Active Modes Crash Report

Table of contents

List of figures

List of maps

List of tables

1 Understanding safety and active transportation

From 2010 to 2019, fatal and severe injury crashes involving people using active modes increased 31% in the Denver region.

Across the U.S., Colorado and the Denver region, traffic deaths and injuries of have steadily increased for the past decade. While the Denver region's population grew by 15% between 2010 and 2019, and total vehicle miles traveled increased by 17%, the number of crashes resulting in death or severe injury among all modes grew 18%.

However, people walking bore the brunt of the increase, as the number of traffic crashes in which a pedestrian was killed or severely injured increased a staggering 42% and the per capita rate of severe pedestrian crashes increased 23% over the decade.

Conversely, while the number of crashes in which people were killed or severely injured bicycling in the region increased in the first half of the decade (42% total and 32% as a rate per capita between 2010 and 2014), both the total number and per capita rate of bicycle-involved crashes with fatalities or severe injuries fell between 2014 and 2019 (26% and 31% respectively).

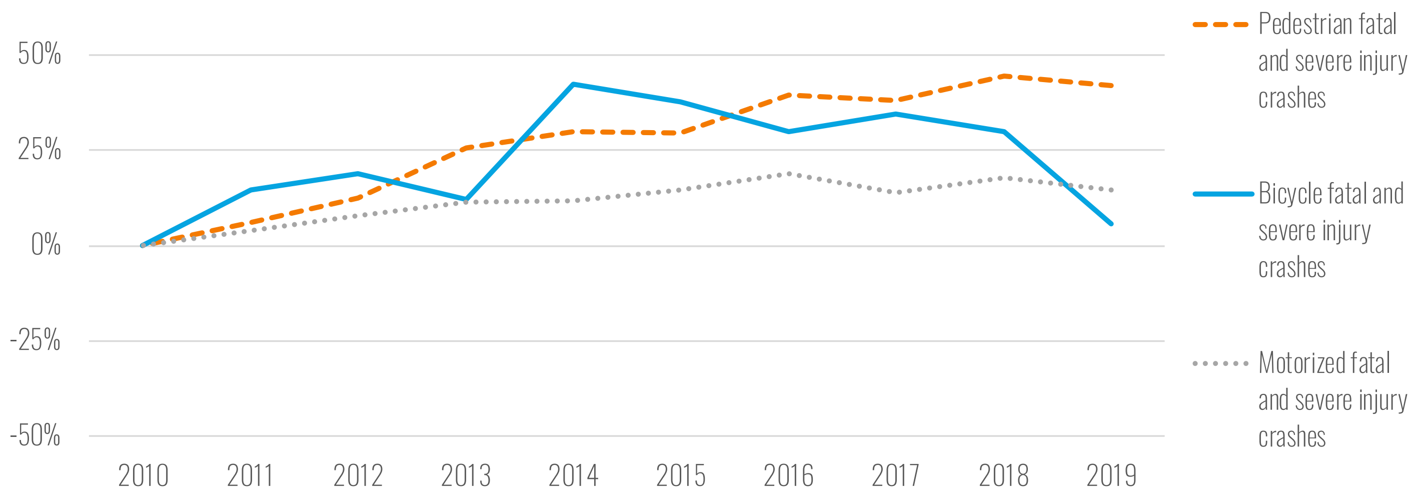


Figure 1: Change in fatal and severe injury crashes with fatalities or severe injuries per year, indexed to 2010

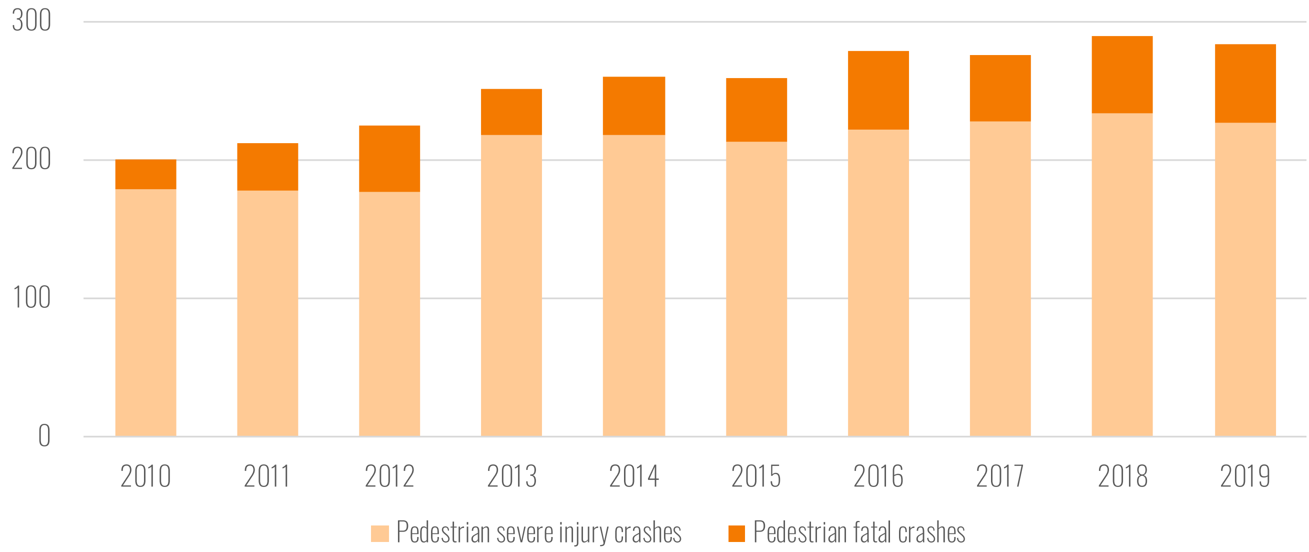


Figure 2: Pedestrian-involved fatal and severe injury crashes, 2010-2019

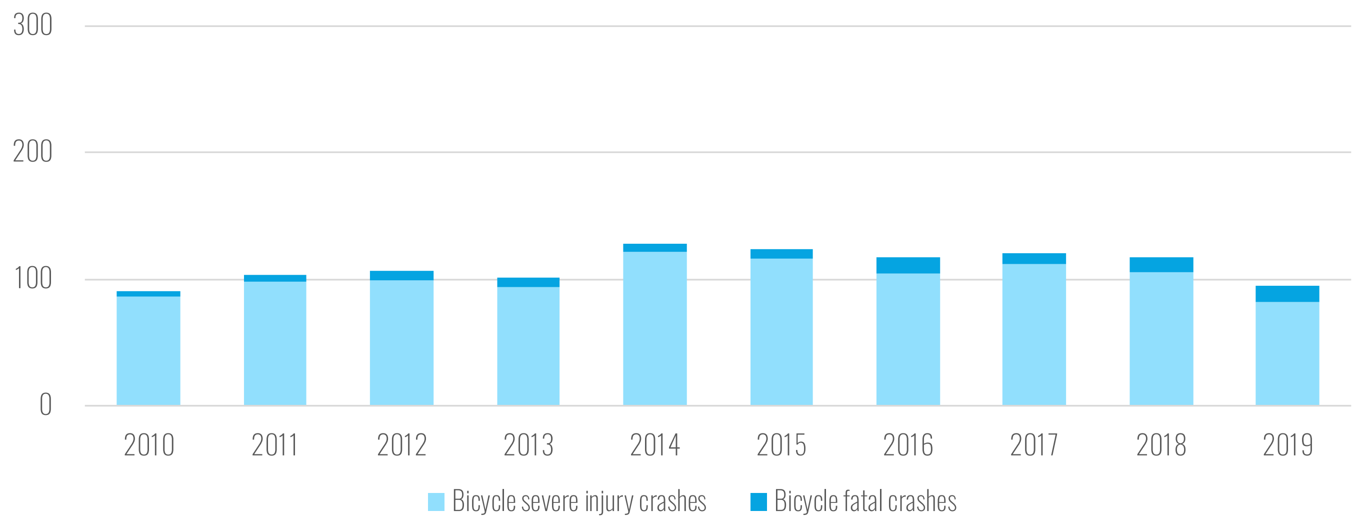


Figure 3: Bicycle-involved fatal and severe injury crashes, 2010-2019

In 2020, the council adopted a Regional Vision Zero goal, which states that any deaths or severe injuries on the region's roadways are unacceptable and preventable. To help council and member government staff better diagnose and address current conditions resulting in death and injury on the region's roadways, the Active Modes Crash Report explores the recent trends and conditions among Denver region travelers using active modes — walking, bicycling and using assistive mobility devices to travel throughout the region.

How the council and its member governments are advancing safety for active mode users.

In 2020, the council adopted Taking Action on Regional Vision Zero, a plan to eliminate traffic fatalities and severe injuries for all modes of transportation. The council's 2050 Metro Vision Regional Transportation Plan includes reducing traffic fatalities and injuries for all modes as a key performance indicator, and the Denver Regional Active Transportation Plan similarly includes reduction of bicycling and walking fatalities and injuries as performance measures.

Within the Denver region, member governments and partners have made similar commitments to improving safety outcomes for active mode users. The City and County of Denver, City of Boulder, City of Brighton and Boulder County have each adopted and taken steps to implement Vision Zero action plans. Jefferson County and the Colorado Department of Transportation's Region 1 (encompassing much of the Denver region) have recently completed comprehensive safety studies to understand site-specific crash conditions for people bicycling and walking.

1.1. Who are active mode users?

Broadly speaking, active mode users encompass all street users outside of motor vehicles and motorcycles — people who are walking and using wheelchairs, people bicycling (or tricycling), scooter users, runners, people waiting for transit, construction crews, or even people sitting and using the street as a public space. Council staff used statewide and regional crash report data to prepare the Active Modes Crash Report, resulting in a broad spectrum of users falling into the active mode user category

Active mode users are sometimes called "vulnerable road users" because active mode users are not protected by vehicle design or crash-protection technology. In contrast, motor vehicles provide a regulated baseline of crash protection to vehicle occupants through the Federal Motor Vehicle Safety Standards and the New Car Assessment Program. Federally administered programs provide little emphasis or guidance on mitigating the effects on active mode road users outside of the vehicle. As such, active mode users are much more susceptible to factors like motor vehicle travel speed, vehicle weight and crash impact location on the body.

People who walk and bicycle also use transit and drive motor vehicles. However, there is a portion of the population that requires active modes to move around, especially children and people with disabilities that make driving impossible. In 2019, 26% of Colorado residents did not have driver's licenses (U.S. Department of Transportation Federal Highway Administration Policy and Governmental Affairs Office of Highway Policy Information Highway Statistics 2019, fhwa.dot.gov/policyinformation/statistics/2019/dl1c.cfm). Statistically, people with higher incomes drive more miles per year and people with lower incomes are more likely to walk or bicycle. Studies have demonstrated that people from low-income households, Black and Indigenous people of color, children and older adults are systemically more likely to be killed or injured while walking or bicycling (Dangerous by Design; smartgrowthamerica.org/dangerous-by-design). Understanding the intersectional impacts of how identity and sociodemographic status influence traffic injury risk is critical to addressing traffic safety effectively and equitably.

1.2. Purpose of the technical report

The Denver Regional Council of Governments Active Modes Crash Report documents recent crash trends for active mode users in the Denver region. The analysis herein is developed using the council's regional crash dataset, developed in collaboration with the Colorado Department of Revenue and Colorado Department of Transportation. In 2019, council staff published Bicycle and Pedestrian Crash Report, 2011-2015, an appendix to the Denver Regional Active Transportation Plan. This report builds upon the 2019 analysis and provides an updated window into the state of safety for active travelers.

In this analysis, council staff, partners and stakeholders seek to understand some key questions:

1) Given the increase in fatalities and injuries among active mode users, what are the most common crash causes and characteristics for people bicycling and walking?

2) What are the primary risk factors that have played a role in traffic fatalities and injuries for reported crashes involving active mode users?

3) What are the demographic and geospatial factors that might amplify risk for pedestrians and bicyclists?

This report is primarily limited to assessing the years 2015 through 2019, for a few reasons. First, when the COVID-19 pandemic began to affect the Denver region in early 2020, traffic movement and travel patterns changed dramatically, making year-to-year comparisons less meaningful. Second, the State of Colorado reformed its crash reporting form in 2020, making it more difficult to conduct apples-to-apples analysis. As such, the report's analysis examines crash trends in the five years prior to the pandemic to offer the most statistically meaningful picture of crash and safety factors.

Third, this report does not dive into specific intersections or street segments. DRCOG staff have previously developed a High-Injury Network and Critical Corridors map through the council's Regional Vision Zero initiative. Instead, the writers of this report used general categories to compare and assess crashes. Using land use context, street network geographic information systems data and Pedestrian and Bicycle Crash Analysis Tool, version 3, crash typing, the report categorizes crashes to draw conclusions about common causes and factors.

Finally, it is expected that some — if not many — active mode crashes are not included in the crash data aggregated by the Colorado Department of Revenue, the Colorado Department of Transportation and the Denver Regional Council of Governments. In many cases, especially those with non-apparent injuries, those involved in a crash may not choose to call first responders and complete a crash report. People involved in the crash may have subsequent injuries or health effects that are meaningful and significant, but which will not be captured in the crash data available for this analysis. As such, this report's analysis should be understood as non-exhaustive related to crash trends involving active mode users.

1.3. What kinds of factors influence safety for people walking, bicycling and rolling?

This report analyzes the factors that influence both the likelihood of active mode-involved crashes, and the severity of such crashes, so staff and stakeholders may ultimately understand where people walking and bicycling encounter the most risk and the factors that amplify risk during crashes. Active mode crashes may be affected or amplified by the following contextual and user factors:

1.3.1. Area type

To reflect the Denver region's diversity of land use contexts, roadway networks and travel characteristics, council staff developed four area types for the Taking Action on Regional Vision Zero plan:

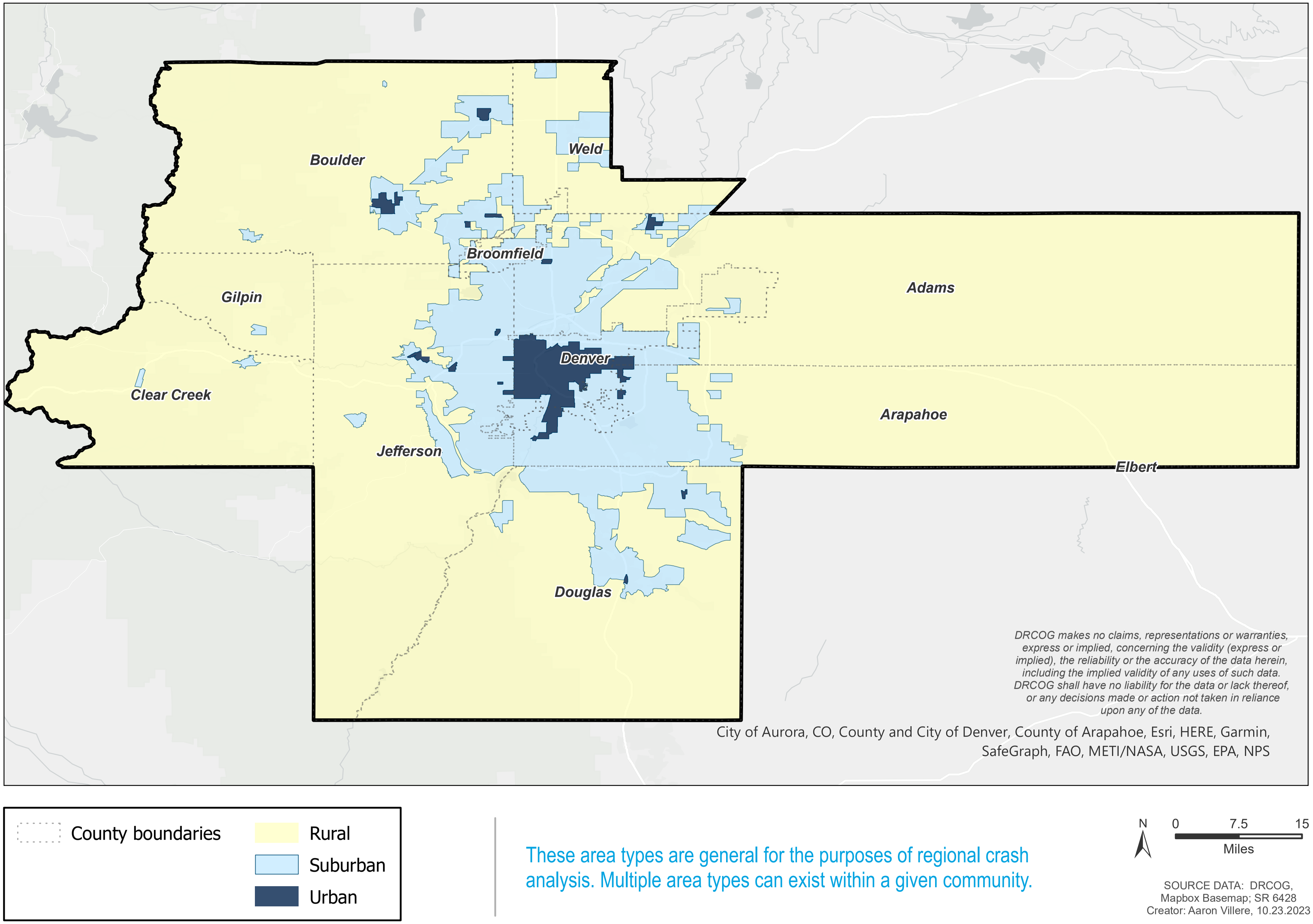
- **Urban**, where residential and commercial activities are most concentrated. The street networks are more dense and oriented toward destination access, with highest volumes of multimodal travel. Urban area types are primarily located in central Denver and Boulder, as well as in downtown Golden, Longmont, Brighton and similar small city centers.

- **Suburban/compact communities**, where land use is primarily residential, with lighter or big box commercial activity centers. The suburban/compact communities area type includes Denver and Boulder's outlying neighborhoods, as well as suburban communities such as Aurora, Lakewood, Westminster and Castle Rock. Additionally, small mountain communities like Evergreen are included in the suburban/compact communities area type. Active mode travel is less concentrated than in the urban area type, but people use active modes both for commute and local trip purposes.

- **Rural**, the least dense and undeveloped portions of the region, include both the Eastern Plains and Front Range mountainous areas. Trips generally cover longer distances and roadways generally prioritize through movement over destination access. Active mode travel includes a greater proportion of recreational trips, such as bicycle touring.

- This report excludes **limited-access highways** as a distinct spatial unit of analysis, as active mode use is prohibited on such facilities. However, active mode crashes on limited-access highways are not excluded from analysis — they are simply grouped with their encompassing area type.

Map 1: Area types within the DRCOG region



These area types are general for the purposes of regional crash analysis. Multiple area types can exist within a given community.

Map 1: Area types within the Denver region

Because travel purposes, mode shares and roadway designs vary so much by area type, in the sections to follow, report authors have divided analysis into these three area types. As illustrated in Table 1, active mode crashes — especially those involving death or severe injury — are more concentrated to the Urban area type, as that is where walking and bicycling is most concentrated in the region. This report seeks to illuminate what the specific risk factors are by area type and the most common crash characteristics in each context.

