridor. These crashes are also common where there is a lack of marked or unmarked crossing locations.

- 405 total crashes of 1,876 categorized crashes
- 72 percent of these 405 crashes resulted in an injury
- 5 percent of mid-block crashes resulted in a fatality

2. Pedestrian in Crosswalk with Signal, Motorist Left Turn

A pedestrian and motorist approach an intersection from the same street. The pedestrian crosses in a crosswalk with the walk signal, and the motorist turns left and strikes the pedestrian. This type of crash is sometimes referred to as a "left hook" crash.

These crashes often occur at locations where motorists are looking for gaps in approaching traffic to make left turns. The mixture of obscured sight-lines from the A-pillar of a vehicle, along with an urgency to beat oncoming traffic often leads to drivers failing to look for crossing pedestrians. At signalized intersections, these crashes typically occur during permissive left turn conditions where left-turning drivers are permitted to turn if there are no oncoming vehicles or pedestrians crossing.

- 353 total crashes of 1,876 categorized crashes
- 63 percent of these 353 crashes resulted in an injury
- 1 percent of these crashes resulted in a fatality

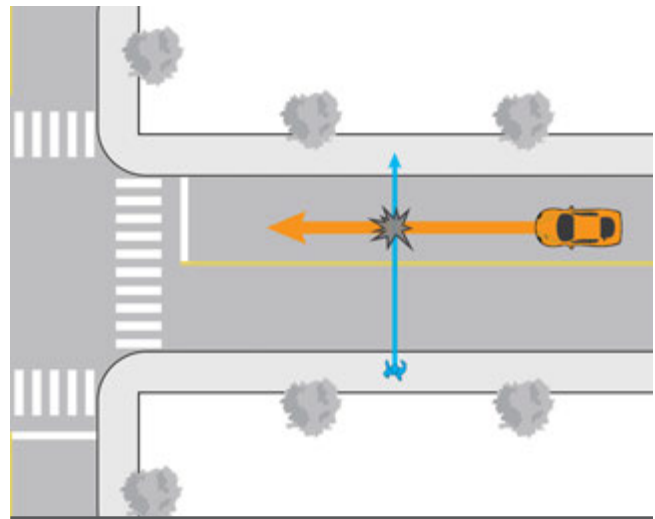


Figure 24: Crash Type 1 - Mid-block Crossings

Mid-block crossings accounted for 22 percent of all reported pedestrian crashes in Denver between 2011 and 2015.

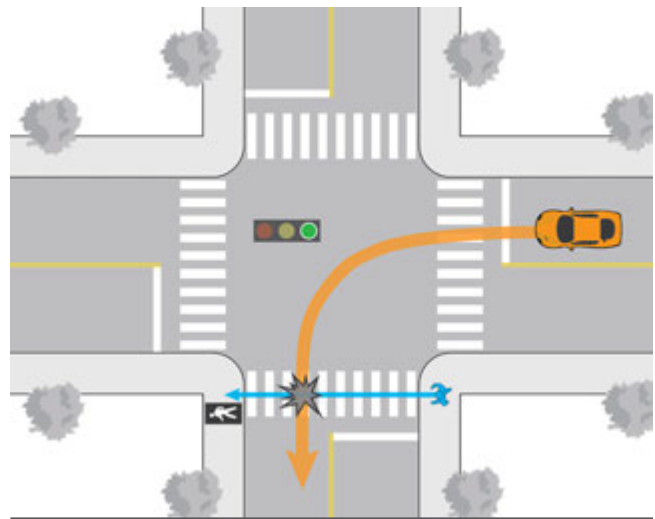


Figure 25: Crash Type 2 - Left Hooks

Left hook crashes accounted for 19 percent of all reported pedestrian crashes in Denver between 2011 and 2015.

3. Pedestrian in Crosswalk without Signal, Motorist Straight

A pedestrian and a motorist approach an intersection with perpendicular pathways. The pedestrian crosses against the signal, and the motorist drives straight through the intersection with a green light, striking the pedestrian in either the near or far crosswalk.

These crashes typically occur in locations with high pedestrian activity, such as downtown or along a commercial corridor.

- 198 total crashes of 1,876 categorized crashes
- 78 percent of these 198 crashes resulted in an injury
- 4 percent of these crashes resulted in a fatality

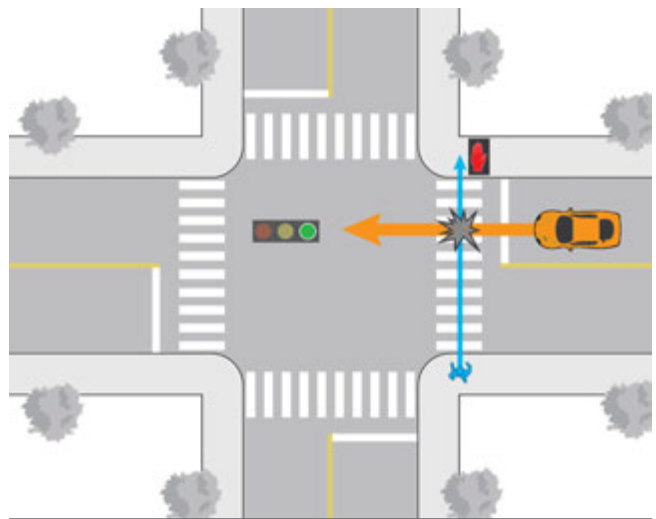


Figure 26: Crash Type 3 - Crossing Against the Signal

Pedestrians crossing against the signal accounted for 11 percent of all reported pedestrian crashes in Denver between 2011 and 2015.

