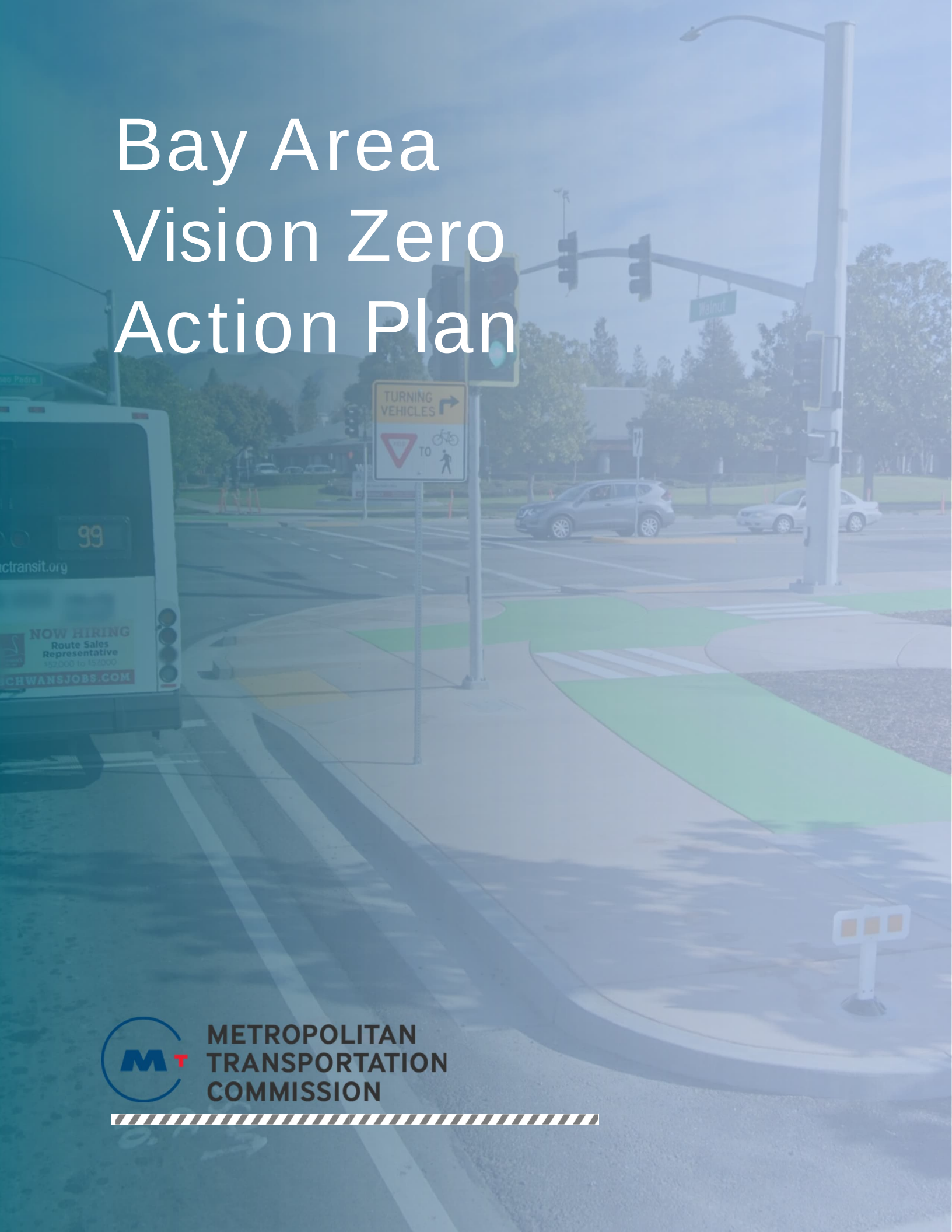
Bay Area Vision Zero Action Plan



METROPOLITAN TRANSPORTATION COMMISSION

BAYVIZ System

Bay Area Vision Zero Action Plan

FINAL

September 2022

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Bay Area Vision Zero Action Plan