Table 1: Fatal and severe injury crashes by area type

Context	Active mode fatal and severe injury crashes	Population (2019)	Area	Population per square mile	Fatal and severe injury crash rate/10,000 population
Urban	768	478,086	72 square miles	6,690	8.7
Suburban	1,075	2,131,821	767 square miles	2,781	2.7
Rural	108	196,154	4,450 square miles	44	1.8

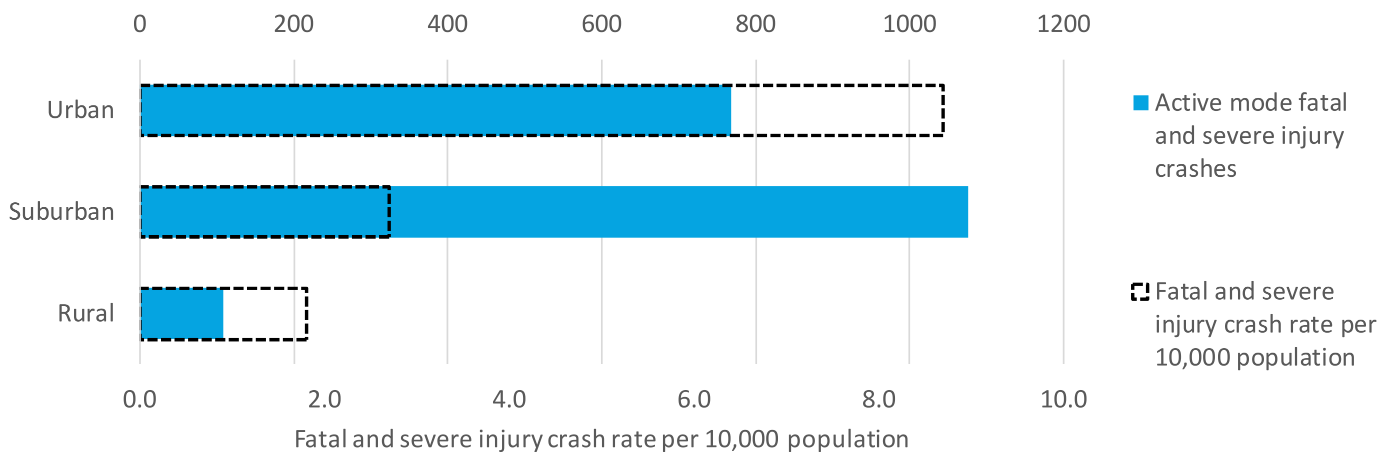


Figure 4: Active mode fatal and severe injury crashes and crash rates by area type

1.3.2. Vehicle size

Motor vehicle height and weight amplify crash severity, both through increased force during crashes and increasing likelihood that active mode users are hit in the torso rather than the lower body. One issue that planners and policymakers are grappling with is the increasing size and weight of motor vehicles. In the state of Colorado, the 10 most registered vehicles include four models of pickup trucks and six models of sport utility vehicles ("Colorado drivers pick these 10 vehicles more than all the others," 9News, May 4, 2023; 9news.com/article/news/local/top-10-most-popular-vehicles-colorado-2022/73-c7a52811-e395-4cae-844b-1446988e6e04).

Additionally, as electric vehicles proliferate, gross vehicle weight is expected to continue to increase with new battery weight. Because of limited information available in crash report data, this report only broadly documents vehicle type.

1.3.3. Vehicle speed

Speed amplifies risk and severity, reducing the ability to react and increasing the physical force of crashes. This report uses functional classification and posted speed to understand the relationship between motor vehicle speed and crash outcomes, included in modal analysis in sections 3 and 4.

1.3.4. Sociodemographic factors

Select demographic and geospatial factors amplify vulnerability to death and injury during crashes. This report itemizes and explores how things like body type and sociodemographic factors are correlated with active mode user risk in the region in Section 5.

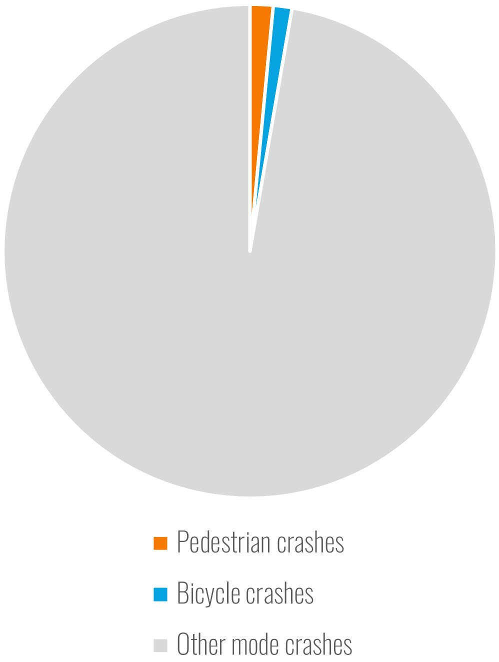
2 Active modes crashes, 2015-2019

Between 2015 and 2019, crashes involving people bicycling and walking represented 3% of all crashes, but 21% of crashes resulting in death or severe injury.

2.1. 2015-2019 crash statistics

In the Denver region between 2015 and 2019, 1,387 people were killed or severely injured while walking, and 574 people were killed or severely injured while riding a bicycle. From 2015-2019, pedestrian- and bicycle-involved crashes made up just 3% of all crashes, but 22% of crashes where a person was killed or severely injured, and 26% of crashes involving a fatality.

All crashes, 2015-2019



Fatal and severe injury crashes, 2015-2019

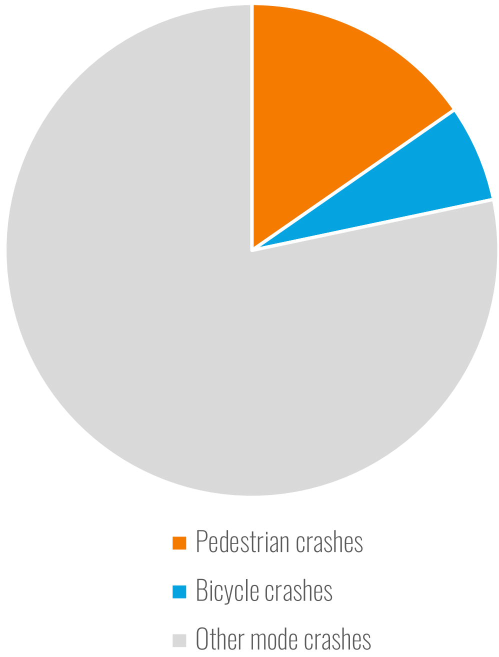


Figure 5: Comparison of all crashes and crashes resulting in fatality or severe injury, 2015-2019

The disparity between injuries and fatalties among all crashes and crashes involving active modes underscores the heightened risk of people walking and bicycling in crashes. While being involved in a comparatively low percentage of crashes, people using active modes are far more likely to be involved in crashes causing severe injury.

Between 2015 and 2019, while crashes, traffic deaths and injuries have generally increased, the region's population grew 6%, and annual vehicle miles traveled increased 4%. Pedestrian- and motor vehicle-involved fatal and severe injury crashes increased 9 and 13%, respectively, both outpacing the growth in population and vehicle miles traveled, while bicycle-involved fatal and severe injury crashes actually decreased by 21% over the five-year period.

Even adjusted for population and annual vehicle miles traveled, pedestrian-involved crashes continued to increase during the study period, while bicycle-involved fatal and severe injury crashes fell year after year.

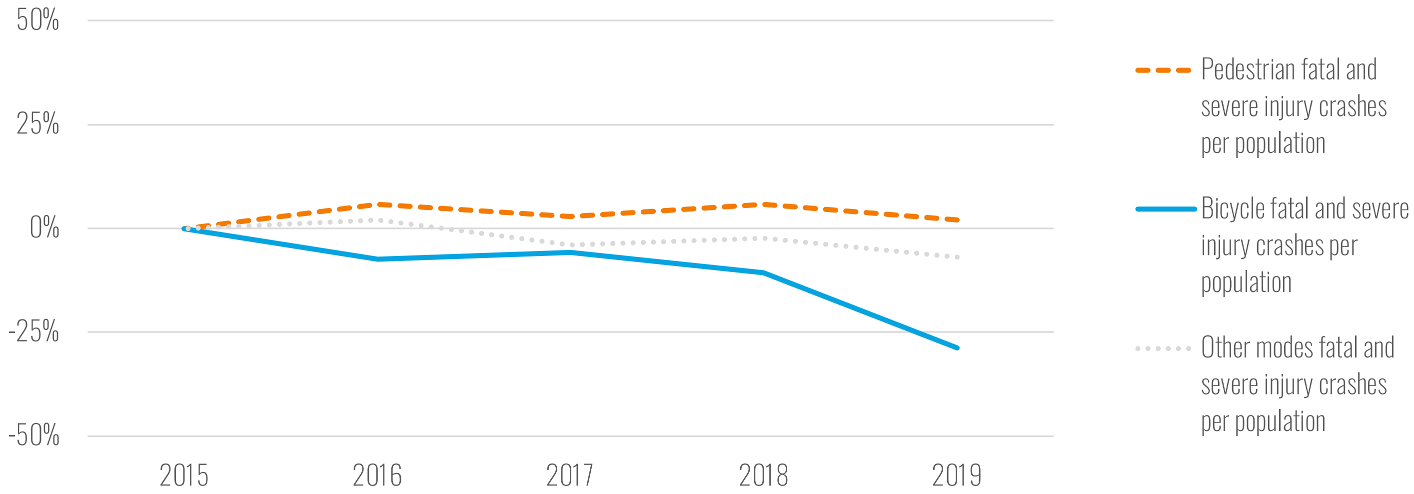


Figure 6: Change in fatal and severe injury crash rate per capita, 2015-2019

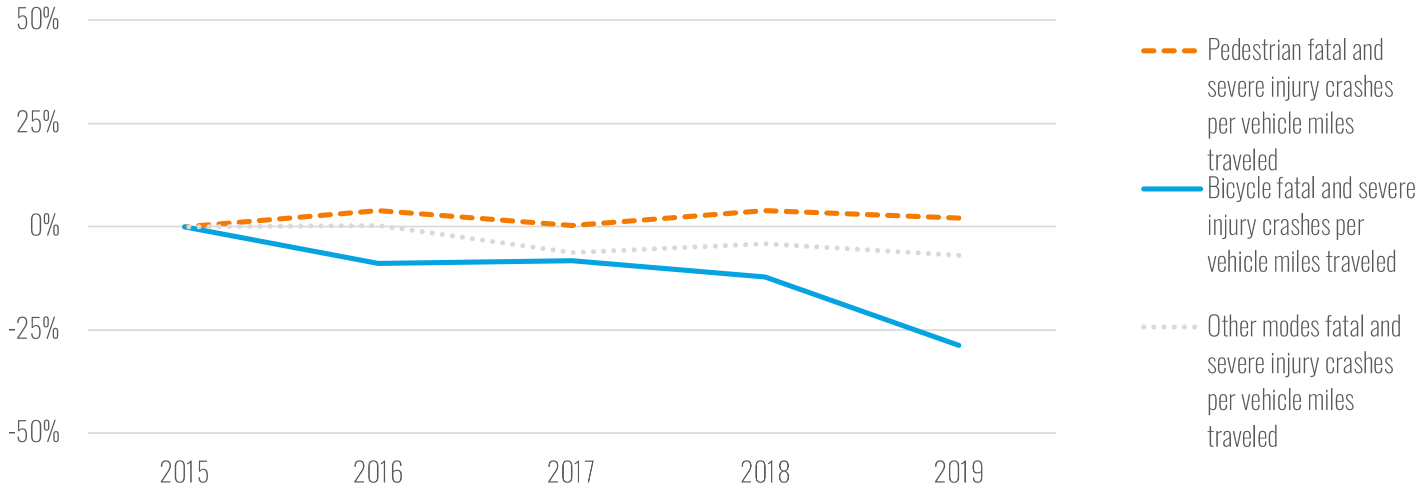


Figure 7: Change in fatal and severe injury crash rate per vehicle miles traveled, 2015-2019

Many factors influence trends among fatal and serious injury crashes involving active mode users, some of which were mentioned in Section 1, and others that are explored elsewhere in this report. However, given the widespread investment across the region in bicycling infrastructure, the proliferation of shared micromobility options such as e-bikes and scooters, and the expansion of bicycling access programs, there is no evidence that bicycling activity has decreased to explain decreasing crash rates. Indeed there were 3.8 million micromobility trips in the City and County of Denver alone in 2021 compared with 1.6 million in 2019, and a 33% increase in bicycle trips logged in Strava — an active transportation activity-tracking app — across the region between the two years.

In the remainder of this report, analysis covers 2015-2019 to better control for outlier conditions during the COVID-19 pandemic (beginning in 2020).

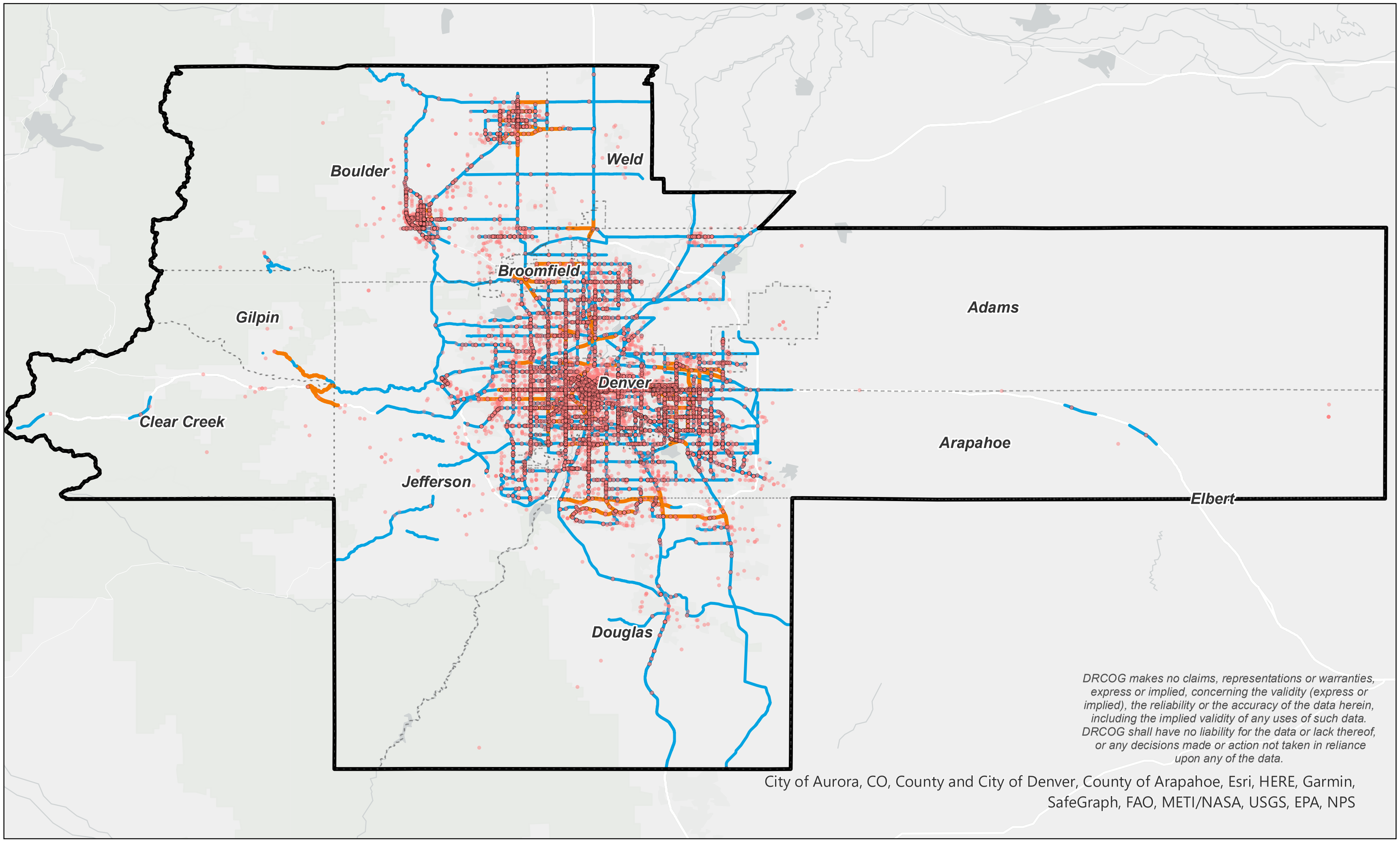
2.2. Comparing bicycle and pedestrian crashes with the High Injury Network

In Taking Action on Regional Vision Zero, Denver Regional Council of Governments staff and stakeholders created a High Injury Network of the region's roadways. The network encompasses 9% of the roadways by centerline miles where 75% of fatal and severe injury crashes occur. When looking solely at active mode crashes, these same roadways encompass a similarly high proportion of fatal and severe injury crashes involving people walking and bicycling. Between 2015 and 2019, 74% of active modes fatal and severe injury crashes (and 67% of all crashes involving active mode users) fell on streets in the region's High Injury Network (using a 50-foot buffer around streets identified as High Injury Network or Critical Corridors). As such, streets and roads that are high-risk for people using active transportation are comparably high risk for people driving motor vehicles.

As mentioned in Section 1, this report does not review specific corridors or sites within the region for crash characteristics — many of these streets have common characteristics, such as having high posted speeds (exceeding 30 miles per hour, the speed at which injury risk dramatically increases for active mode users) or multiple travel lanes. As such, this report assesses common crash causes by roadway and intersection type found within the High Injury Network to understand the contexts throughout the region where risk increases for people walking and bicycling and to set the stage for predictive safety analysis.

In Section 3, the report explores the social and demographic factors that intersect with traffic safety to understand the undue burdens borne by historically marginalized groups. Section 4 explores crash trends and common characteristics among crashes involving people walking, while Section 5 discusses trends among people bicycling. Finally, Section 6 explores seasonal variations in crash activities to understand how environment influences risk, while Section 7 discusses some of the limitations regarding pandemic-era crash data and Section 8 details the methodology of this analysis.

Map 2: Active modes crashes and the regional High Injury Network



Active Mode Crashes (HIN)
- Active Mode Crashes (HIN)

Active Mode Crashes (non-HIN)
- Active Mode Crashes (non-HIN)

Regional High Injury Network
- High Injury Network
- Critical Corridors

74% of fatal and severe injury crashes involving active mode users (and 64% of all active mode-involved crashes) occurred on the region's High Injury Network.

N 0 7.5 15 Miles

SOURCE DATA: DRCOG, Mapbox Basemap; SR 6428
Creator: Aaron Villere, 10.23.2023

Map 2: Active modes crashes and the regional High Injury Network

3 Social and demographic factors influencing safety

Across the U.S. and throughout the Denver region, people in historically marginalized communities are more likely to be affected by traffic violence, and the disparity is acutely illustrated among active transportation fatalities and injuries. Understanding how factors such as age, gender and sex, socioeconomic status and access to a multimodal transportation system is critical to understanding the factors that exacerbate risk for active mode users.