4. Pedestrian in Crosswalk with Signal, Motorist Right Turn

A pedestrian and a motorist approach an intersection from the same roadway. The pedestrian crosses with the signal, and the motorist turns right into the pedestrian's path. This is sometimes referred to as a "right hook" crash.

This crash type mostly occurs when the motorist has a green light and fails to look for or see a crossing pedestrian. It is also possible for this crash type to occur at intersections with all-pedestrian signal phases and where right turns on red are permitted.

- 123 total crashes of 1,876 categorized crashes
- 46 percent of these 123 crashes resulted in an injury
- 1 percent of these crashes resulted in a fatality

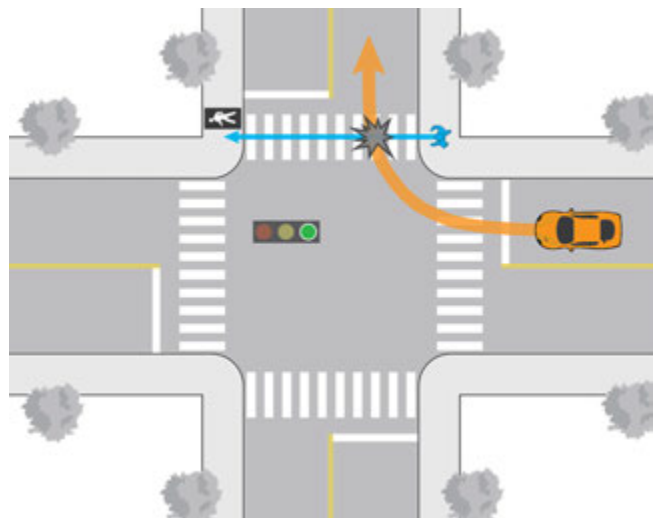


Figure 27: Crash Type 4 - Right Hooks

Right hook crashes accounted for 7 percent of all reported pedestrian crashes in Denver between 2011 and 2015.

5. Pedestrian in Crosswalk with Signal, Motorist Straight

A pedestrian and a motorist approach an intersection with perpendicular pathways. The pedestrian crosses with the signal, and the motorist runs a red light, striking the pedestrian in the near or far crosswalk.

It is likely that this crash type is more prevalent than it appears. In an additional 35 crashes, the motorist was traveling straight and the signal was undetermined or there were conflicting reports from the parties involved.

- 89 total crashes of 1,876 categorized crashes
- 49 percent of these 89 crashes resulted in an injury
- 1 percent of these crashes resulted in a fatality

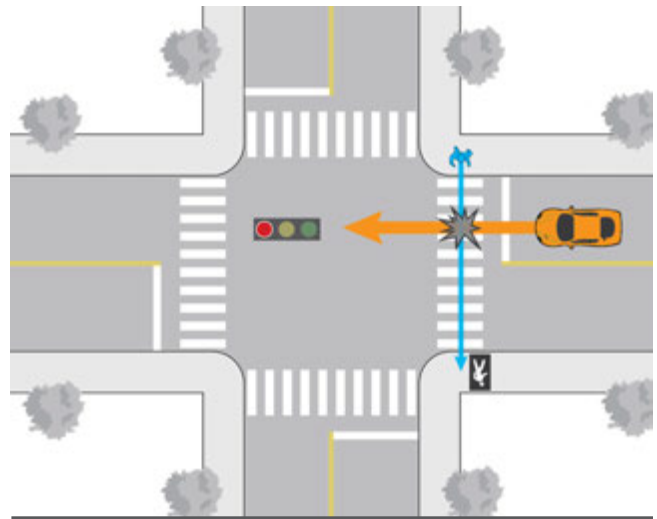


Figure 28: Crash Type 5 - Running Red Lights

A motorist running a red light accounted for 5 percent of all reported pedestrian crashes in Denver between 2011 and 2015.

Next Steps

Denver Public Works developed this report to better understand pedestrian safety in Denver. It provides a baseline for trends and crash characteristics to inform future planning for pedestrian-related projects and programs. Using this data, the next steps in addressing pedestrian 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. This information is also helpful in coordinating with partner agencies and community organizations that affect pedestrians in Denver.

Pedestrian Network Implementation

Denver Public Works recently completed Pedestrian Crossing Guidelines. The document can be found here: <https://www.denvergov.org/content/dam/denvergov/Portals/706/documents/CCD-pedestrian-crossing-guidelines-2016.pdf>. These guidelines provide standards for implementing mid-block pedestrian crossings throughout the City and County of Denver, and criteria to determine the appropriate tool to use given the roadway speed and type.

DPW is currently engaged in the planning process for *Denver Moves: Pedestrians and Trails*. This will identify citywide needs and define priorities for improving and completing both Denver's on-street pedestrian and off-street trail networks. The results of this Pedestrian Crash Safety Study will inform crossings identified from *Denver Moves: Pedestrians and Trails*.