Integrating a Vision Zero mindset into traffic safety activities requires a long-term commitment from a range of stakeholders. MTC and the Bay Area communities have made this commitment. In June 2020, MTC adopted the Vision Zero resolution to eliminate traffic fatalities and serious injuries on our streets by 2030, while increasing safe, healthy, equitable mobility for everyone. Traffic safety is a very grave issue in the Bay Area. In the 10 year period from 2010 to 2020 there were:

4,230 LIVES LOST

20,300 PEOPLE SERIOUSLY INJURED

45% OF THESE CRASHES WERE YOUNG PEOPLE

60% INCREASE IN FATAL CRASHES SINCE 2010

$53.1 BILLION IN ECONOMIC LOSSES

BLACK USERS HAD 87% INCREASED CHANCE OF BEING KILLED

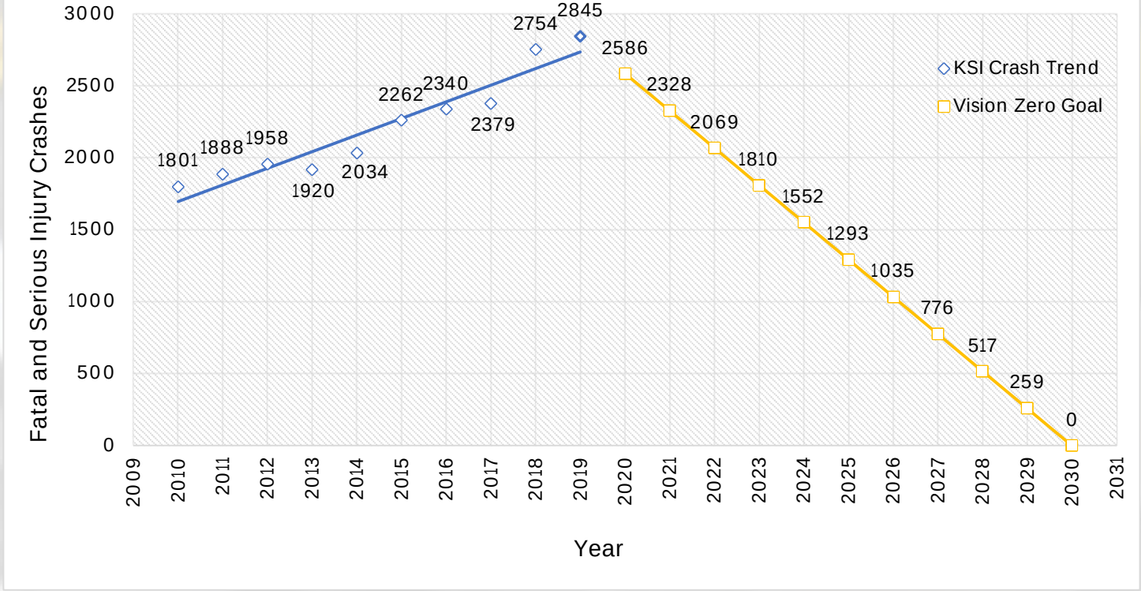


Figure 1: Fatal and Serious Injury (KSI) Crashes in the Bay Area 2010 - 2019 and Targeted KSI Crashes to Achieve 2030 Goal of Zero

To achieve our Vision Zero goals, we must focus on the specific factors that relate to the most extreme safety issues and have a higher proportion of fatal and serious injury crashes:

Equity – 29% of all High Injury Network (HIN) corridors are in equity priority communities (EPCs), but just 12% of Bay Area road-miles are in EPCs. We must focus safety funding in disadvantaged areas of the metro.

Speed and Aggressive Driving – A user outside a car has only a 10% chance of being killed when hit at 23 mph. That user has a 50% chance of being killed at 42 mph. At 58 mph, the user has a 90% chance of being killed. We must focus on reducing speeds and speeding by reducing speed limits and incrementally implementing design changes that reduce tendencies to speed.

High Crash Locations – 34% of the fatal and serious injury crashes in the city occurred on just 2% of roads. These roads have a fatal and serious injury crash rate 17x higher than a road not on the High Injury Network. We must include our HIN in prioritizing all infrastructure spending.