3.1. Sex designation

Consistent with national trends, men are more likely to be represented among people involved in crashes than women in the Denver region. From 2015-2019, men represented 62% of those involved in pedestrian crashes and 67% of those in fatal and severe injury crashes. This is slightly more than in the five years prior, during which men represented 65% of fatal and severe injury crashes involving pedestrians.

Even more pronounced, men represent 78% of participants in bicycle crashes and 77% of those involved in fatal and severe injury crashes. In the five years prior (2011-2015) to this report's analysis period, 73% of people involved in fatal and severe injury crashes were men, reflecting a small increase in proportion in the more recent study period.

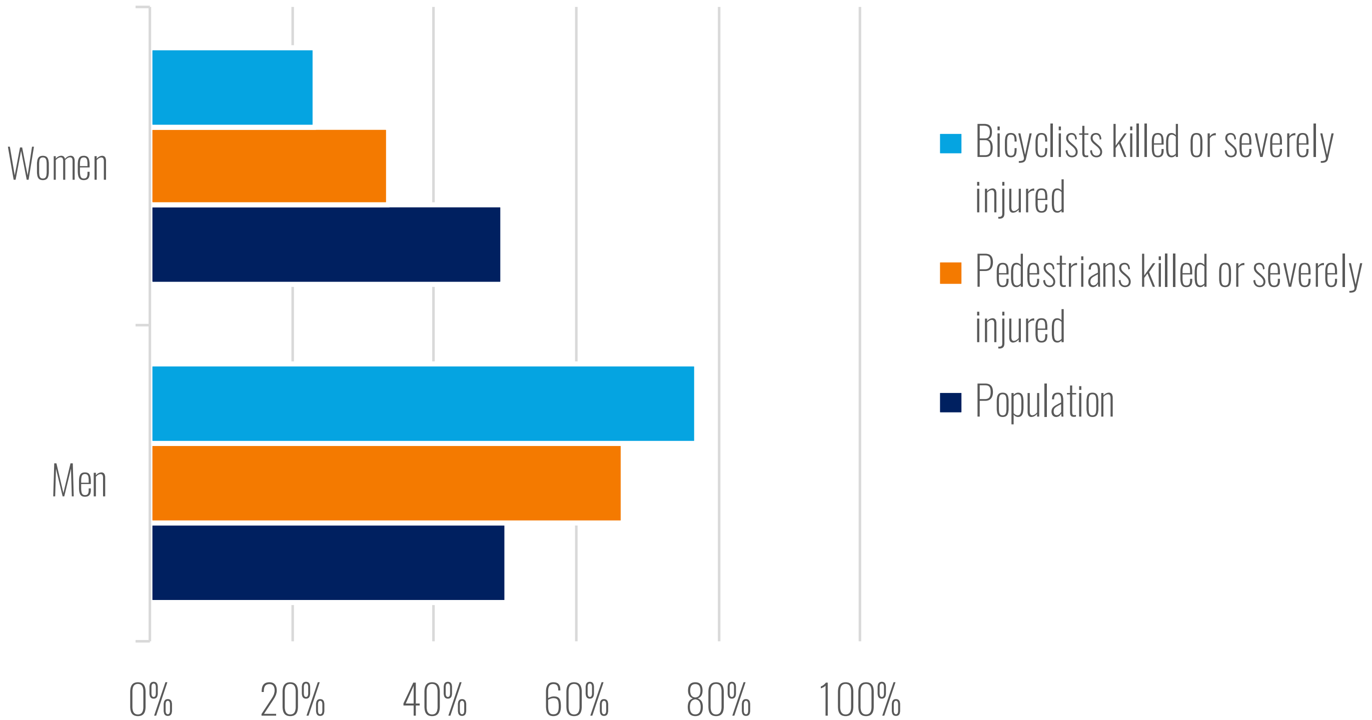


Figure 8: Sex designation of people involved in fatal and severe injury crashes relative to population

There may not be enough information to explain the disparity, but there is instructive research into the topic, especially related to people bicycling.

First, there is disparity in identified sex among people who bike — men make up a larger percentage of bicyclists on the roadway, with research estimating that men comprise roughly 70% of people bicycling in the U.S. ("Cycling behaviour in 17 countries across six continents: levels of cycling, who cycles, for what purpose, and how far?" Taylor & Francis Online, May 9, 2021; tandfonline.com/doi/full/10.1080/01441647.2021.1915898). Survey-based research has revealed that women may avoid bicycling due to travel needs (such as making a larger share of chained trips) and concerns about personal safety. A diary-based study in the U.K. found that women reported experiencing 50% more near misses, or interactions with motor vehicles while bicycling that induce stress and discomfort and may discourage people from continuing to cycle for transportation ("Cycling Near Misses: Findings from Year One of the Near Miss Project", Rachel Aldred, 2015; rachelaldred.org/wp-content/uploads/2019/03/Nearmissreport-final-web.pdf). This gender disparity in bicycling participation may, in part, explain why men are overrepresented in bicycling crashes.

While advancements in bicycling infrastructure throughout the Denver region, as well as policy and encouragement tools like the City and County of Denver's e-bike rebate program, have sought to expand access, inclusivity and comfort of cycling to a more diverse population, future research into active mode crashes should assess whether this gender disparity evolves in coming years and explore the factors contributing to it.

3.2. Age

Because of their physiology, children and older adults are more likely to be killed or severely injured in crashes. Active mode users older than 80 are more than twice as likely as people in their 20s to be killed or severely injured during a crash. Related to active mode crashes in the Denver region, the risk of death or injury increased with age between 2015 and 2019, as did the risk for the youngest group of children (younger than 5).

Further analysis of active mode fatal and severe injury crashes by age demonstrates that street users age 15-34 and 50-59 were the most overrepresented among crash participants. People age 25-29 make up 8% of the region's population, but represent 13% of those involved in both bicycling and walking crashes.

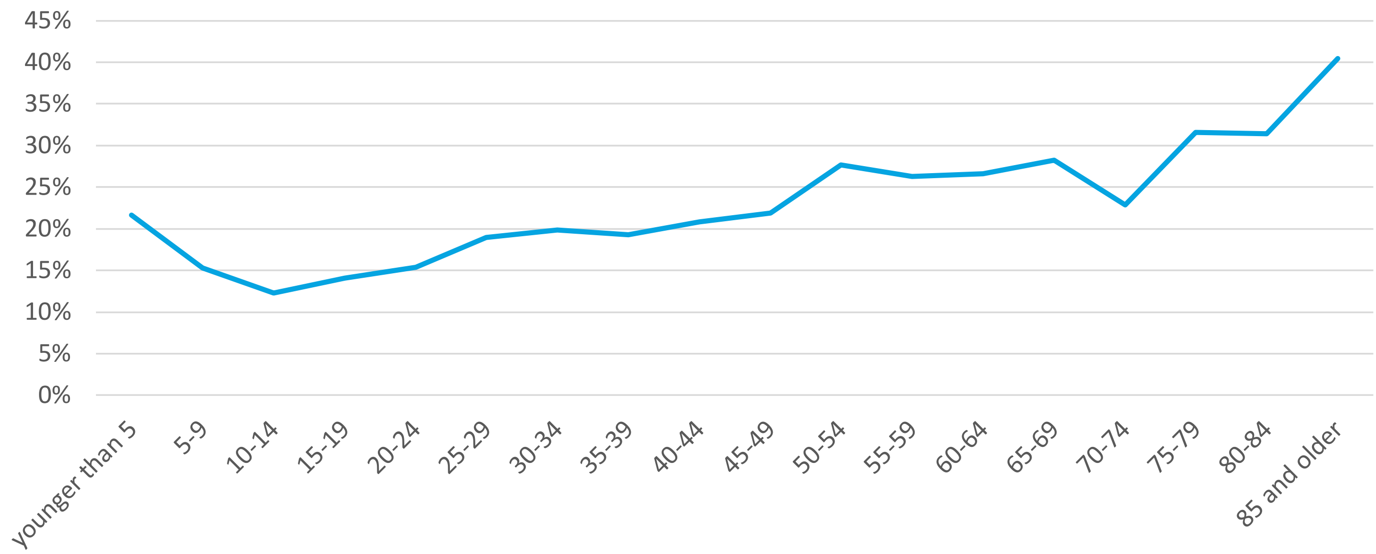


Figure 9: Percent of active mode crashes resulting in fatality or severe injury by age

When broken down by age and gender identity, the disparities become extremely pronounced:

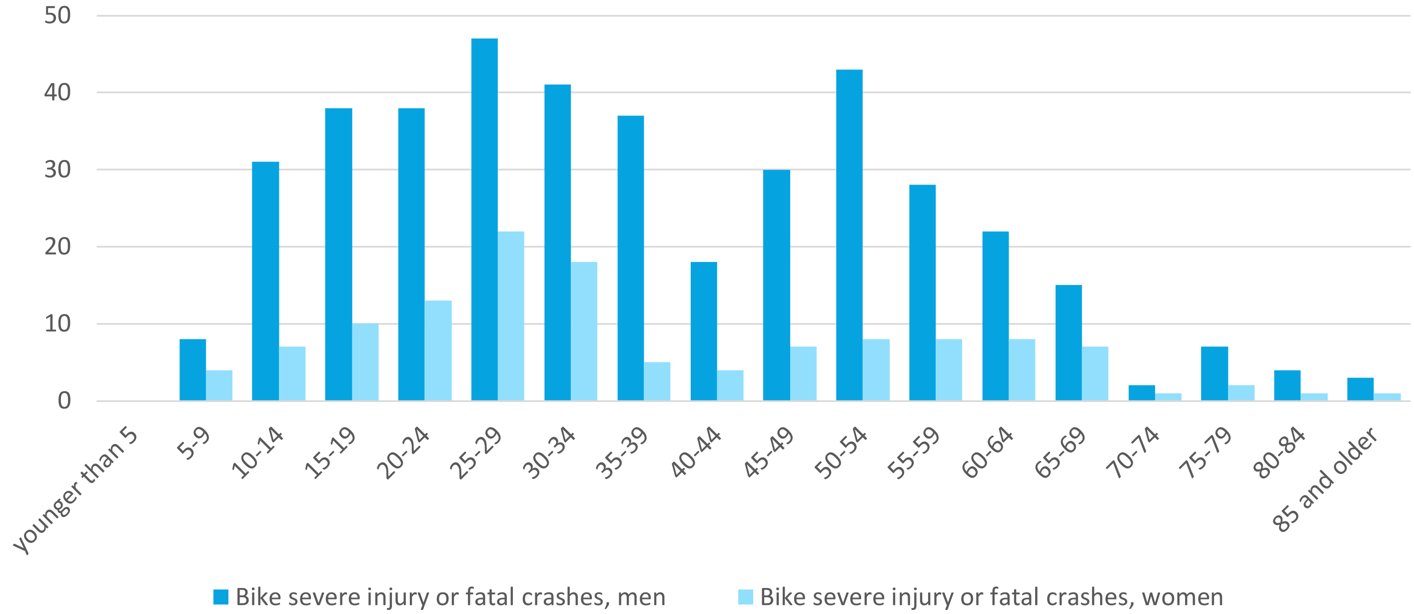


Figure 10: Bicycle-involved fatal and severe injury crashes by age and sex

At every age cohort, men are involved in a greater number of bicycle crashes throughout the region, representing between 67% and 88% of those in fatal and severe injury crashes. Men between 35 and 39 are more than seven times more likely than women of the same age to be involved in a fatal or severe injury bicycle crash.

Men are overrepresented among pedestrian-involved fatal and severe injury crashes too, especially those aged 20 to 34 and 50 to 59, though the disparity is less pronounced than with bicycling.

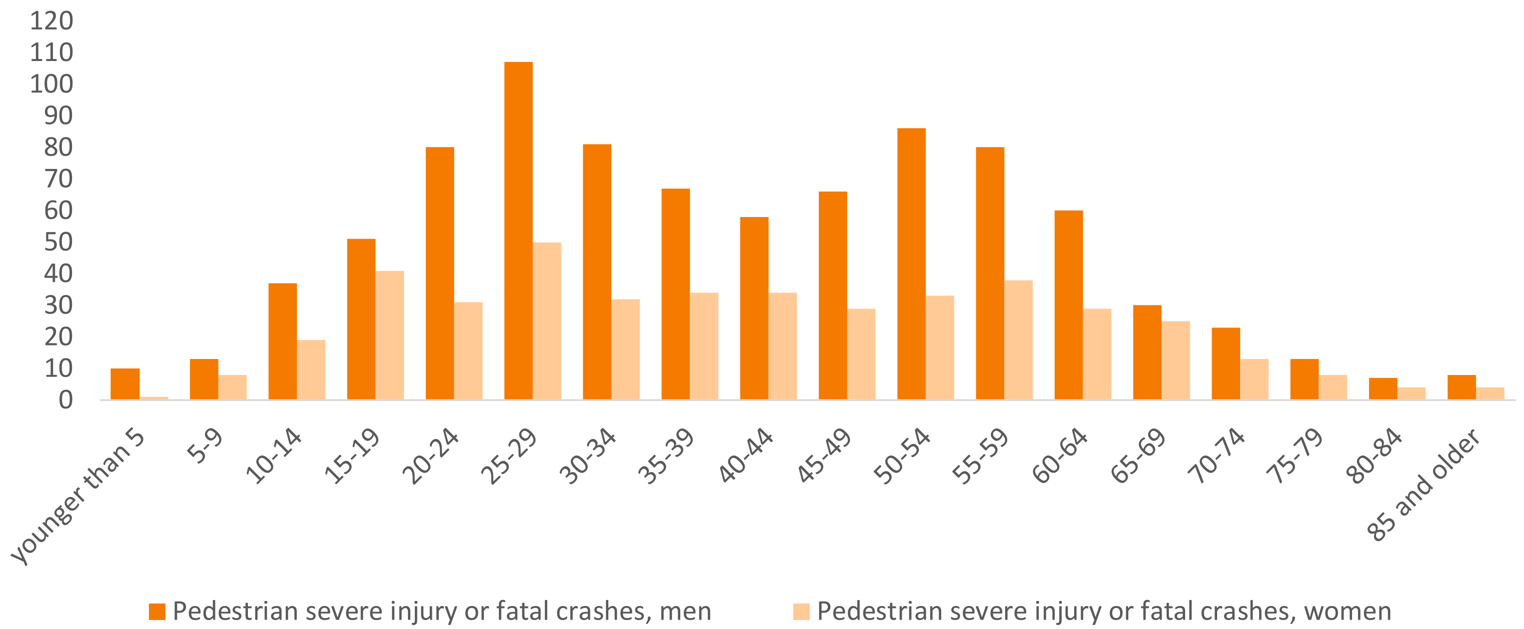


Figure 11: Pedestrian-involved fatal and severe injury crashes by age and sex

3.3. Sociodemographic factors

The Justice40 Initiative, created by the Biden-Harris administration, has developed tools to explore the relationship between socioeconomic and geospatial factors such as environmental and climate risk, transportation cost, public health indicators and transportation policy and investment. Using the Equitable Transportation Community Explorer, developed by U.S. Department of Transportation, report authors assessed whether communities across the region have experienced disproportionate risk to active transportation death or injury based on these socio-economic factors. The Equitable Transportation Community Explorer provides normalized scoring by Census tract of a series of six measures, which enables geospatial analysis of the risk of active modes crashes. Table 2 breaks down the differences between the highest- and lowest-scoring quintile tracts throughout the region (highest-scoring being those tracts that have faced the most historic marginalization or disadvantage) by measure area and the correlating difference in fatal and severe injury crash rates.

Table 2: Pedestrian and bicycle fatal and severe injury crash rates by Equitable Transportation Community Explorer Indicator, comparing highest- and lowest-scoring census tracts

	Pedestrian fatal and severe injury crash rate			Bike fatal and severe injury crash rate		
	Top quintile	Bottom quintile	Risk difference	Top quintile	Bottom quintile	Risk difference
Transportation access	1.8	6.5	27%	1.0	2.5	39%
Transportation cost burden	8.5	1.5	549%	2.6	1.3	199%
Health vulnerability	6.1	3.4	178%	1.7	1.8	91%
Hazard vulnerability	6.7	2.1	313%	1.6	1.6	103%
Environmental burden	8.5	1.2	230%	3.2	0.8	397%
Social vulnerability	8.5	1.4	604%	2.5	0.7	375%

Social vulnerability

The Equitable Transportation Community Explorer's Social Vulnerability measure showed by far the most powerful difference in fatal and severe injury crash risk between the highest and lowest quintile tracts throughout the region. The social vulnerability measure uses indicators such as percent of households below 200% of the poverty threshold, population with less than a high school diploma, unemployment, renter-occupied housing rates, high proportions of either older adults or children, housing cost burden and people with disabilities. The social vulnerability measure does not use race or ethnicity as indicators, though race and ethnicity correlate with the indicators chosen.

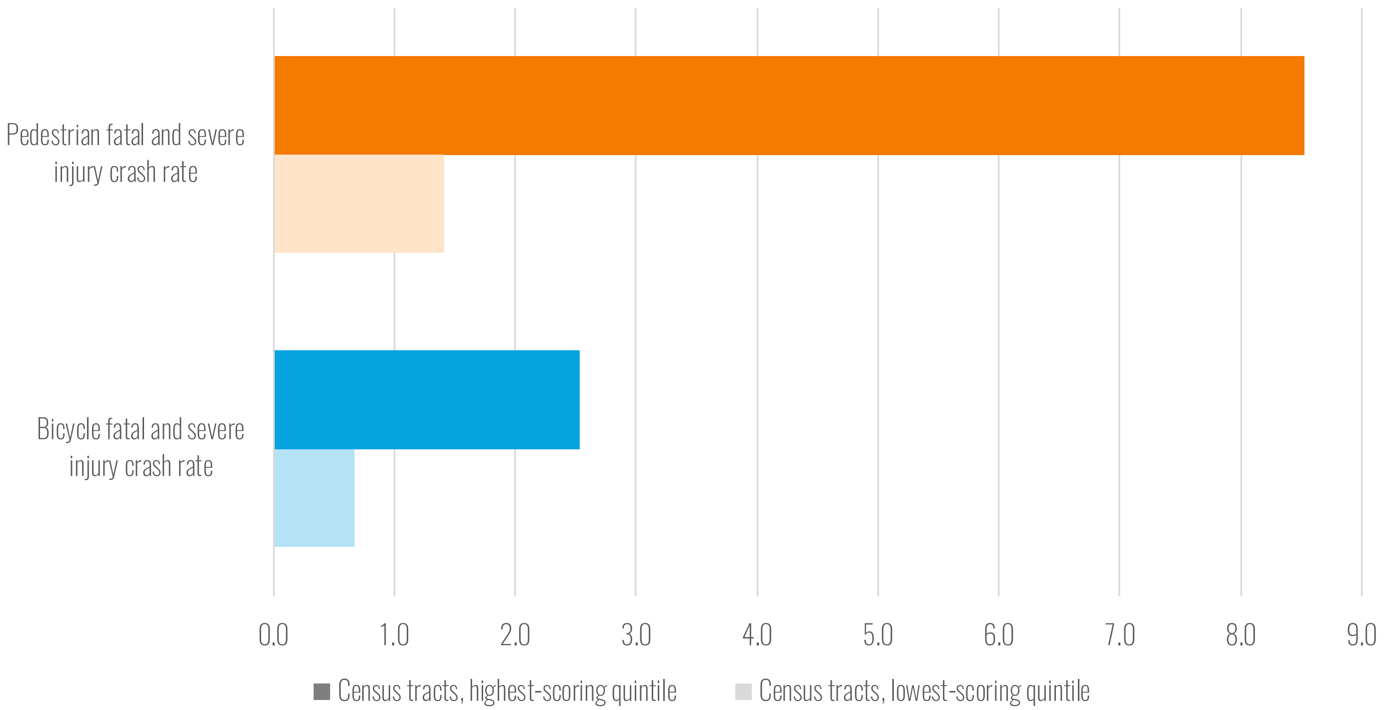


Figure 12: Fatal and severe injury crash risk by Social Vulnerability measure

The rate of pedestrian-involved fatal and severe injury crashes in the top quintile-scoring tracts for the social vulnerability indicator was more than six times higher than the bottom quintile; that is, where residents are measured to be more socially vulnerable, or more economically stressed, there is a sharp coinciding increase to traffic injury risk. Similarly for bicycle-involved crashes, fatal and severe injury collisions were 3.75 times as likely in the top quintile as bottom. People in socially vulnerable areas of the Denver region are at greater risk of traffic violence than the more socially advantaged areas of the region.