Vision Zero

In addition to the Denver Moves: Pedestrians & Trails Plan, the City has committed to Vision Zero. Vision Zero is a proven, data-driven approach to reducing transportation-related injuries and saving lives. Vision Zero is a goal of working toward the only acceptable number of traffic deaths and serious injuries: zero. Denver's commitment to Vision Zero starts with the idea that safety is our top priority, and with the knowledge that we can eliminate fatal crashes and serious injuries. It assumes we have the power to achieve this goal but we need a shared vision. Denver's commitment to Vision Zero is established in its five year Action Plan, a roadmap to achieve zero serious injuries and fatal crashes.

Future Reporting and Study

As a part of Vision Zero, crash analyses of this nature will be updated regularly as new crash data becomes available to continue evaluating and addressing pedestrian safety in Denver. Recommendations and data from this study will also be used as a basis for other pedestrian planning efforts in the City and County of Denver.

The study identified a few logistical recommendations through this crash analysis. With more comprehensive data from the outset, future pedestrian crash analyses could be further refined. The State of Colorado is currently in the process of improving its crash reporting form; representatives involved in this pedestrian crash analysis have participated in their important effort.

This report also found that it would be beneficial for Public Works to input the injury severity field into the Public Works crash database. This data is collected on a 0-4 scale where 0 represents "no injury," 1 represents "complaint of injury," 2 represents "evident non-incapacitating injury," 3 represents "evident incapacitating injury," and 4 represents "fatal." For this study, crashes coded with a 1, 2, or 3 in the injury severity field were classified the same, simply indicating an injury occurred.

With more detailed injury data, efforts in Vision Zero and the next pedestrian crash analysis could provide a more nuanced understanding of the severity of crashes in relation to other variables.

In addition to the Vision Zero Action Plan, there is ongoing work led by DPW that address many of the crash trends and locations identified in this Report. DPW is leading a study to evaluate the top seven high crash locations in the City that involve a high number of pedestrian and bicycles; as a part of this study, DPW will implement short-term solutions and also develop designs for longer term construction.

Pedestrian Safety Tool Box

This next section describes various countermeasures tools that can be used to reduce pedestrian crashes and injuries. Many of these tools are being used in applications throughout the city to improve the pedestrian environment in Denver.

Mid-block Crossings

Mid-block Signals

With 22% percent of all crashes occurring mid-block, the City should evaluate installing either pedestrian signals or full signals in places that are 300 feet away or greater than the nearest intersection provided adequate pedestrian demand is observed. This is consistent with the City's mid-block crossing standards. Options for mid-block crossings include a full traffic signal, Rapid Flashing Rectangular Beacons (RRFBs) or HAWK signals.

Pedestrian Refuge Islands

Medians or pedestrian refuge islands allow pedestrians to cross a portion of the street when there is not a reasonable gap in traffic to cross the entire street at once. Pedestrians then have a place to wait to cross the remaining travel way until safe to do so. Raised islands are placed in the middle of a roadway with a cutout for pedestrians in the middle, providing for crossing pedestrians. This can also serve to slow traffic.

Speed Limit Reduction

Lower speeds increase sight distance by opening up the drivers cone of vision and providing more time to react and stop should an incident occur. Thus, decreased speeds reduce the chances of an injury shall a crash occur. Recommendations include implementing engineering solutions and reducing speed limits accordingly.

Multimodal Safety Toolbox

As a part of the Neighborhood Transportation Management Program, DPW is drafting a Multimodal Safety Toolbox to provide guidance for the planning and implementation of in-street multimodal infrastructural or operational safety improvements. These improvements include pedestrian facility improvements, bicycle facility

treatments, multimodal operational treatments, and traffic calming treatments. The treatments outlines in this resource are additional tools that may be implemented to address specific crash types.

Intersection Treatments

With 54% of crashes occurring at or near a signalized intersections between 2011 and 2015, engineering tools are valuable to consider in the reduction of crashes.

Compact Intersection Design

Streets that are narrowed for fewer lanes, curb extensions, tight corner radii, pedestrian safety islands, and conversion of one-way to two-way streets can help prevent speeding, therefore reducing the chance of crashes. Intersections with insufficient visibility should be reconstructed to be more compact, giving all users a better view of potential conflicts. Elements of these intersections are described in more detail below:

Curb extensions

Curb extensions (sometimes referred to as bulbouts) are extension of the curb into the roadway to make crossing distances shorter, improve pedestrian visibility, and reduce motorist turning speed. They can be located at intersections or mid-block crossings.

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.

Right Turn Slip-Lane Removal

Right turn slip-lanes create an exclusive channelized lane with a large turning radius, creating an extra lane for pedestrians to cross. When a slip-lane is removed, the corner radius can be tightened.

Improved Sight Distance/ Daylighting Intersections

Restricted sight lines can contribute to all crashes, but especially hook crashes. Maintaining 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. Initiating no-parking zones within 50 feet of the intersection, on a contextual basis, is one strategy to improve sight lines and decrease left hook crashes.

Signal/ Access

Access Restrictions

Consider banning left or right turns where they are problematic or create safety conflicts on arterial roadways.

Dedicated Left Turn Signal

Where warranted, develop a separate left turn only signal phase and lane in areas with a high prevalence of left-hook crashes.

Shorter Signal Cycles

Shorter signal lengths encourage pedestrians to wait for the signal before crossing. Evaluate shorter cycle lengths on high-crash corridors and downtown streets.