High Risk Locations – Certain Road characteristics lead to elevated risk like roads with 4- and 6-lane, 30mph and 35mph speed limits, excess capacity, and signalized intersections. We must enact policy and standards to prohibit design with high-risk characteristics.

People Walking and Biking – 40% of fatal and serious crashes on local access roads involve pedestrians and bicyclists although walking and biking account for only 17% of the overall mode share. We must improve visibility and increase designated space for pedestrians and bicyclists.

Motorcycle Crashes – 21% of all KSI crashes in the Bay Area involve motorcycles. Motorcyclists only account for 0.4% of commute mode trips in the Bay Area. This means that motorcyclists are 50x more likely to be killed or seriously injured in a traffic crash than the average user. We must focus behavior change efforts towards motorcycle users.

Broadside Crashes – commonly called “t-bone” crashes—are the #1 type of crash leading to fatal and serious injuries in the city. These crashes most often happen at traffic signals. We must systematically address signalized intersections.

Rural Lane Departure Crashes – Rural areas account for the 2nd highest amount of fatal and serious injury crashes after suburban areas, with only a fraction of the population. The most prominent KSI crash type are lane departures. We must implement known safety countermeasures in rural areas of the metro area to decrease and eliminate these crashes.

Impaired Road Users – Within the Bay Area, impaired road users account for 13% of killed and severe injury crashes. We must focus behavior change efforts towards impaired road user behavior.

Young Drivers – Young drivers (aged 35 and younger) are involved in 45% of all fatal and serious injury crashes. To achieve Vision Zero in the Bay Area, we must focus behavior change efforts towards younger drivers and provide drivers education programs.

Male Drivers – Males make up a disproportionate amount of roadway deaths—70% of all crashes. We must target education, design, and enforcement toward male roadway users.

Where Should we Focus our Efforts?

One-third of all KSI crashes in the Bay Area happen on just 1.9% of the roads. These 1.9% of roads constitute nearly 550 miles of Bay Area Roads and 3,090 KSI crashes. High Injury Networks (HINs) are the mapping of corridors where high numbers of people have been killed and severely injured in traffic crashes and are an important tool of the Vision Zero approach. Overall, HIN segments are highly concentrated in equity priority communities, especially for non-motorized users. When looking at all modes, 29% of HIN corridors are in EPCs, but just 12% of Bay Area streets are in EPCs. For pedestrians it is even worse—38% of pedestrian HIN segments are in EPCs with only 12% of Bay Area streets in EPCs. The HIN maps can be viewed online at this link.