Transportation cost burden

Similar to social vulnerability, the Equitable Transportation Community Explorer's calculated cost burden of transportation exhibited a strong relationship between cost burden and transportation injury or fatality risk for active mode users. Tracts where residents spend the most on transportation as a percentage of their income are also the tracts with the greatest rates of pedestrian and bicycle-involved fatal and severe injury crashes.

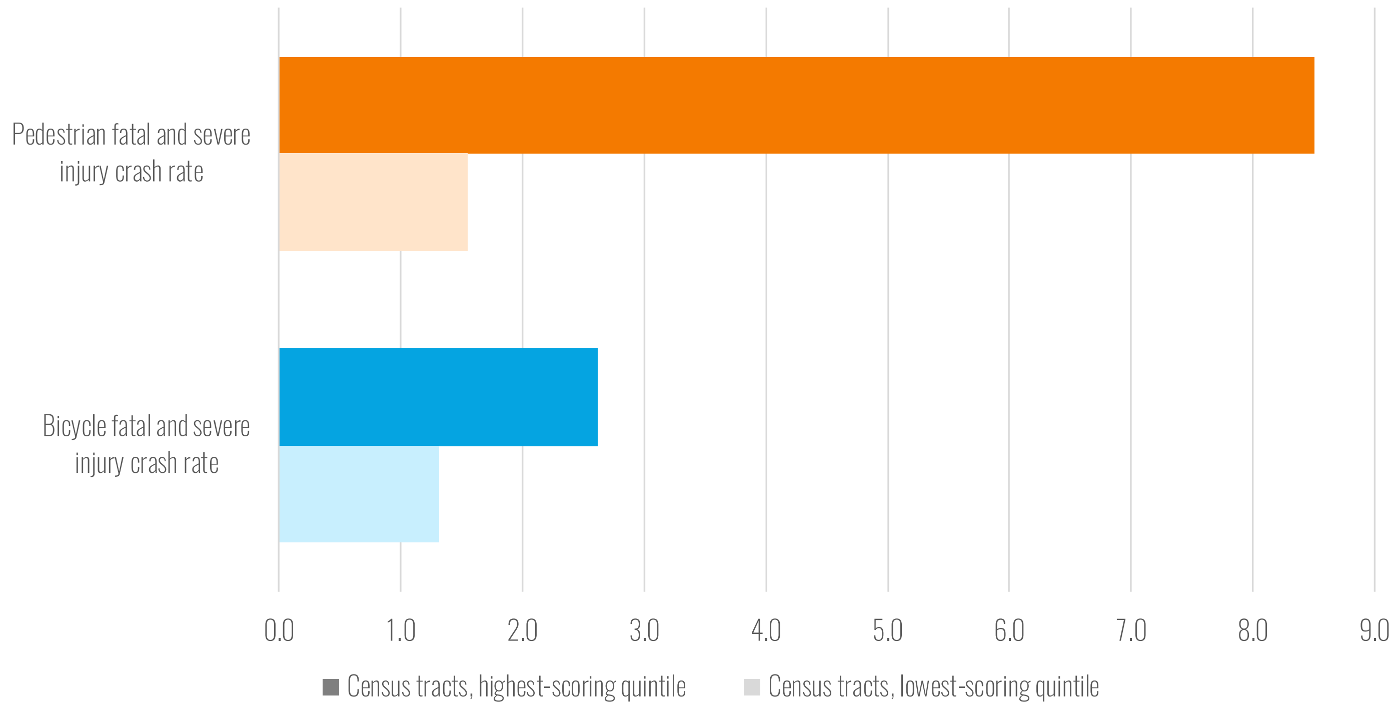


Figure 13: Fatal and severe injury crash risk by transportation cost burden measure

In part, the analysis reveals some collinearity between the social vulnerability and transportation cost burden measures. Because transportation cost burden is a calculated percentage of households' average expenditures for vehicle ownership, vehicle maintenance and transit fares, households with lower incomes and higher proportions of the nonworking population can be expected to spend a higher share of their household incomes on mobility as well.

Environmental burden

Finally, the third-strongest relationship was observed by the environmental burden measure, which accounts for factors such as air quality and pollution, proximity to environmentally hazardous sites, and proximity to high-intensity transportation facilities such as airports, railroads and high-volume roads.

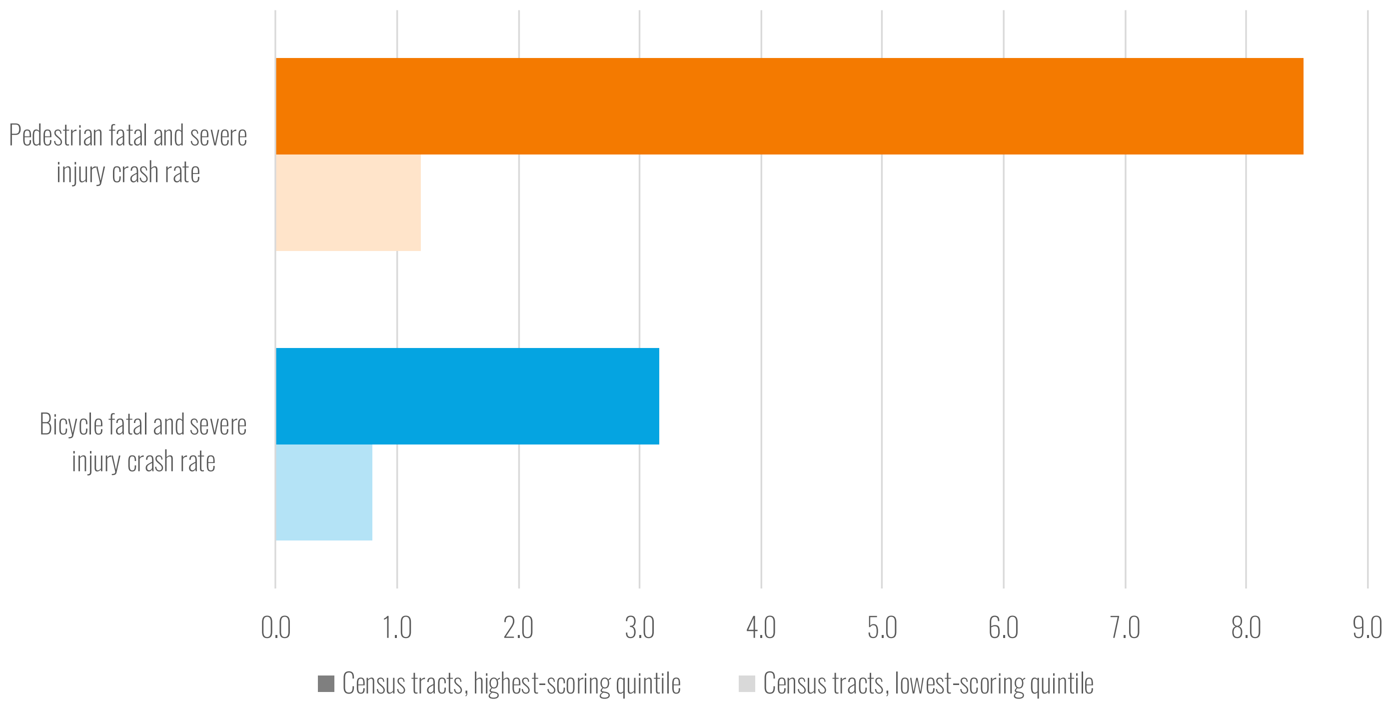


Figure 14: Fatal and severe injury crash risk by environmental burden measure

Health and Hazard Vulnerability, and Transportation Access

The Equitable Transportation Community Explorer includes two other component scores and one additional sub-component score. The two remaining component scores, hazard vulnerability and health vulnerability, showed little correlation with active mode crashes, while the transportation access subcomponent showed relatively strong negative correlation.

Hazard vulnerability itemizes risk for climate hazards, including excessively hot or precipitous weather, and impervious surface, while health vulnerability tracks chronic health conditions such as asthma, cancer, diabetes, high blood pressure and mental illness. These are factors that interrelate with transportation infrastructure and access, along with other sociodemographic factors. However, as illustrated in Table 15, these measures showed less powerful relationships with fatal and severe injury crash risk for active mode users.

Conversely, transportation access measures proximity and ease of reach to destinations, as well as provision of multimodal options by tract. This measure showed negative correlation with bicycle and pedestrian crashes — that is, those tracts with the least access to walkable street networks, dense destinations and frequent transit (such as the highest scoring) also represented fewer active mode fatal and severe injury crashes during the study period. This is almost certainly due to reduced active mode travel, as fewer people are likely to walk or bicycle where destinations are difficult to access by those modes.

3.4. Operator factors

In addition to the design and geospatial factors that influence crash incidence and severity, some operator factors may cause or amplify active modes crashes. These factors are itemized in the subsections that follow; however, because of limitations with crash data, it is difficult to differentiate in some cases which user (active mode user versus motor vehicle driver) the human-contributing factor applies to. These represent broad findings that merit further investigation.

3.4.1. Drugs or alcohol suspected

Vehicle operation while under the influence of alcohol or drugs amplifies crash risk for all road users, reducing judgment and reaction time, and making travel significantly more dangerous. In the Denver region, based on crash data between 2015 and 2019, more than one in five pedestrian-involved fatal and severe injury crashes included suspected use of alcohol or drugs by at least one party, while 7% of bicycle-involved fatal and severe injury crashes had suspected substance usage.

Table 3: Percentage of fatal and severe injury rashes for which alcohol was suspected by responding officer

Crash type	Pedestrian-involved	Bicycle-involved	All other modes
Alcohol suspected, all crashes	11%	3%	4%
Alcohol suspected, fatal and severe injury crashes	20%	6%	17%

Table 4: Percentage of fatal and severe injury crashes for which drugs were suspected by responding officer

Crash type	Pedestrian-involved	Bicycle-involved	All other modes
Drugs suspected, all crashes	2%	1%	1%
Drugs suspected, fatal and severe injury crashes	4%	2%	6%

Table 5: Pedestrian fatal and severe injury crashes for which drugs or alcohol were suspected by lighting conditions

Area type	Daylight	Dawn/dusk	Dark, lighted	Dark, unlighted
Denver region (total)	47	10	225	53
Urban	15%	3%	77%	5%
Suburban	14%	3%	63%	20%
Rural	8%	-	8%	85%

While time of day and lighting conditions influence visibility and subsequent reaction times for travelers, time of day specifically correlated with increased crash risk where drugs or alcohol were suspected. Lighting conditions did not show a strong correlation with substance-involved pedestrian crash incidence. Crashes were more likely to happen at night, but lighting conditions correlated primarily with area type, as urban areas are more likely to have street lighting while rural areas are less likely.

3.4.2. Human-contributing factors

In some cases, crash reports include details about suspected human-contributing factors, or actions by involved parties that may have resulted in a crash. Table 6 itemizes reported human factors that may have contributed to a crash. In most cases, the crash report does not list human-contributing factors. However, when reported, the most common contributing factors include operator distraction, driver inexperience or aggressive driving behavior.

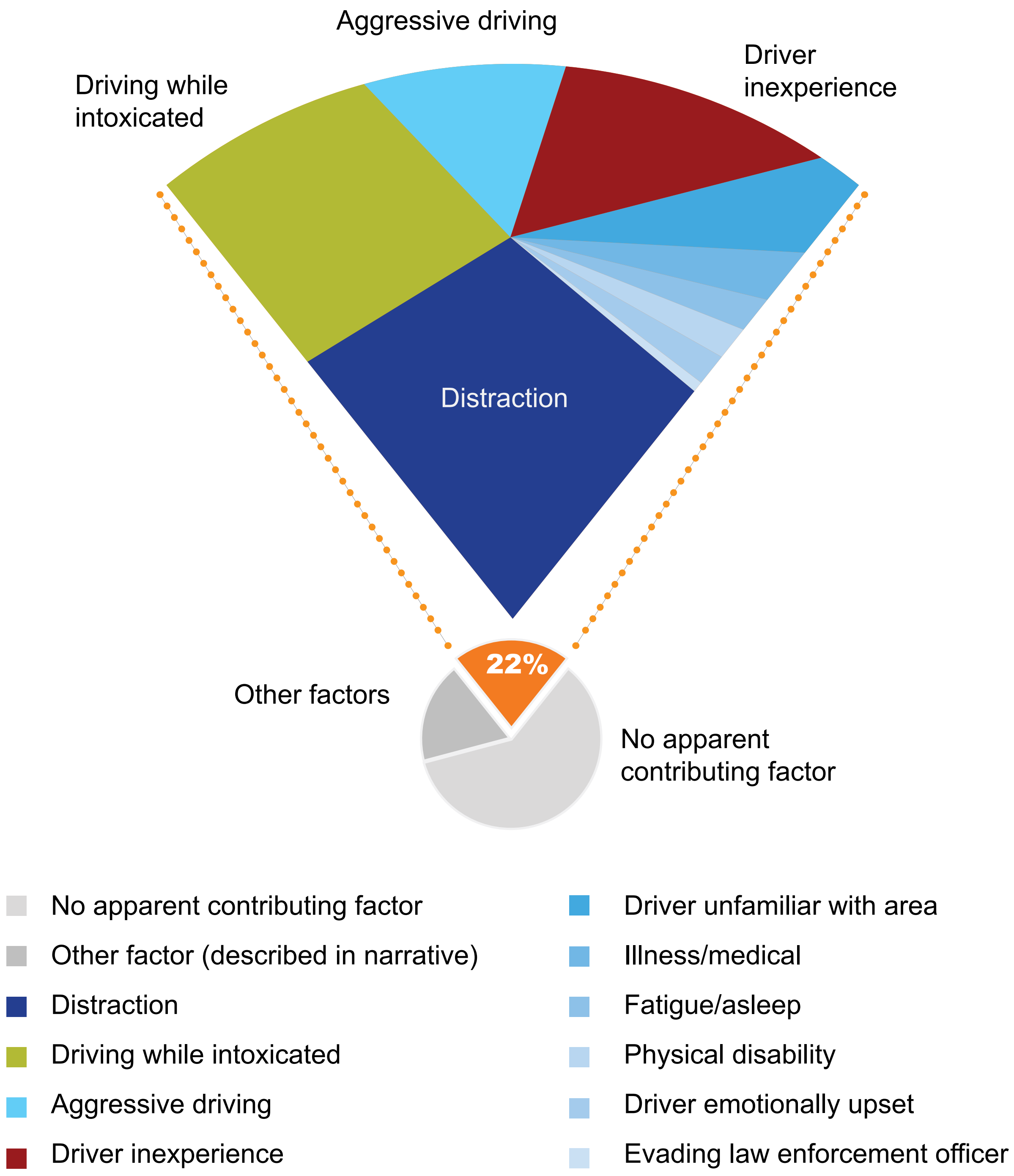


Figure 15: Human-contributing factors, pedestrian fatal and severe injury crashes

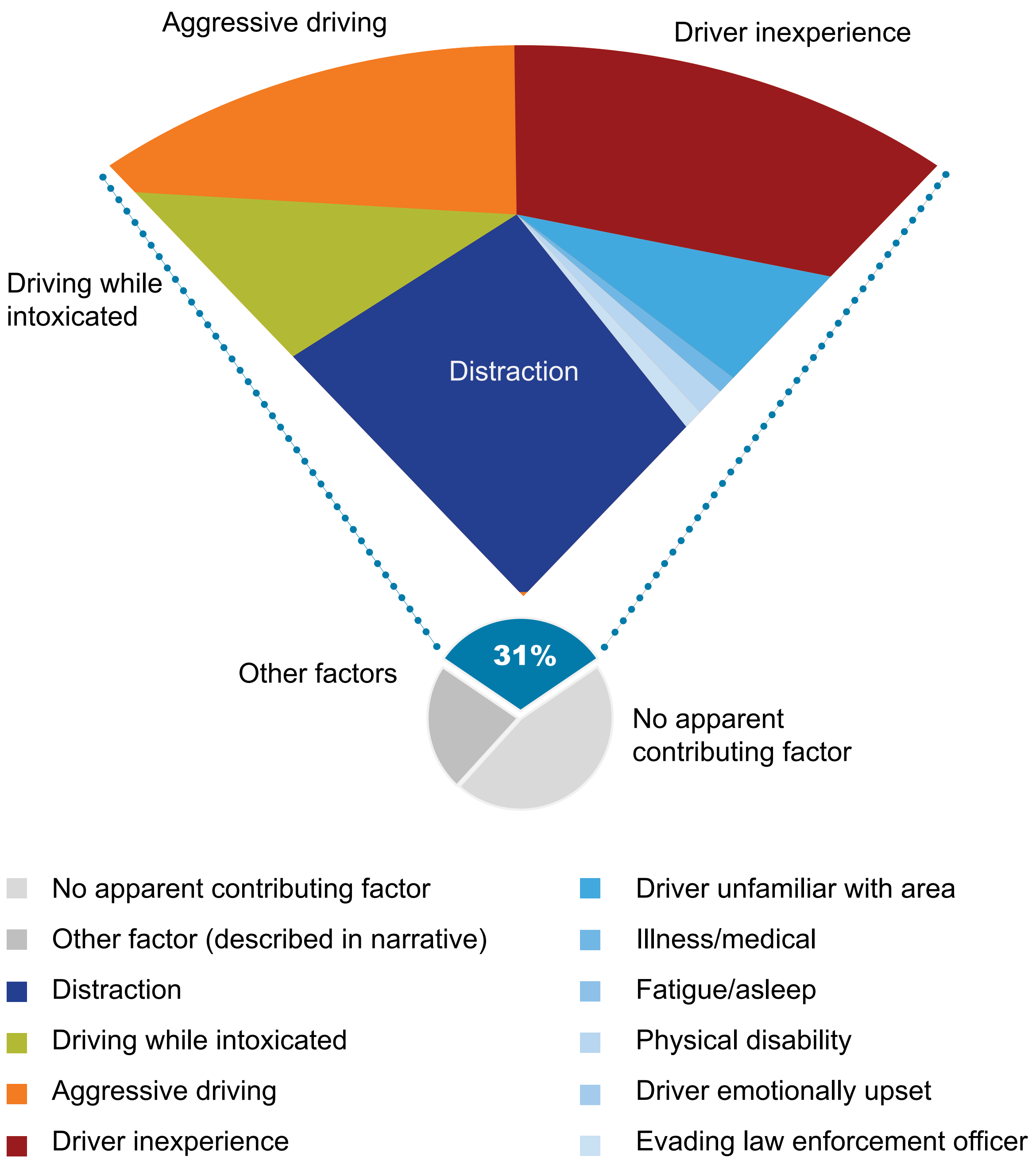


Figure 16: Human-contributing factors, bicycle fatal and severe injury crashes

4 Crashes involving people walking

Pedestrian-involved crashes constituted 2% of crashes in the region from 2015-2019, but 15% of crashes where a person was killed or severely injured. In particular, 55% of pedestrian-involved fatal and severe injury crashes happened in the suburban/compact communities context, which includes 76% of the region's population and 58% of its roadway network.