Leading Pedestrian Interval (LPI)

Use LPIs to give pedestrians a head start when entering the crosswalk where there is a high instance of left-hook or right-hook crashes.

Accessible Pedestrian Signals

At signalized crossings, particularly large multi-lane intersections, some pedestrians who are visually impaired may have difficulty navigating the intersection. This can be improved by providing traffic signals that provide auditory information to pedestrians who are blind or have low vision.

Interim Strategies

Interim strategies include using low-cost materials such as pavement markings and bollards. These have the effect of creating a more compact intersection which decreases crossing distances, increasing intersection visibility, and slows down turning movements.



Figure 29: Striping materials and bollards have the affect of a curb-extension at 17th & Wynkoop in downtown Denver.

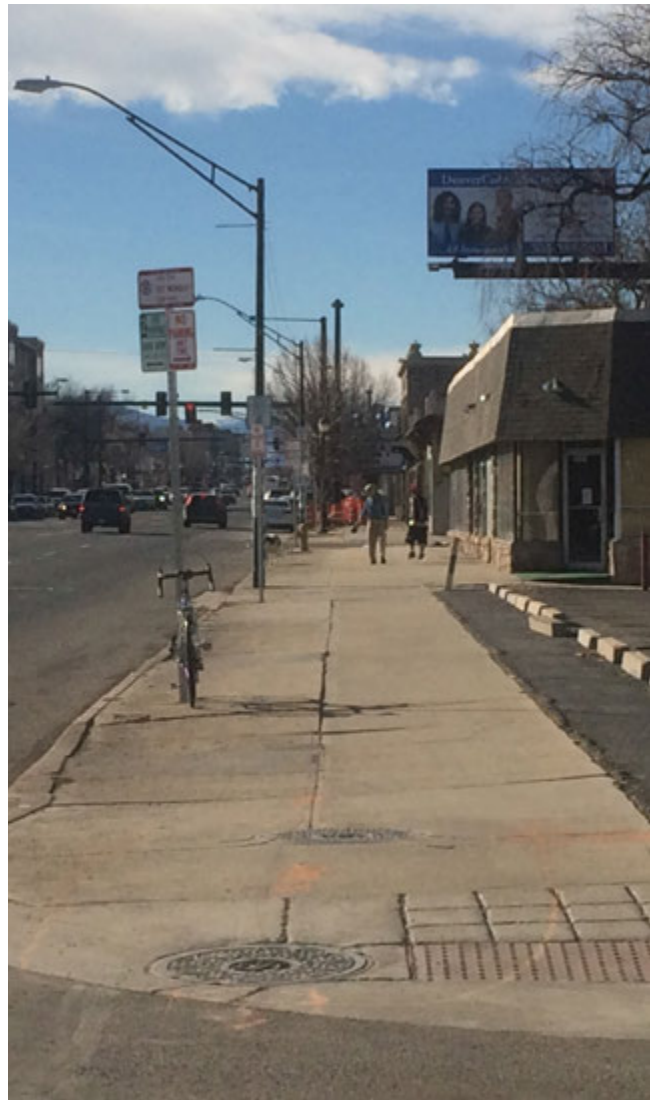


Appendix A

High Crash Corridors & Downtown

Corridor Analysis

In addition to the Citywide analysis, additional analysis was completed for this report that performed a deeper look on Federal Boulevard, Colfax Boulevard, and Colorado Boulevard. These three arterial streets were analyzed further for a variety of reasons. Colfax and Federal are among the top five high crash corridors, and Colorado is among the top 10 crash corridors. Additionally, these are all State-Highway Corridors, have higher speeds and volumes.



Colfax Avenue

Colfax Avenue was identified within this report as a high-crash corridor, and is the top crash corridor within the City. When broken into segments, East Colfax remains the highest crash corridor and West Colfax is the 5th highest. When these segments are normalized for length, this equals a crash rate of 7.1 crashes per mile and 3.5 per mile respectively for the five year study period.

The top crash type on Colfax Avenue were mid block crashes, which matches the top crash type citywide. This accounted for 25% of the crashes that occurred on this corridor. The second highest crash type on Colfax Avenue was crossing in the crosswalk without a walk signal which accounted for 16% of the crashes.

Colfax Avenue saw the most pedestrian crashes on the segment of East Colfax between Kalamath Street and Colorado Boulevard. Medians are largely absent in this segment, however this section also has the lowest speed limit of the corridor at 30 MPH.

From approximately Vine Street to Monroe Street and from Tamarac Street to Wabash Street, there was a higher prevalence of mid block and unsignalized crashes far from the nearest crosswalk.

Additional analysis of Colfax Avenue has yielded the following results:

- 14 percent of crashes citywide occurred on Colfax Avenue (273 crashes out of 1,924 crashes citywide).
- Only 34 percent of intersections on Colfax Avenue are signalized, but 51 percent of the Colfax Avenue crashes (140) occurred at these locations.
- There were 4 transit bus crashes and 2 non-school bus crashes on Colfax Avenue.
- Pedestrians were listed first (typically determined by responding officer to be at fault) in 62 percent of crashes between 10pm and 4am versus the citywide average of 39 percent.
- The top crash time is between 6pm and 8pm compared to the Citywide average between 4pm and 6pm.