Across the Denver region between 2015 and 2019, 32% of pedestrian-involved crashes where people were killed or severely injured were broadside crashes, and 18% involved left turns. Such crashes happen overwhelmingly on major arterial roadways and often at crossings with minor streets where traffic movements may be less separated in space and time.

This section explores by context the recent trends and risk factors for people walking.

4.1. By location on street

Throughout the region, nearly two in three active modes crashes occurred at intersections, most of these occurring in the urban and suburban area types. Conversely, in the rural area type, 62% of crashes involving a pedestrian took place at non-intersection locations, where intersections are less common and fewer conflicts can be expected to occur at intersections.

Table 6: Pedestrian crash location by area type

Area type	Non-intersection	Intersection	Driveway	Alley	Other (for example, ramp, parking)
Urban	11%	28%	1%	1%	0.2%
Suburban	16%	35%	4%	0.1%	0.5%
Rural	2%	1%	0.1%	-	0.1%
Denver region	29%	64%	5%	1%	0.7%

Table 7: Pedestrian fatal and severe injury crash locations by area type

Area type	Non-intersection	Intersection	Driveway	Alley	Other (for example, ramp, parking)
Urban	15%	23%	1%	1%	0.4%
Suburban	23%	30%	3%	0.2%	0.5%
Rural	3%	1%	0.1%	0%	0.1%
Denver region	41%	54%	3%	1%	1%

However, when narrowed to crashes involving a fatality or severe injury, non-intersection crashes increased as a share of crash locations significantly to 41% regionwide and 69% of rural area crashes. Non-intersection crashes commonly include broadside, rear-end and head-on collisions between active mode users and motor vehicles, where vehicles may be expected to operate at a higher running speed than at intersection crash locations.

4.1.1. By street type (functional class)

Functional classification, which defines roadways by their role in the transportation network, is used in this report as a proxy indicator for roadway design factors that amplify risk to active mode users — posted speed limit, daily traffic volumes, number of travel lanes and types of traffic control devices each influence crash and safety conditions for people walking. This report uses county-level datasets of roadway functional classification to categorize crashes.

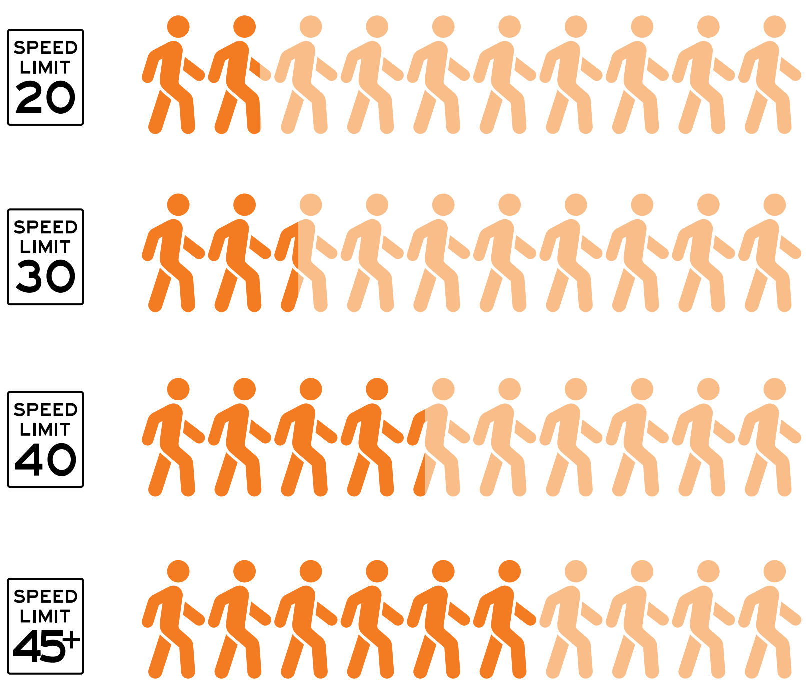
Increases in the posted speed limit have correlated with increased risk to people outside of motor vehicles. In the Denver region during the study period, analysts observed a consistent correlation between crash severity and speed limits. Where the posted speed limit was 20 miles per hour or slower, 17% of pedestrian-involved crashes resulted in death or severe injury. Where the speed limit was 25-30 miles per hour, fatal and severe injury crashes represented 25% of all collisions. At 35-40 miles per hour, 43% of crashes resulted in a fatal and severe injury. And when the posted speed limit was 45 miles per hour or faster, 59% of crashes involving people walking had a death or severe injury.

However, travel characteristics of each type of roadway classification vary widely by context — arterial streets in urbanized contexts have more dense population centers and destination demand, while rural contexts expect fewer intermodal interactions and network density. In the sections to follow, this report explicates some of the specific crash trends and factors by urbanized context, using the area types geography developed for the Denver Regional Council of Governments' Taking Action on Regional Vision Zero.

Urban area crashes by street type

Urban areas in the Denver region consist of dense urban centers, including Denver's downtown and urban core neighborhoods, central Boulder and the downtown sections of communities like Golden, Longmont, Castle Rock and Arvada.

Urban crash types are overwhelmingly intersection-related (68%), with 37% of urban crashes occurring at intersections on major arterial roadways (and another 16% on minor arterials) as illustrated in Table 8. However, non-intersection crashes are more likely to pose risk to people walking than to those driving — while representing 27% of overall crashes, they compose 38% of fatal and severe



Where posted speed was **20** miles per hour or less **16%** of pedestrian crashes resulted in fatality or severe injury.

Where speed was **35** miles per hour or more, **37%** resulted in fatality or severe injury.

At **45** miles per hour or more, **59%** resulted in death or severe injury.

injury crashes (Table 2). Section 3.2 provides a deeper analysis of urban area crashes, including common movements and conditions.

Arterial streets represent the highest risk roadways for pedestrians — despite major and minor arterials together comprising only 18% of the total centerline mileage of urban street networks throughout the region, 77% of fatal and severe injury crashes (and 74% of all crashes) occurred on arterial streets.

Table 8: Urban area pedestrian-involved fatal and severe injury crashes by functional classification and crash type

Functional classification	Centerline mileage	Non-intersection	Intersection	Driveway-related	Alley-related
Arterial	148	117	191	5	2
Minor arterial	148	24	65	1	2
Collector	219	23	26	1	1
Local	1,086	25	25	1	6
Other (for example, alley, private)	17	1	0	0	0
Highway	29	8	0	0	0
Total fatal and severe injury Crashes		199	307	8	11

Suburban area crashes by street type

The suburban/compact communities areas in the Denver region compose much of the region's land area, which can generally be characterized by single-family and low-density residential development, with some big box commercial areas, office parks and town centers. The street network is generally more curvilinear than urban contexts, with large arterial roadways carrying much of the travel volume. In the region's suburban area type, major arterial roads represent 9% of centerline mileage and 60% of fatal and severe injury crashes.

Table 9: Suburban area pedestrian-involved fatal and severe injury crashes by functional classification and crash type

Functional Classification	Centerline mileage	Non-intersection	Intersection	Driveway-related	Alley-related
Arterial	982	155	275	19	-
Minor arterial	616	49	49	2	-
Collector	1,100	38	43	4	-
Local	7,444	40	25	12	2
Other (for example, alley, private)	361	7	1	0	0
Highway	467	23	4	0	0
All crashes		304	397	37	2

Rural area crashes by street type

While the rural area type makes up 84% of the region's land area and 40% of the roadway mileage, only 4% of the region's pedestrian-involved fatal and severe injury crashes occur in this context. The rural area's street network can be divided into two geographic categories: rural plains, where roadways are constructed on flat topography primarily to serve agricultural or industrial access and movement; and rural mountains, where roadways contour to steep and varied topography, and serve a mix of residential, recreational and conservation land uses. Rural roads typically lack sidewalks or dedicated walking facilities, though these roads may have wide shoulders where pedestrians may walk adjacent to traffic.

Table 10: Rural area pedestrian-involved crashes by functional classification and crash type

Functional Classification	Centerline mileage	Non-intersection	Intersection	Driveway-related	Alley-related
Arterial	724	33	24	2	-
Minor arterial	1,051	13	12	0	-
Collector	1,028	12	6	1	-
Local	4,677	10	8	2	2
Other (for example, alley, private)	364	2	0	0	0
Highway	509	25	0	0	0
All crashes		95	51	5	2

4.2. Understanding urban area crashes

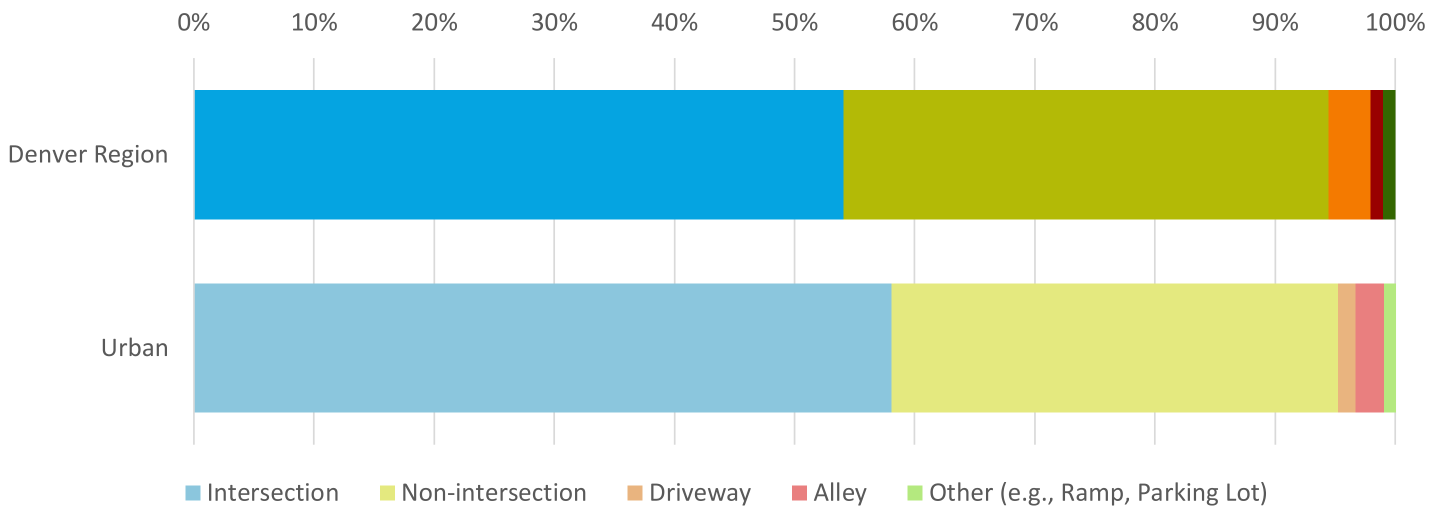


Figure 17: Pedestrian fatal and severe injury crashes by location on street, urban area type

4.2.1. Non-intersection crashes

As noted in the previous section, 27% of crashes in the urban context were non-intersection crashes, or crashes not associated with an intersection, driveway, highway ramp or alley location. Of the 603 urban non-intersection crashes involving pedestrians between 2015 and 2019, 33% resulted in a death or severe injury. By comparison, 20% of intersection-associated crashes resulted in deaths or severe injuries; non-intersection crashes were significantly more likely to amplify the severity of crashes, likely owing to higher impact speeds.

47% of all crashes and 59% of fatal and severe injury crashes involving people walking happened on major arterial streets, despite those arterials representing only 9% of the street network. Nearly three in four non-intersection crashes on major arterials involved a broadside collision.

4.2.2. Intersection crashes, by intersection type

41% of all intersection-related crashes and 38% of fatal and severe injury crashes in the urban context involved left-turn movements. Although the most crossing activity might be expected to take place at major arterial crossings, crashes and injuries were notably concentrated at crossings of major and minor streets, especially where major arterials intersect local and collector streets.

With left-turn crashes one of the most common crash types, in 80% of crashes, the pedestrian was crossing in or entering the intersection, and in only 5% of crashes was the pedestrian crossing against a signal. Of left turn-involved pedestrian fatal and severe injury crashes at major arterial-to-local intersections, 71% occurred at signalized locations.

68% of urban intersection crashes occurred during daylight, while 27% occurred at dark but in lighted conditions. Only two urban intersection crashes occurred at dawn or dusk between 2015 and 2019.

Table 11: Urban area pedestrian-involved fatal and severe injury crashes by pre-crash maneuvers and intersection type

Intersection type	All traveling straight (same direction)	All traveling straight (cross direction)	Left turn involved	Right turn involved
All intersection types	8%	44%	38%	10%
Major arterial-to-major arterial	less than1%	4%	3%	less than 1%
Major arterial-to-minor arterial	0%	5%	4%	2%
Major arterial-to-collector	2%	4%	5%	1%
Major arterial-to-local	3%	16%	9%	4%
Minor arterial-to-minor arterial	less than 1%	2%	4%	1%
Minor arterial-to-collector	less than 1%	2%	3%	1%
Minor arterial-to-local	1%	5%	4%	1%
Collector-to-collector	0%	0%	less than 1%	0%
Collector-to-local	0%	3%	3%	less than 1%
Local-to-local	1%	3%	3%	0%

Major arterial to local and major arterial-to-collector intersection crashes

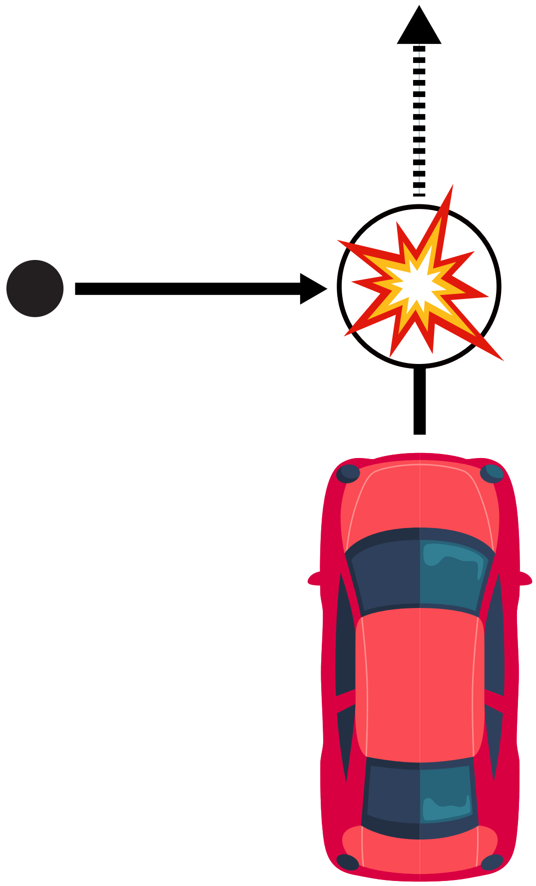
Of pedestrian-involved crashes located at intersections, 22% (325) of all crashes and 32% of fatal and severe injury crashes in the urban area type occurred at major arterial-to-local street junctions and another 12% occurred at major arterial-to-collector street junctions. The crashes at this intersection type were the most likely of all intersection types to result in a death or severe injury, with 42% of major arterial-to-local intersection crashes resulting in a fatal and severe injury. Of major arterial-to-local intersection crashes, 82% occurred at signalized locations.

The two most frequent crash types either involved left-turning movements by the vehicle (38%), or 90-degree broadside crashes (44%).

70% of left-turn fatal and severe injury crashes in the intersection type involved a turn from the minor street onto the major street, a common crash type where vehicles turn concurrently with crossing pedestrians onto a wide, multilane receiving street.

74% of broadside crashes at major arterial-to-local and major arterial-to-collector intersection crossings occurred at unsignalized locations.

Figure 18: Example of a broadside crash



4.3. Understanding suburban/compact community area crashes

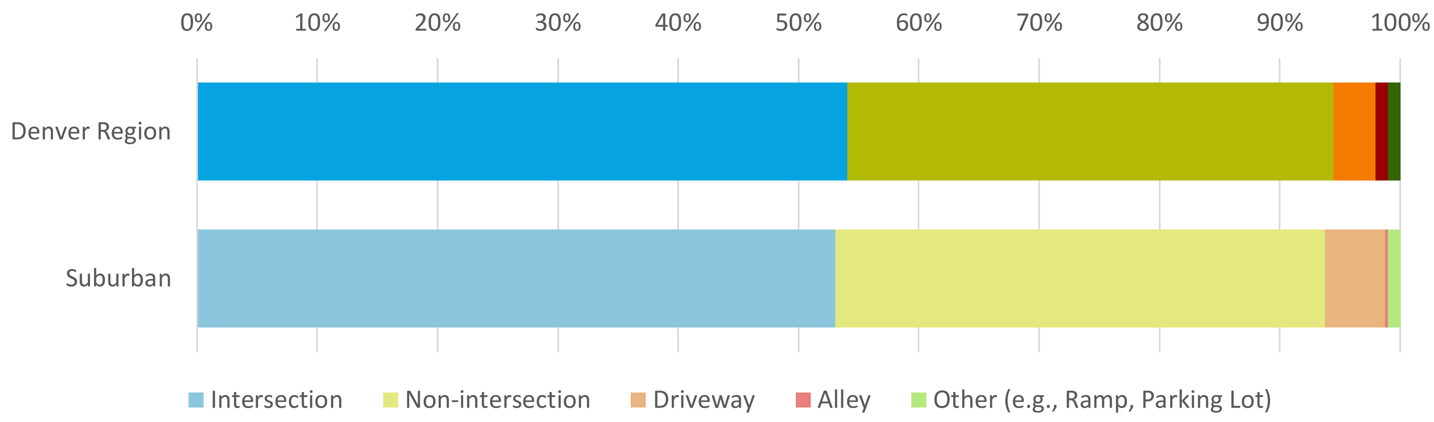


Figure 19: Pedestrian fatal and severe injury crash locations, suburban area type

4.3.1. Non-intersection crashes

In the suburban/compact communities context 46% of all crashes and 51% of fatal and severe injury crashes occurred on major arterial roadways. Among those pedestrian-involved crashes on arterial roads, 34% of crashes resulting in death or severe injury involved (according to details available in the incident report) a pedestrian crossing at a non-intersection location — in many (if not most) cases, such crashes are likely influenced, at least in part, by long distances between signalized crossing opportunities.