Nearest Intersection	Count
Colfax Avenue & Broadway	15
Colfax Avenue, Park Ave & Franklin St.	11
Colfax Avenue & Colorado Boulevard	10
Colfax Avenue & Pennsylvania Street	9
Colfax Avenue & High Street	8
Colfax Avenue & Washington Street	8

Table A-1: Top Crash Intersections, Colfax Avenue 2011-2015

Top Crash Type	Count of Crashes	Percent of Crashes	Number of Injuries	Number of Fatalities
Ped Midblock, Motorist Straight	67	25%	49	2
Ped in CW w/o Signal, Motorist Straight	45	16%	29	1
Ped in CW w/o Signal & Motorist Left Turn	37	14%	22	2
Ped in Intersection, w/o ROW, Motorist Straight	15	5%	12	0
Ped in CW w/ Signal, Motorist Right Turn	14	5%	9	0
Corridor Totals	273	N/A	176	8

Table A-2 Top Crash Types, Colfax Avenue 2011-2015

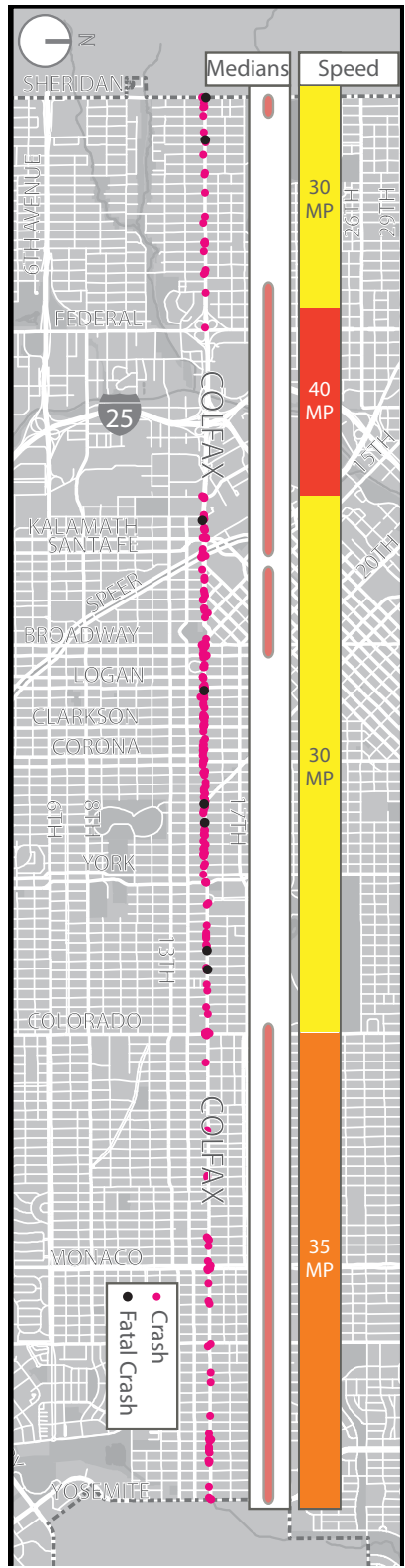


Figure A-1: Crashes on Colfax with Median Presence and Speed Limit.

Federal Boulevard

Federal Boulevard was identified within this report as a high-crash corridor. When broken into segments, both North Federal and South Federal are the 4th and 5th highest crash corridors. When these segments are normalized for length, this equals a crash rate of 7.1 crashes per mile and 3.5 per mile respectively for the five year study period.

The top crash type on Federal Boulevard was a pedestrian crossing mid block, consistent with the top crash type citywide. Just under half of the midblock and unsignalized crashes along Federal Boulevard occurred more than 300 feet from the nearest crosswalk.

The top crash times on Federal were between 4 and 6 PM consistent with the Citywide average, as well as from 8 to 10 pm.

Federal Boulevard had slightly fewer pedestrian crashes along areas with medians and had the highest crash density in the southern portion of the corridor where the speed limit is 40 miles per hour.

Additional analysis of Federal Boulevard has yielded the following results:

- 21 percent of fatalities citywide occurred on Federal Boulevard (12 fatalities out of 57 citywide)
- 73 percent of intersections along Federal Boulevard are unsignalized, and 55 percent of crashes (95) occurred at these locations, compared to 42 percent of citywide crashes
- The fatality rate at unsignalized locations was more than 4 times that of signalized intersections (10.5 percent and 2.6 percent, respectively)
- The fatality rate was more than twice the citywide average (7 percent versus 3 percent, respectively)
- 33 percent of the fatalities were hit-and-run crashes
- 33 percent of pedestrians struck by an intoxicated driver were killed (2 fatalities out of 6 crashes attributed to driving under the influence)
- Pedestrians were listed first (typically determined by responding officer to be at fault) in 80 percent of crashes between 10pm and 4am, double the citywide average

Nearest Intersection	Count
Federal Boulevard & Florida Avenue	10
Federal Boulevard & Kentucky Avenue	10
Federal Boulevard & Alameda Avenue	9
Federal Boulevard & Evans Avenue	9
Federal Boulevard & 10th Avenue	8
Federal Boulevard, 50th Avenue & Regis Boulevard	8

Table A-3 Top Crash Intersections, Federal Boulevard 2011-2015

Crash Type	Count of Crashes	Percent of Crashes	Number of Injuries	Number of Fatalities
Ped Crossing Midblock, Motorist Straight	61	35%	43	10
Ped in CW w/ Signal, Motorist Left	24	14%	18	0
Ped in CW w/o signal, Motorist Straight	22	13%	16	1
Ped in Intersection w/o ROW, Motorist Straight	15	9%	13	1
Ped in CW w/ signal, Motorist Right	11	6%	8	0
Corridor Totals	173	N/A	122	12

Table A-4 Top Crash Types, Federal Boulevard 2011-2015

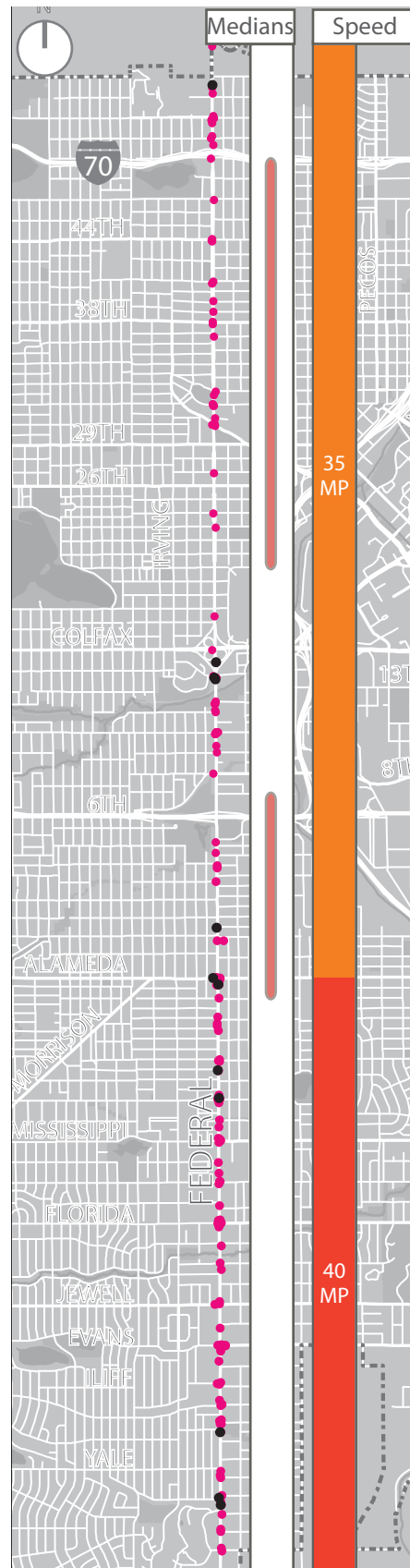


Figure A-2: Crashes on Federal Blvd with Median Presence and Speed Limit.

Colorado Boulevard

Colorado Boulevard was identified as the 6th highest crash corridor in the City, however, this only represents the segment North of Colfax. The South Segment of Colorado Boulevard was the 8th highest corridor by number of crashes.

The top crash type was from a motorist making a left turn while a pedestrian had the signal. This accounted for 29% of the crashes. Colorado Boulevard had fewer mid-block crashes and crashes at unsignalized intersections. Of these, no crashes occurred more than 300 feet from a crosswalk. This may be attributed to the fact that there is the presence of a median for most of the corridor.

The highest crash period was between 4 and 8pm, overlapping the Citywide average from 4-6pm.

Additional analysis of Colfax Avenue has yielded the following results:

- 3 out of the 4 fatalities (75 percent) occurred at signalized intersections, compared to 60 percent of fatalities citywide
- The injury rate was lower than the citywide

average (52 percent versus 60 percent, respectively) and the fatality rate was slightly higher than the citywide average (4 percent versus 3 percent, respectively)

- 14 percent of crashes were attributed to distracted driving compared to 6.4 percent citywide
- 19 percent of crashes were hit-and-run crashes, slightly lower than the citywide average of 23 percent
- There were 2.3 crashes per mile per year on Colorado Boulevard

Nearest Intersection	Count
Colorado Boulevard & Colfax Avenue	10
Colorado Boulevard & Iowa Avenue	9
Colorado Boulevard & Mississippi Avenue	9
Colorado Boulevard & 29th Avenue	8
Colorado Boulevard & Louisiana Avenue	7

Table A-5 Top Crash Intersections, Colorado Boulevard 2011-2015

Crash Type	Count of Crashes	Percent of Crashes	Number of Injuries	Number of Fatalities
Ped in CW w/ Signal, Motorist Left	31	29%	22	0
Ped in CW w/ Signal, Motorist Right	17	16%	2	1
Ped Crossing Midblock, Motorist Straight	15	14%	11	0
Ped in CW w/o Signal, Motorist Straight	14	13%	5	1
Corridor Totals	107	N/A	56	4

Table A-6 Top Crash Types, Colorado Boulevard 2011-2015

Downtown

A larger portion of all of the crashes occurring in Denver occurred downtown (442 or 23% of all crashes). This can be partially attributed to the large number of pedestrians downtown. In this analysis, downtown is roughly considered to be the area bounded by I-25, Park Avenue, Broadway, and Colfax Avenue/Speer Blvd (see Figure A-5). Downtown has the highest concentration of one-way streets in the city, and is unique in having a large number of signalized intersections that include all-pedestrian phases.