Additionally, speed played a significant role in both crash incidence and severity across roadway classifications — 55% of crashes occurred on roadways posted for 35 miles per hour or faster, and 72% of fatal and severe injury crashes on the same streets. As speed increased, the likelihood that crashes would result in death or severe injury also increased.

4.3.2. Intersection crashes, by intersection type

As with urban area intersections, the most common crossing type where crashes occur is the junction of major and minor roadways. However, while left-turn crashes were most pronounced in the urban context, and though they remain the most frequent crash type in suburban contexts, right-turn and broadside crashes represent more fatal and severe injury crashes on suburban streets.

Figure 20: Example of a left turn-involved crash

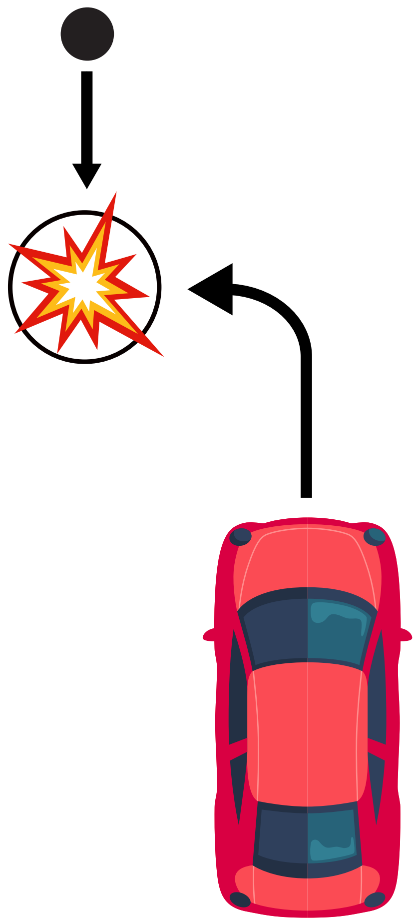


Table 12: Suburban area pedestrian-involved fatal and severe injury crashes by pre-crash maneuvers and intersection type

Intersection type	All traveling straight (same direction)	All traveling straight (cross direction)	Left turn involved	Right turn involved
All Intersection Types	11%	32%	43%	14%
Major arterial-to-major arterial	1%	5%	3%	3%
Major arterial-to-minor arterial	1%	2%	1%	1%
Major arterial-to-collector	1%	7%	14%	3%
Major arterial-to-local	4%	8%	12%	3%
Minor arterial-to-minor arterial	1%	0.3%	2%	1%
Minor arterial-to-collector	0	0.3%	1%	1%
Minor arterial-to-local	1%	3%	4%	0.3%
Collector-to-collector	0	2%	1%	1%
Collector-to-local	3%	3%	2%	1%
Local-to-local	2%	2%	3%	0.3%

4.4. Understanding rural area crashes

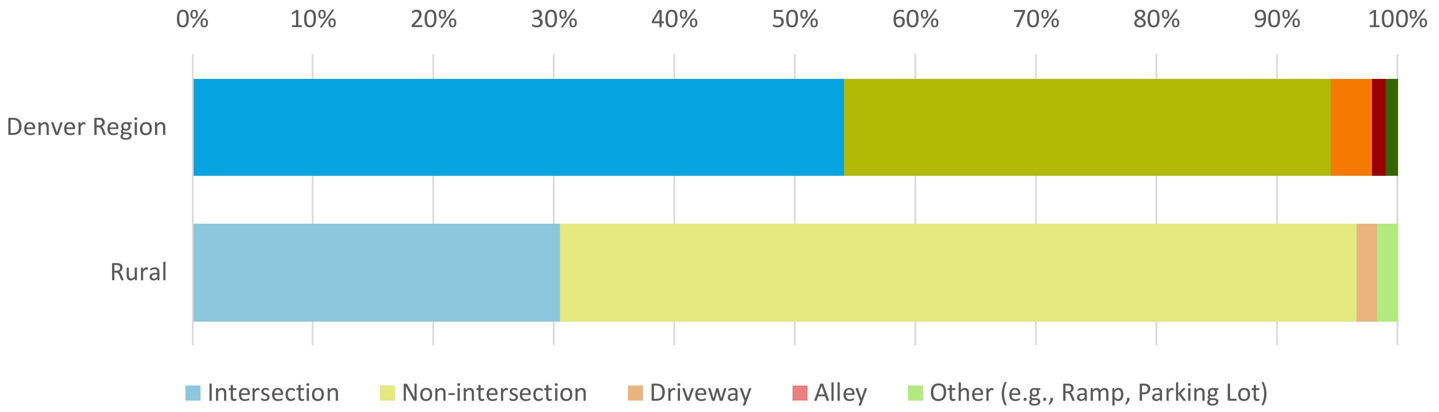


Figure 21: Pedestrian fatal and severe injury crash locations, rural area type

Left-turn involved crashes

Of pedestrian-involved fatal and severe injury crashes in the suburban area type, 77% occurred at signalized locations, and 70% involved the pedestrian and vehicle traveling parallel. Of those left-turn crashes, 64% occurred on major arterial-to-collector or local street intersections, where permissive turns are more likely to occur.

4.4.1. Non-intersection crashes

Unlike in the urban and suburban contexts, 62% of rural area crashes occurred at non-intersection locations, while only a third occurred at intersections, likely due to lower intersection density and fewer intersection conflicts. Additionally, because a larger proportion of the roadway network is made up of two-lane highways and arterial roadways, pedestrian-involved crashes were more likely to occur on highways, which in many places may be the only travel option between places. While highway non-intersection collisions made up less than 9% pedestrian-involved fatal and severe injury crashes in other areas, they represented 39% of rural fatal and severe injury crashes.

Speed and visibility played a significant role influencing crash severity. Where posted speed was 20 miles per hour or slower, only 15% of crashes resulted in death or severe injury. Where posted speed was 40 miles per hour or greater, 62% of crashes resulted in death or severe injury. Finally, a higher proportion of crashes (18%) occurred in dark, unlighted conditions (compared with 5% in urban and suburban contexts), as rural roads are less likely to be lit.

In 51% of pedestrian non-intersection crashes (and 46% of fatal and severe injury crashes), all parties were traveling the same direction; in 19% of cases (24% of fatal and severe injury crashes) the involved parties were traveling in opposite directions. 27% of these crashes involved a pedestrian walking or standing in the roadway (and 36% of fatal and severe injury crashes), while only 32% involve a pedestrian crossing the roadway (compared with 63% or more in other area types).

4.4.2. Intersection crashes by intersection type

During the study period, comparatively few pedestrian-involved fatal and severe injury crashes occurred at intersections — 12, in fact. Therefore, while the locations and pre-crash maneuvers are included in Table 13, they should be understood as not significant enough to draw conclusions from.

Table 13: Rural area pedestrian-involved fatal and severe injury crashes by pre-crash maneuvers and intersection type

Intersection type	All traveling straight (same direction)	All traveling straight (cross direction)	Left turn involved	Right turn involved
All intersection types	17%	27%	45%	9%
Major arterial-to-major arterial	0%	0%	0%	0%
Major arterial-to-minor arterial	0%	0%	0%	0%
Major arterial-to-collector	0%	0%	0%	0%
Major arterial-to-local	9%	9%	18%	9%
Minor arterial-to-minor arterial	9%	0%	0%	0%
Minor arterial-to-collector	0%	0%	0%	0%
Minor arterial-to-local	9%	9%	0%	0%
Collector-to-collector	0%	0%	0%	0%
Collector-to-local	0%	0%	18%	0%
Local-to-local	0%	0%	9%	0%

5 Crashes involving people cycling and rolling

Bicycle-involved crashes constituted 1% of crashes in the region from 2015-2019, but 6% of fatal and severe injury crashes.

The safety challenges associated with bicycling are distinct among all modes — people bicycling often share the roadway with motor vehicles, but have significantly lower travel speeds (usually no more than 15 to 20 miles per hour), resulting in large speed differences between travelers. People bicycling ride in a variety of conditions, ranging from streets with developed infrastructure to shared roadways, and in some cases choosing to ride on sidewalks where no dedicated facilities are provided. These variable riding conditions can result in unpredictability for both active mode users and motorists, which can result in or amplify crashes and conflicts.

In particular, 42% of bicycle fatal and severe injury crashes happened in the urban context, which includes 17% of the region's population and 8% of its roadway network. The urban context is where the region's bicycle facility network is most concentrated with a large proportion of bicycle facilities including on-roadway lanes and shared markings. This section explores by context the recent trends and risk factors for people bicycling.

Table 14: Bicycle crash locations by area type

Area type	Non-intersection	Intersection	Driveway	Alley	Other (for example, ramp, parking)
Urban	5%	30%	4%	2%	0.2%
Suburban	6%	42%	7%	0.3%	0.5%
Rural	1%	2%	0.5%	0.02%	0
Denver region	12%	74%	11%	2%	0.8%

5.1. By location on street

Throughout the region, three-quarters of bicycle-involved crashes occurred at intersections. Although more rural area crashes occurred at non-intersection locations (32%), conflicts were primarily focused at major arterial junctions with other roadways. Driveways also played a more noticeable role in crash locations in all contexts, particularly in the suburban area type.

When narrowed to fatal and severe injury crashes involving bicyclists, non-intersection crashes were more likely to result in death or severe injury, comprising 20% of fatal and severe injury crashes.

Table 15: Bicycle fatal and severe injury crash locations by area type

Area type	Non-intersection	Intersection	Driveway	Alley	Other (for example, ramp, parking)
Urban	5%	29%	3%	2%	0.2%
Suburban	11%	33%	7%	1%	0
Rural	4%	4%	1%	0	0
Denver region	20%	66%	11%	3%	0.2%

Where posted speed was **20** miles per hour or less, **10%** of bicycle crashes resulted in fatality or severe injury.

Where speed was **35** miles per hour or more, **15%** resulted in fatality or severe injury.

At **45** miles per hour or more, **35%** resulted in death or severe injury.

5.1.1. By street type (functional class)

Similar as with pedestrian conditions, functional classification of streets and roads is a significant indicator for the types and severity of conflicts people bicycling were involved in. Contextual factors such as posted speed limit, daily traffic volumes, number of travel lanes and intersection design influence traffic stress and crash risk for people bicycling.

Where the posted speed limit was 20 miles per hour or slower, 10% of bicycle-involved crashes resulted in death or severe injury. Where the speed limit was 25 to 30 miles per hour, fatal and severe injury crashes represented 18% of all collisions. At 35 to 40 miles per hour, 35% of crashes resulted in a fatal or severe injury. And when the posted speed limit was 45 miles per hour or faster, 51% of crashes involving people bicycling had a death or severe injury.

Urban area crashes by street type

Bicycling for functional transportation is most concentrated to the urban area type, where destinations and residential are most dense and bicycles serve short trips most effectively. 74% of fatal and severe injury crashes in the urban areas occurred at intersections during the study period, and 72% happened on major or minor arterial streets, despite those streets making up only 18% of the geography's centerline mileage.

Table 16: Urban area bicycle-involved fatal and severe injury crashes by functional classification and crash type

Functional classification	Centerline mileage	Non-intersection	Intersection	Driveway-related	Alley-related
Arterial	148	11	73	5	2
Minor arterial	148	8	47	9	5
Collector	219	2	28	2	1
Local	1,086	3	17	4	3
Other (such as alley, private)	17	2	0	0	0
Highway	29	0	1	0	0
Fatal and severe injury crashes		26	166	20	11

Additionally, using 2019 Bicycle Facility Inventory data, analysts found that 58% of non-intersection fatal and severe injury crashes occurred on streets without dedicated bicycle facilities (such as bicycle lanes, shared-use paths or separated bicycle lanes). Of fatal and severe injury crashes, 59% occurred on arterial streets that had no dedicated bikeways as of 2019.

Suburban area crashes by street type

In the Suburban area type, 43% of crashes with a fatality or severe injury occurred on an arterial road, with 64% of those crashes happening at intersections. Notably, 13% of crashes occurred at driveway locations, primarily along arterial roads.

Table 17: Suburban area bicycle-involved fatal and severe injury crashes by functional classification and crash type

Functional classification	Centerline mileage	Non-intersection	Intersection	Driveway-related	Alley-related
Arterial	982	25	83	20	1
Minor arterial	616	12	50	10	0
Collector	1,100	13	38	2	0
Local	7,444	12	19	6	4
Other (such as alley, private)	361	0	0	0	0
Highway	467	1	1	1	0
Fatal and severe injury crashes		63	191	39	5

49% of non-intersection fatal and severe injury crashes occurred on streets without dedicated bicycle facilities (as of 2019).

Rural area crashes by street type

In the rural context, half of fatal and severe injury crashes happened at non-intersection locations; similar to pedestrian-involved crashes, the decreased intersection density and travel activity lends itself to fewer crossing conflicts and more interactions between bicyclists and vehicles traveling in the same direction.

Table 18: Rural area bicycle-involved fatal and severe injury crashes by functional classification and crash type

Functional classification	Centerline mileage	Non-intersection	Intersection	Driveway-related	Alley-related
Arterial	724	10	10	1	0
Minor arterial	1,051	3	5	1	0
Collector	1,028	11	6	1	0
Local	4,677	0	1	0	0
Other (such as alley, private)	364	0	0	0	0
Highway	509	1	1	0	0
Fatal and severe injury crashes		25	23	3	0

5.2. Urban context crashes

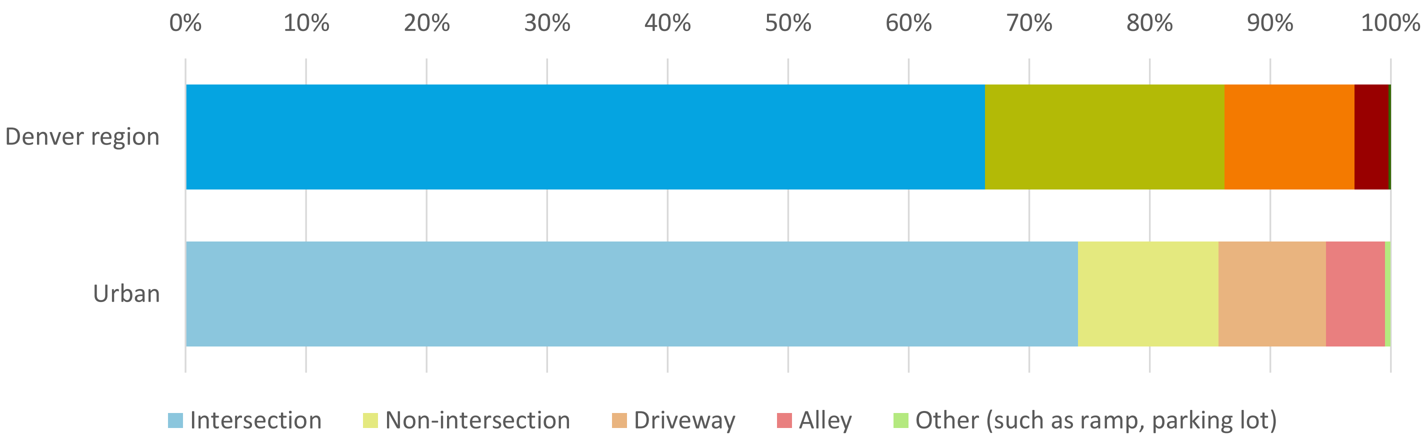


Figure 22: Bicycle fatal and severe injury crashes by location on street, urban area type

68% of non-intersection fatal and severe injury crashes occurred on streets without dedicated bicycle facilities (as of 2019).

With 40% of the region's bicycle-involved fatal and severe injury crashes, the urban area type is where bicycle crashes are most concentrated in the Denver region. Bicycle facilities in the urban area type evolved rapidly during the study period, with Denver and Boulder in particular implementing a variety of striped and separated bicycle lanes, as well as neighborhood bikeways, during the period. Of fatal and severe injury crashes involving bicyclists during the study period, 74% occurred at intersections.

5.2.1. Non-intersection crashes

While representing only 12% of fatal and severe injury crashes in the area type, non-intersection crashes remain a critical component of crash reduction. 48% of fatal and severe injury crashes involved same-direction travel, or crashes that can be averted with appropriate bicycle facility design. Of same-direction fatal and severe injury crashes, 83% occurred on arterial streets and 54% on streets with bicycle facilities as of 2019. However, for the purposes of this report, there was not enough information available to accurately assess the characteristics of facilities on the dates of each crash.

Table 19: Urban area bicycle-involved fatal and severe injury crashes by pre-crash maneuvers and intersection type

Intersection type	All traveling straight (cross direction)	All traveling straight (same direction)	Left turn involved	Right turn involved
All intersection types	41%	5%	36%	18%
Major arterial-to-major Arterial	3%	0%	4%	1%
Major arterial-to-minor Arterial	2%	1%	5%	2%
Major arterial-to-collector	7%	1%	7%	4%
Major arterial-to-local	1%	1%	1%	1%
Minor arterial-to-minor Arterial	4%	0%	2%	1%
Minor arterial-to-collector	9%	1%	6%	4%
Minor arterial-to-local	1%	0%	1%	0%
Collector-to-collector	7%	1%	5%	2%
Collector-to-local	5%	0%	3%	1%
Local-to-local	3%	0%	4%	1%

5.2.2. Intersection crashes by intersection type

With nearly three in four fatal and severe injury crashes occurring at intersections, they remain the primary conflict points for people bicycling in urban areas. The most common pre-crash maneuvers involved cross-direction travel (broadside crashes) and left-turn movements.

Among broadside fatal and severe injury crashes, 44% occurred where an arterial (major or minor) crossed a local street and 61% occurred at signalized locations (though in only 32% of those crashes did the responding officer cite a failure to stop at the signal for either party).

Among left-turn crashes, 79% occurred at signalized locations, though at arterial crossings with local streets (36% of left-turn fatal and severe injury crashes), 52% of crashes occurred at signalized crossings.

With 76% of the region's population and 55% of the region's bicycle-involved fatal and severe injury crashes, the suburban area type contains a diverse set of land use and travel contexts. Bicycle facilities in the suburban area type are often anchored around the regional trail network, though on-street bikeways tend to be striped bicycle lanes or shared lane markings, which may vary widely across jurisdictions. Nearly two-thirds of fatal and severe injury crashes involving bicyclists during the study period occurred at intersections.

5.3. Suburban/compact communities area crash types (such as intersection or driveway)

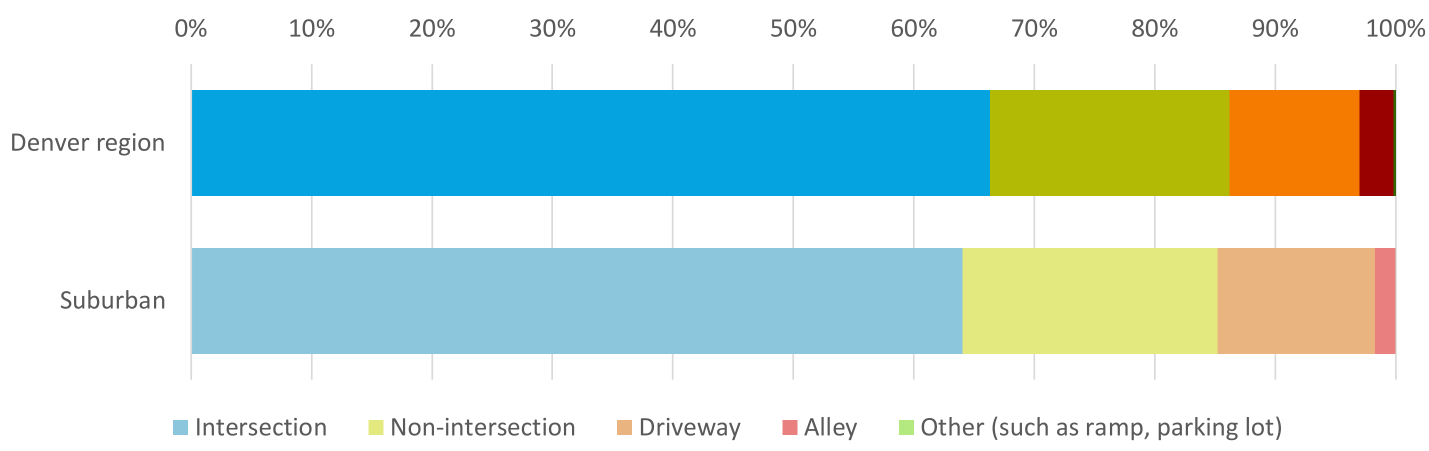


Figure 23: Bicycle fatal and severe injury crashes by location on street, suburban area type

5.3.1. Non-intersection crashes

In suburban/compact communities, 58% of non-intersection fatal and severe injury crashes during the study period involved parallel travel with both the bicyclist(s) and involved motor vehicles traveling the same direction. Of these, 64% occurred on streets that did not have a dedicated bikeway (such as a bicycle lane, sidepath or separated bicycle lane). A further 21% of fatal and severe injury crashes involved broadside collisions.

5.3.2. Intersection crashes by intersection type

While a slightly smaller proportion of crashes in suburban areas occur at intersections than in urban areas, nearly two in three fatal and severe injury crashes occur at junctions and remain the top crash location. As with urban area bicycle crashes, the intersections of major arterial and local streets emerge as the leading intersection crash context with 20% of fatal and severe injury crashes.

Table 20: Suburban area bicycle-involved fatal and severe injury crashes by pre-crash maneuvers and intersection type

Intersection type	All traveling straight (same direction)	All traveling straight (cross direction)	Left turn involved	Right turn involved
All intersection types	32%	3%	32%	33%
Major arterial-to-major arterial	3%	0%	1%	1%
Major arterial-to-minor arterial	2%	1%	2%	2%
Major arterial-to-collector	2%	0%	6%	3%
Major arterial-to-local	5%	0%	5%	10%
Minor arterial-to-minor arterial	2%	0%	4%	5%
Minor arterial-to-collector	1%	0%	1%	1%
Minor arterial-to-local	7%	1%	4%	5%
Collector-to-collector	1%	0%	2%	1%
Collector-to-local	5%	0%	5%	5%
Local-to-local	4%	2%	3%	2%

While left-turn and broadside crashes remain a persistent issue in suburban contexts, two other crash types emerged as major contributors: right-turn and driveway crashes.

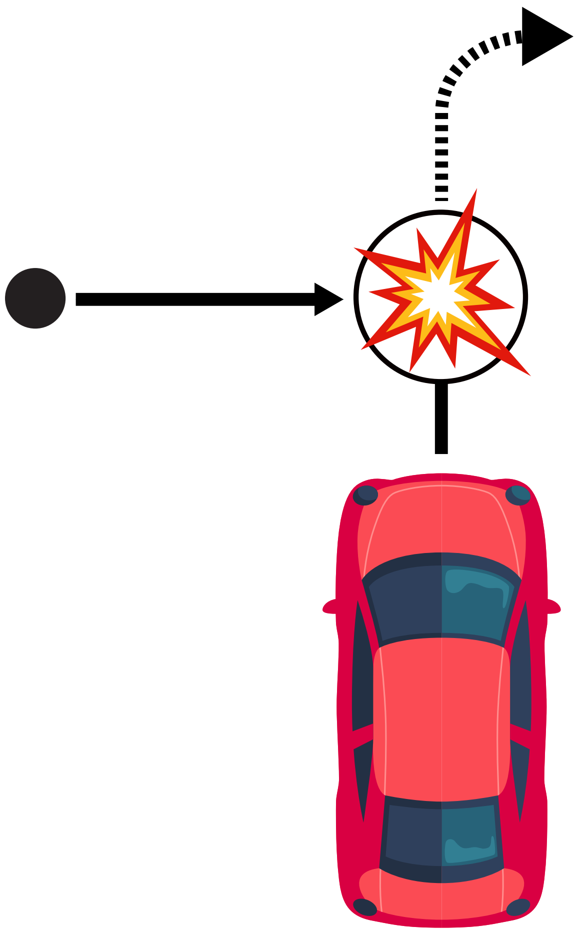
Right turn crashes

One-third of bicycle fatal and severe injury crashes involve right turns, and one-third of those (11% of total bicycle fatal and severe injury crashes) fit the right-hook crash type, or an approach-turn crash across the bicyclist's travel path. However, 55% of right-turn crashes (and 15% of total bicycle fatal and severe injury crashes) involve a right turn from a cross-street into the bicycle travel path. 62% of those right turn-cross street crashes were at signalized locations, which may coincide with a right-turn-on-red. The prevalence of this crash type likely relates to the ubiquity of either stop-controlled right turns, or signalized locations where right turn on red is permitted. (In Colorado, right turn on red is permitted at all signalized intersections unless explicitly signed and prohibited.)

Driveway-access related

While not a majority contributor to crash causes, driveway-related crashes were observably higher in the suburban area type than in other contexts, with the majority of fatal and severe injury crashes taking place on either major or minor arterial roads. Of the fatal and severe injury driveway-related crashes, 40% involved left-turn movements and 28% involved broadside collisions.

Figure 24: Example of a right turn-involved crash



5.4. Rural area crash types (for example, intersection, driveway)

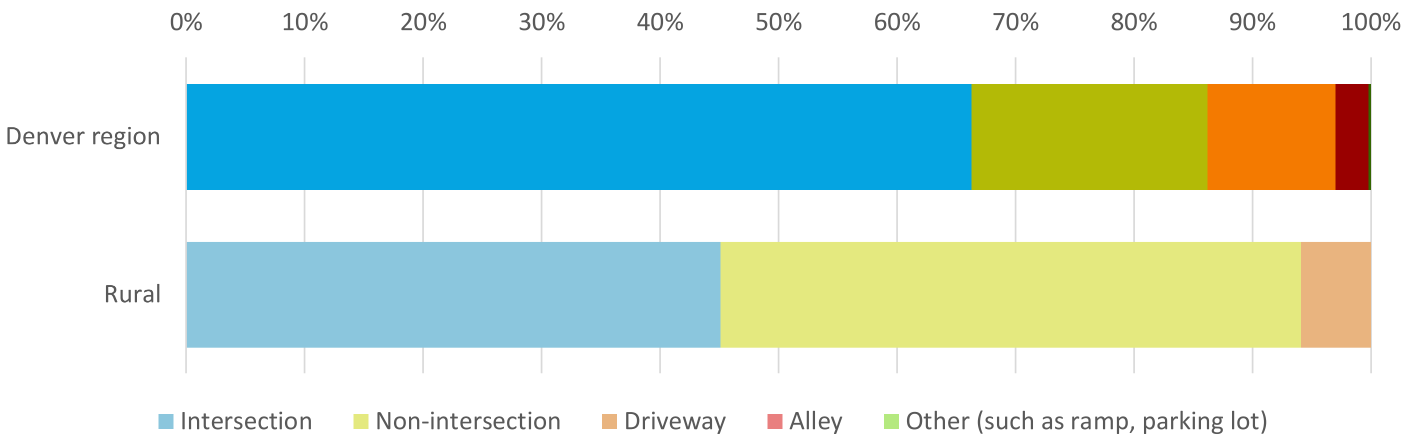


Figure 25: Bicycle fatal and severe injury crashes by location on street, rural area type

In rural areas, bicycle travel is much less common for utility trips than for recreation. As such, the types of bicyclists expected to ride on rural roads in the Denver region — especially in the more mountainous terrains — are typically experienced sport cyclists. Additionally, rural roadways have much lower intersection density and destination access, leading to less intersection and driveway conflict than in urban and suburban areas. As such, non-intersection crashes make up a larger share in rural areas.

5.4.1. Non-intersection crashes

During the study period, there were 25 non-intersection fatal and severe injury crashes in rural areas, the majority of which involved same-direction travel (56%). Half of the rural non-intersection fatal and severe injury crashes occurred on streets with no dedicated bicycle facility, and only one crash occurred on a road with a dedicated bicycle lane. Areas where bicycles operated in a marked shared lane represented 18% of fatal and severe injury crashes, and streets with another type of facility, such as a climbing lane or paved shoulder, represented 22%.

5.4.2. Intersection crashes by intersection type

At intersections in rural areas, half of all crashes involved a left-turn movement, though only 23 fatal and severe injury crashes occurred between 2015 and 2019 (limiting the significance of analysis). Rural roads throughout the region may have some similar contextual factors across functional classes (such as rural arterials and collectors alike may commonly have one travel lane per direction), which may explain why there is less crash concentration on arterial roads than in other contexts.

Table 21: Rural area bicycle-involved fatal and severe injury crashes by pre-crash maneuvers and intersection type

Intersection type	All traveling straight (same direction)	All traveling straight (cross direction)	Left turn involved	Right turn involved
All intersection types	21%	16%	53%	11%
Major arterial-to-major arterial	5%	0%	0%	0%
Major arterial-to-minor arterial	0%	11%	5%	5%
Major arterial-to-collector	0%	0%	5%	5%
Major arterial-to-local	5%	0%	5%	0%
Minor arterial-to-minor arterial	5%	0%	5%	0%
Minor arterial-to-collector	0%	0%	0%	0%
Minor arterial-to-local	5%	0%	5%	0%
Collector-to-collector	0%	0%	11%	0%
Collector-to-local	0%	5%	11%	0%
Local-to-local	0%	0%	5%	0%

Of the intersection crashes reported, 53% involved left-turn movements, again likely owing to permissive turns; 23% of fatal and severe injury intersection crashes in rural areas involved a left turn across a traveler moving in the opposite direction.

6 Seasonal variations

In addition to the other factors explored in this report, crash characteristics vary throughout the day and calendar year, often following factors such as daylight hours, seasonal climate, travel schedules and activities (such as school sessions) and peak-hour travel. This section explores how such variations influence crash conditions.

6.1. Time-of-day trends

One of the primary controlling factors for when crashes occur is time of day — as travel congestion increases during peak commute hours, more conflicts are likely to occur as well. However, when comparing bicycle- and pedestrian-involved crashes, both modes spike during the afternoon peak hours (approximately 4-6 p.m.), and bicycle crashes also increase during the morning peak hours. Pedestrian crashes do not significantly increase (both fatal and severe injury and non-fatal and severe injury crashes alike) during morning peak hours. Conversely, pedestrian crashes are much more likely to occur in the evening, when lighting conditions change from day to dusk to night.

As illustrated in Figure 26, while bicycle crashes are strongly correlated with weekday peak commute hours, pedestrian crashes are more distributed throughout the day and peak on Saturday and Sunday afternoons and evenings (illustrated in Figure 27), when people are more likely to be traveling recreationally, or are running errands.

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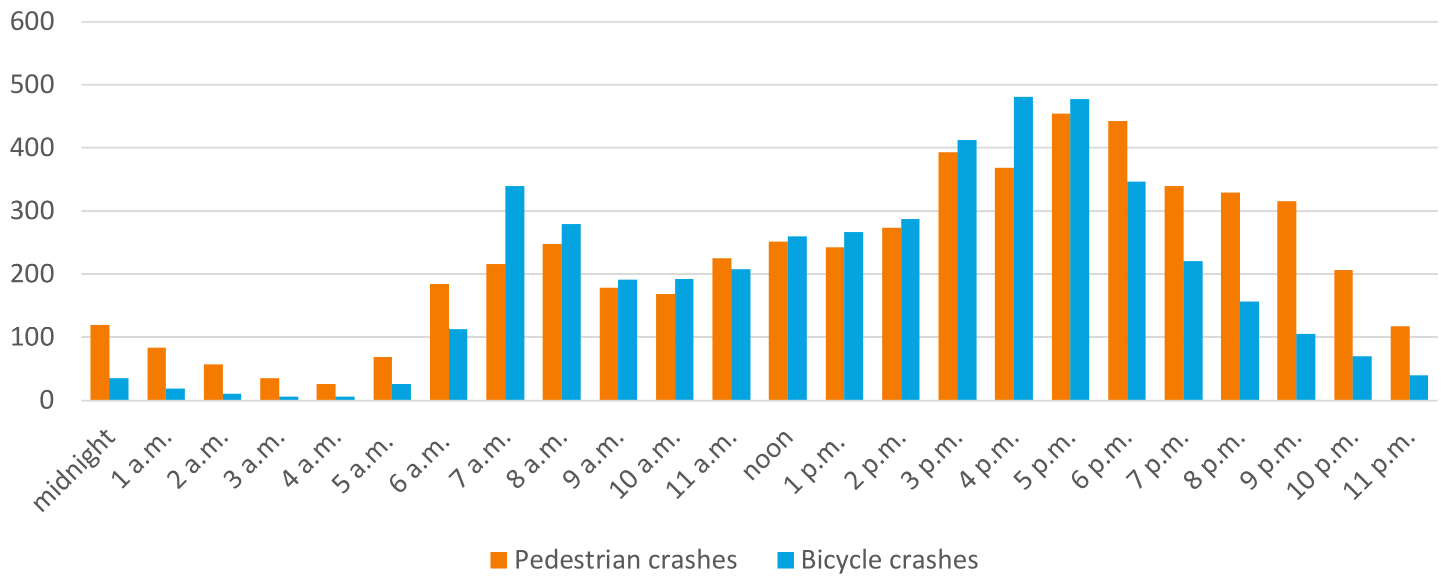

Figure 26: Crashes by hour of day, 2015-2019

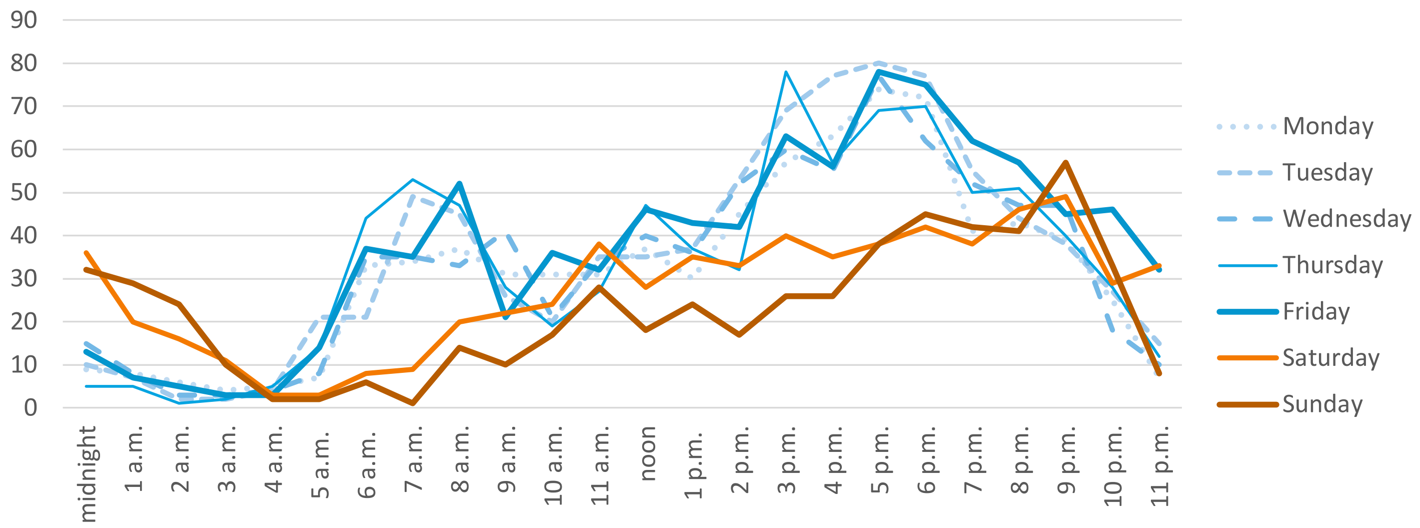

Figure 27: Pedestrian crashes by day of week

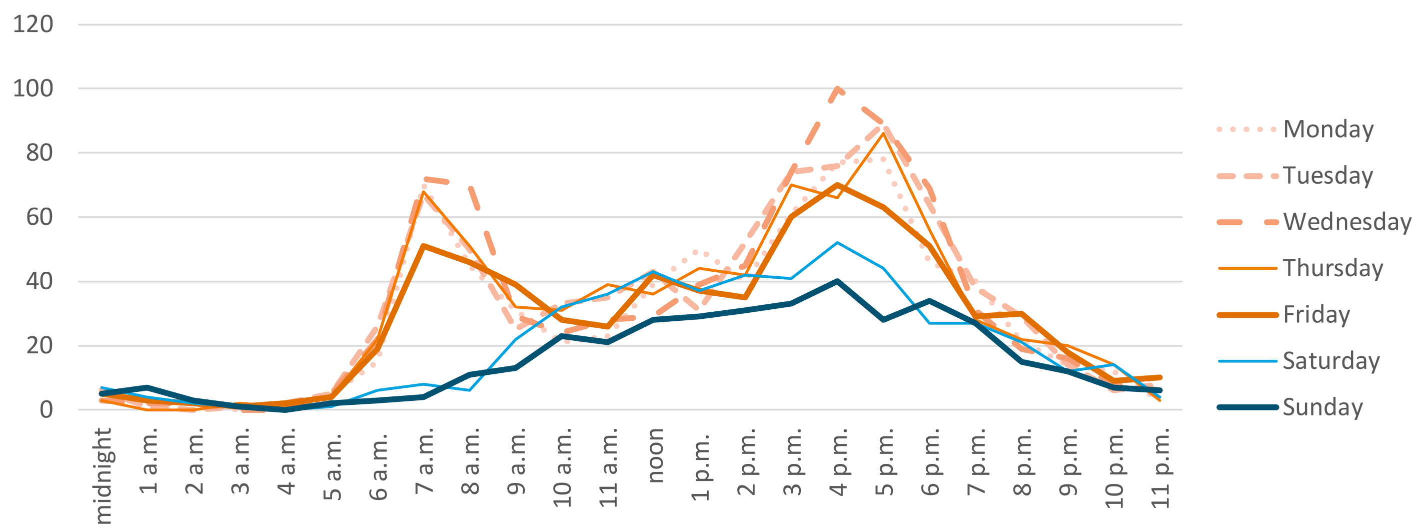

Figure 28: Bicycle crashes by day of week

6.2. Crashes by time of year

In addition to varying throughout the week with traffic conditions, crash trends are largely correlated to seasonality. As illustrated in Figure 29, pedestrian-involved crashes increase in the fall and winter, and decrease during the spring and summer. During the peak month for pedestrian crashes, November, there were 185% more crashes per day than during the lowest ranked month, June. This may be due to a combination of factors including fewer lighted hours during the day, increased school travel and increased likelihood of poor roadway conditions (though wet or snowy road conditions were only cited in 12% of pedestrian-involved crashes).