There are 2 key concentrated areas of crashes downtown: around Coors Field and around the Colfax Avenue and Broadway intersection. Around Coors Field there are high volumes of pedestrians and high concentrations of bars and restaurants along with high vehicular volumes and wider roadways as shown with 20th Street. The Colfax Avenue and Broadway intersection is a major transfer point for RTD, is adjacent to Civic Center Station, and also has high volumes of pedestrians.

35 crashes (8 percent) occurred between 10 pm and 4 am. More than 50 percent of these were hit-and-run crashes. 11 percent of nighttime crashes were attributed to drivers under the influence, compared to 2.5 percent citywide at all times.

Intersection Trends

The top 3 crash intersections downtown also represent the top 3 crash intersections citywide. 20th Street and Market Street had the most pedestrian crashes of any intersection citywide. 7 of the 17 crashes at this intersection occurred in the southeast crosswalk, 5 of which involved pedestrians crossing against the signal. Another 4 of the crashes at this intersection occurred in the northwest crosswalk, 2 of which involved pedestrians walking against the signal. Among the 17 crashes at this intersection, there were 14 injuries. 7 of the crashes were hit-and-runs, and 2 of the 17 crashes were attributed to driving under the influence.

Of the 13 crashes at 13th Avenue and Broadway, 12 were left hooks from westbound 13th Avenue onto southbound Broadway, all occurring in the 2 easternmost lanes on Broadway. Pedestrians were crossing with the signal in all 13 crashes. Three of these crashes occurred between 8 am and 10am, and 9 occurred between 1pm and 6pm.

Intersection	Count of Crashes	Number of Injuries	Number of Fatalities
20th Street and Market Street	17	14	0
Colfax Avenue and Broadway	15	5	0
13th Avenue and Broadway	13	6	0
Colfax Avenue and Pennsylvania Street	9	7	0
14th Avenue and Lincoln Street	7	4	0
15th Street and Market Street	6	4	0
20th Street and Blake Street	6	4	0
20th Street and Larimer Street	6	1	0
17th Avenue and Lincoln Street	6	3	0
Colfax Avenue and Logan Street	6	1	1

Table A-6 Top Crash Locations, Downtown Denver 2011-2015

Downtown Subareas

The downtown area was split into two parts: Lower Downtown and anywhere not in Lower Downtown. The southern boundary of Lower Downtown is Market Street. This analysis was done to better understand the nature of crashes downtown, particularly in relation to the presence of signals with all-pedestrian phases. Lower Downtown largely does not have all-pedestrian phases, while the remainder of downtown does have these signal types.

Based on Figure A-4 below, there are far fewer mid-block crossings in Lower Downtown and the remaining downtown area than there are across the city. Lower Downtown in particular had a low occurrence of mid-block crashes at only 7 percent of all crashes, whereas 22 percent of all crashes in Denver were mid-block crossings. On the other hand, left hooks were far more common downtown than throughout the entire city.

Crossing against the signal and mid-block crashes (both crash types where the vehicle has the right of

way) were more prevalent in non-Lower Downtown areas than in Lower Downtown. Lower Downtown consistently had more crashes where pedestrians had the right of way (right hooks, left hooks, and motorist straight with pedestrian crossing in a crosswalk with the signal) than the remainder of downtown.