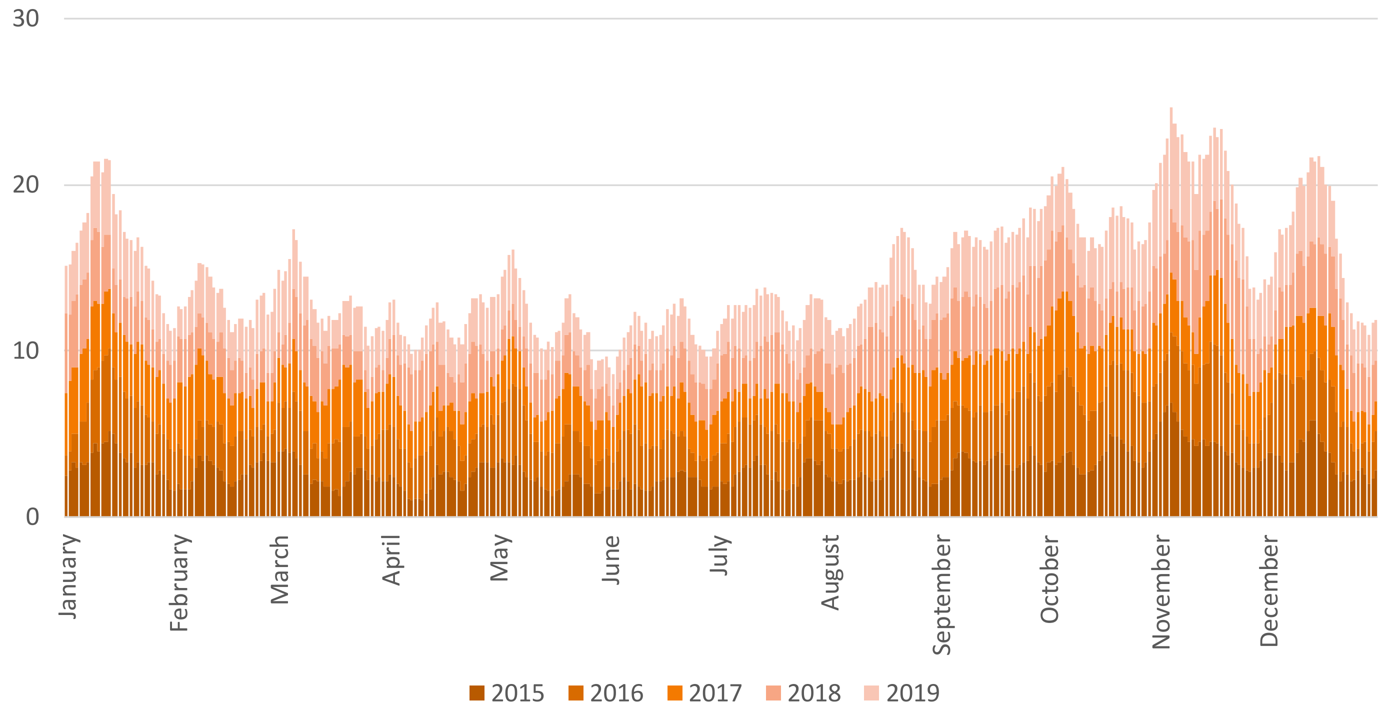

Figure 29: Pedestrian crashes per day, (seven-day rolling average), 2015-2019

For bicyclists, peak crash months were concentrated in the late summer and early fall with almost four times as many crashes per day in August as in December. Data reveals an increase in crash frequency beginning in March and April extending through November, most likely driven by an increase in people bicycling, due in part to favorable weather and the ability to bicycle on dry roads.

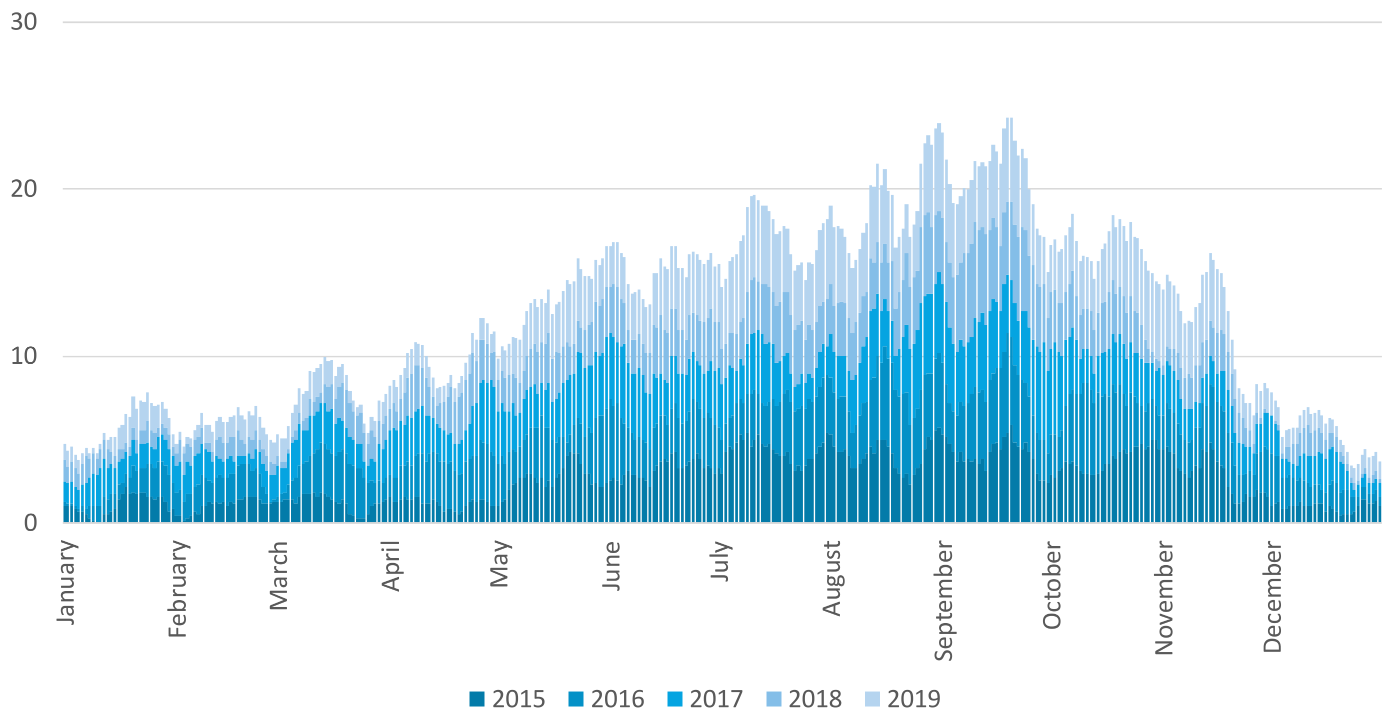

Figure 30: Bicycle crashes per day, (seven-day rolling average), 2015-2019

Finally, analysis included consideration of whether the end of daylight saving time, typically occurring during the first week of November, was correlated with a change in active mode crashes, as the change in clock setting also changes daylight and travel time conditions. Data indicates that only for pedestrian-involved crashes is there a significant change, with roughly 29% more pedestrian crashes a day occurring in the week after daylight savings time ended than in the two weeks prior.

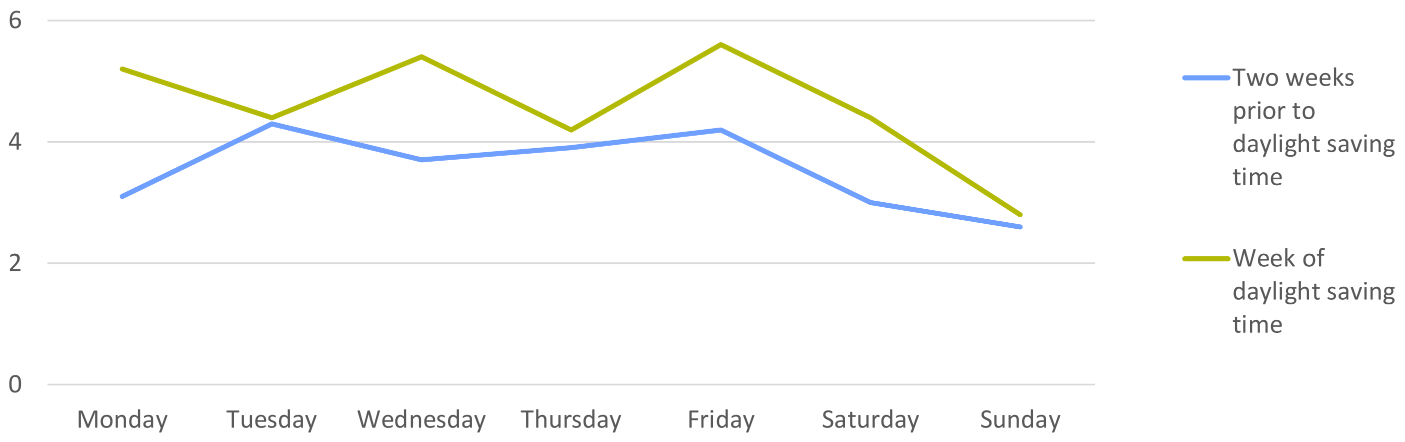

Figure 31: Pedestrian crash frequency at end of daylight saving time

7 2020 and 2021: A new travel paradigm

Two major changes have affected the reporting of active mode crash data in the Denver region. First, the State of Colorado, including agencies in the Denver region, changed crash reporting forms completed by responding officers. Standardized form fields allowed greater access to new and more granular data, allowing policymakers, first responders and designers to better understand crashes and crash patterns and make more informed decisions about how to prevent or mitigate them. However, the change did not come without understandable growing pains, making comparative analysis between years prior to 2020 and years following difficult. Many crash forms from 2020 are missing information, and some of the report fields did not map cleanly together, limiting the validity of analysis.

Secondly, and perhaps more importantly, in March 2020 the COVID-19 pandemic began emerging in Colorado. As the State of Colorado and local governments instituted "Safer at Home" directives and guidance, many commuters transitioned immediately to remote work, changing all aspects of historical commute patterns. Many businesses temporarily closed or transitioned to limited hours and occupancy. Nationwide and regionwide travel dwindled to a fraction of its previous baseline. Not only did travel times change, shifting away from peak commute periods to more distributed all-day demand, but travelers purposes for getting around the region shifted dramatically too. Jurisdictions throughout the region piloted shared or flex streets to unlock spaces for physical distancing and active transportation, understanding that many residents might shift modes from transit, ride-hailing services or multi-passenger vehicle travel to walking, bicycling and scooting.

While inconsistencies related to 2020 crash data prevent deep comparative analysis with prior years, report authors have identified two trends have emerged:

- Changes in fatal and severe injury crashes among all modes fell more than vehicle miles traveled did in 2020, and then pedestrian and motor vehicle crashes returned greater than vehicle miles traveled when travel bounced back in 2021. When regionwide vehicle miles traveled fell 15% from 2019 to 2020, bicycle-involved fatal and severe injury crashes fell 16% and pedestrian-involved fatal and severe injury crashes fell 26%. In 2021, when vehicle miles traveled bounced back to nearly pre-pandemic levels (97%, or a 23% year-over-year increase), pedestrian-involved fatal and severe injury crashes jumped 35% from 2020 to 2021, while bicycle-involved fatal and severe injury crashes increased 14% (both returning to 2019 levels).

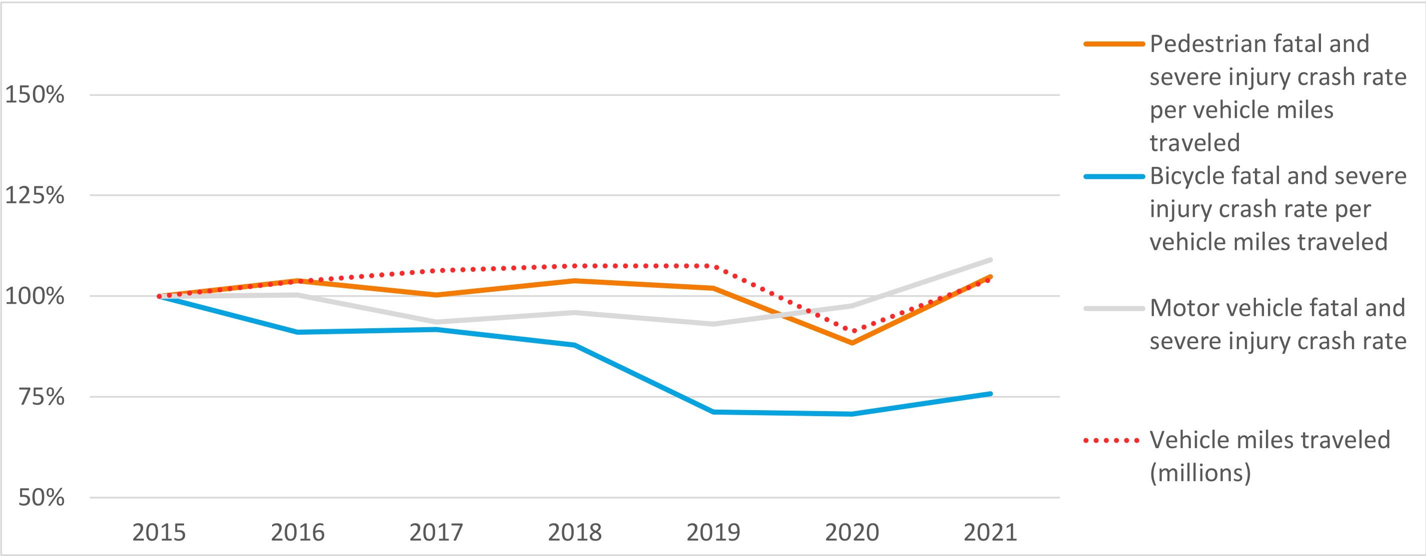

Figure 32: Fatal and severe injury crashes per 1 million vehicle miles traveled, 2015-2021

- Travel activities — and traffic injuries — shifted in part to local streets, especially in the urban area type, where travel patterns moved away from commutes and toward neighborhood trips. Local and collector pedestrian-involved fatal and severe injury crashes increased across area types, and local bicycle-involved fatal and severe injury crashes increased specifically in urban areas.

Table 22: Pedestrian-involved fatal and severe injury crashes by functional classification

Functional classification	2015-2019 Urban	2015-2019 Suburban	2015-2019 Rural	2020 Urban	2020 Suburban	2020 Rural
All	37%	52%	11%	42%	55%	3%
Major arterial	60%	61%	39%	53%	55%	50%
Minor arterial	18%	14%	17%	23%	12%	17%
Collector	10%	11%	13%	7%	10%	17%
Local	11%	11%	13%	14%	14%	0%
Highway	2%	4%	17%	2%	2%	17%
Ramp	0%	1%	1%	1%	4%	0%

Table 23: Bicycle-involved fatal and severe injury crashes by functional classification

Functional classification	2015-2019 Urban	2015-2019 Suburban	2015-2019 Rural	2020 Urban	2020 Suburban	2020 Rural
All	39%	52%	9%	29%	63%	9%
Major arterial	41%	43%	41%	39%	52%	0%
Minor arterial	31%	24%	18%	30%	24%	14%
Collector	15%	18%	35%	4%	16%	43%
Local	12%	14%	2%	22%	8%	14%
Highway	1%	0%	0%	0%	0%	29%
Ramp	0%	1%	4%	4%	0%	0%

8 Methodology

This report was prepared using the Denver Regional Council of Governments 2015-2019 crash datasets, a collaborative effort among the Denver Regional Council of Governments, the Colorado Department of Revenue and the Colorado Department of Transportation.

When crashes involving vehicles occur, responding officers fill out a crash form and send it to the Department of Revenue, which processes the records and enters data into the Colorado Driver Identification and Vehicle Enterprise Solution database. The Colorado Department of Transportation receives crash data from the Colorado Driver Information and Vehicle Enterprise Solution database, then processes the data. This process adds an additional crash type field, corrects common errors, updates location information and normalizes the data. The Colorado Department of Transportation sends the Denver regional crash data to the Denver Regional Council of Governments, which geocodes the data. Once geocoded, the Colorado Department of Transportation verifies the final product. The database does not include records for crashes not reported to, or by, law enforcement agencies.

This report presents data on motor vehicle crashes involving pedestrians and bicyclists from calendar years 2015 through 2019. Pedestrian crashes refer to crash types that were classified as “pedestrian” or if a pedestrian was involved in a harmful event that took place during the crash. Bicycle crashes refer to crash types that were classified as “bicycle” or if a bicycle was involved in a harmful event that took place during the crash.

Given data limitations, it is not possible to determine which individual or person type (for example, the driver, passenger, pedestrian or bicyclist) was injured in a crash. For data tabulations, analysts assumed the most vulnerable person was the most likely to suffer the most severe injury. Detailed injury data was not available for this crash report. There are also gaps in the data, as most of the crashes do not have all detailed fields available. For example, the age of the person associated with a crash may be available for one crash but not for another. All numbers in this report were derived from available data.

This report also draws upon the Pedestrian and Bicycle Crash Analysis Tool, version 3, a crash-typing methodology developed by researchers at the University of North Carolina Highway Safety Research Center as a project of the Federal Highway Administration. Using information contained in the crash report including vehicle movements and travel directions, generalized pre-crash maneuvers were assigned to all reported crashes containing sufficient information.

Finally, the report uses a consolidated set of county and city roadway functional classification geographic information systems datasets to create the typology of intersection types. To develop the intersection typologies, analysts created a geographic information systems point layer to type all intersections based on each leg of the intersection. Where functional classification changes or is irregular (for example, if a functional classification of a street changes from one side of the intersection to the other), the “higher” classification was assigned to that leg (so a street classified as a collector on one leg and a local on the other leg would be assigned collector, as that is likely to be a better indicator of the intensity of use and contextual characteristics of the intersection).

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