Common Crash Types Downtown

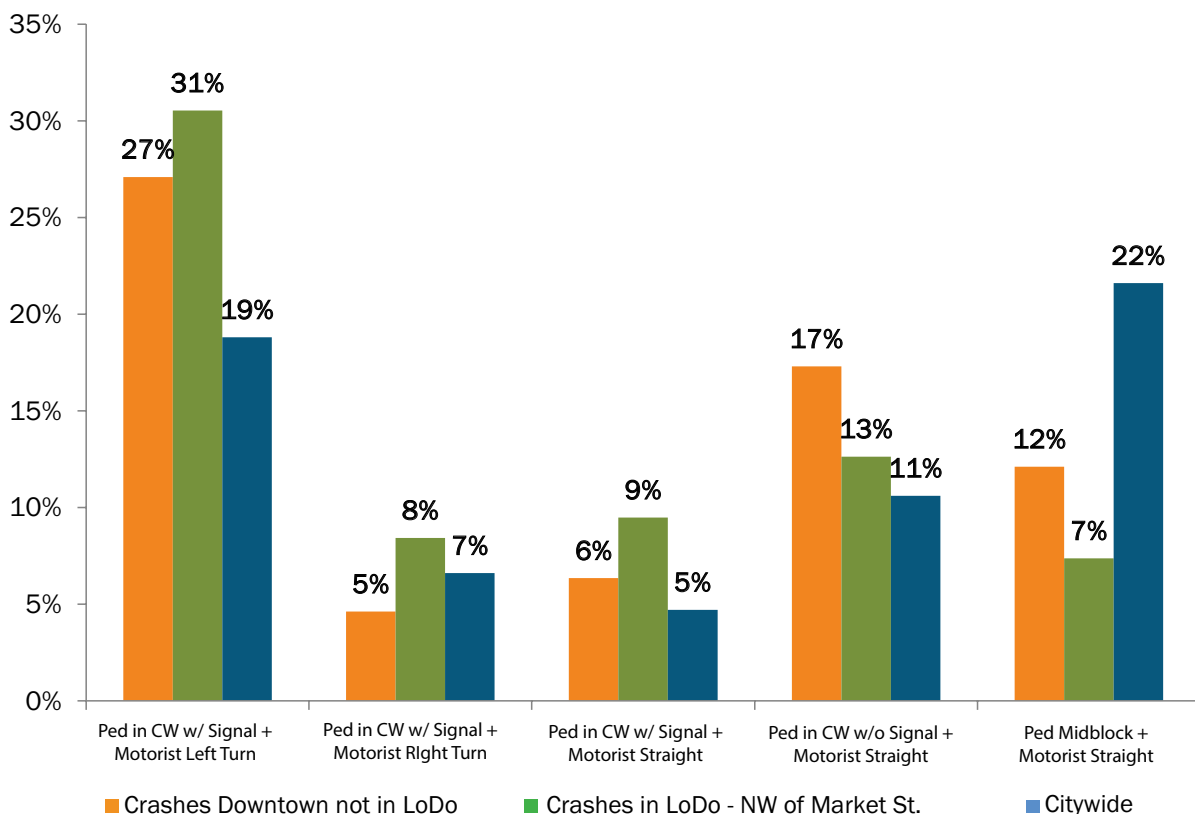


Figure A-4: Common Crash Types in Lower Downtown, Downtown not in Lower Downtown and City Wide.

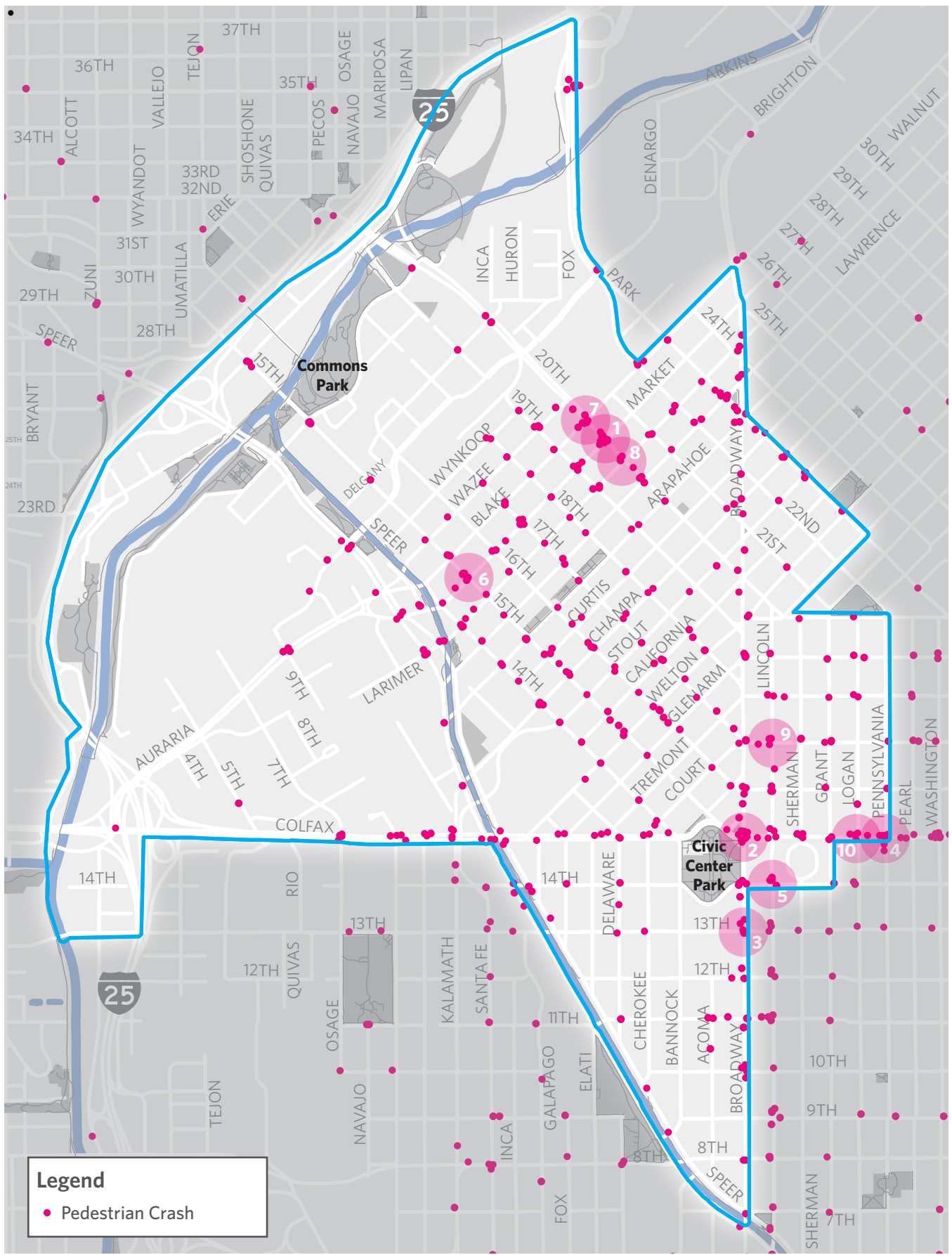


Figure A-5: Pedestrian Crashes in Downtown Denver 2011-2015

Pedestrian Crash Analysis

Understanding and Reducing
Pedestrian & Motor Vehicle Crashes