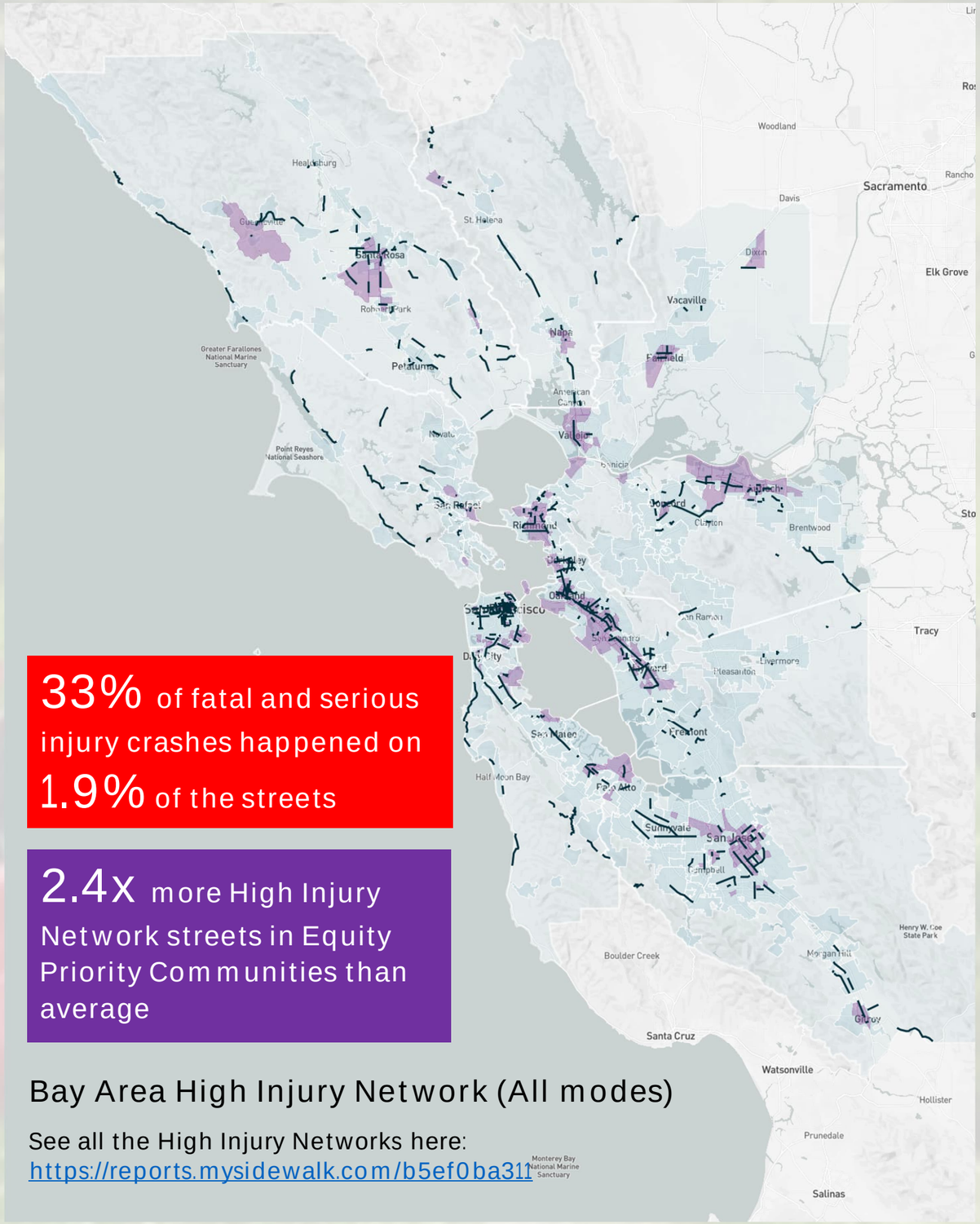
This Action Plan includes a systemic risk analysis that looked at roadway and context factors leading to elevated risk of fatal and serious injury crashes. At the highest level, these types of roadways and intersections were found to have a highly elevated risk compared to average:

- 4-Lane, Two-Way Undivided Streets
- 2-4 Lane One-Way Streets
- Traffic Signal Intersections

This systemic risk analysis was used to create a High Risk Networks (HRN) The HRN maps can be viewed online at this link. The HRN segments for vehicles had a 3.7x higher rate and for bicyclist and pedestrians a 6.1x higher rate of fatal and serious injury crashes than the average street in the Bay Area. 23% of these HRN streets were in EPCs, compared to just 12% of the streets in EPCs.

Vision Zero is a data-driven approach to road safety. A centralized, comprehensive, and georeferenced crash database helps provide a full picture of current road safety performance, enabling in-depth analysis. An extensive survey of users was conducted to identify use cases and tailor the regional safety data system to the needs of Bay Area users. This system has been dubbed the Bay Area Vision Zero System (BAYVIZ). A dashboard was created for BAYVIZ so that users can draw their own area-of-interest (AOI) by selecting Census Tracts, Cities/Places, or Counties; drawing a custom polygon; or drawing a radius around a point. Informational overlays, such as the HINs, EPCs, or crash data can be toggled on or off. This system is available to all public agency staff in the Bay Area.





33% of fatal and serious injury crashes happened on **1.9%** of the streets

2.4x more High Injury Network streets in Equity Priority Communities than average

Bay Area High Injury Network (All modes)

See all the High Injury Networks here:
https://reports.mysidewalk.com/b5ef0ba311

How will we Achieve Vision Zero?

To achieve Vision Zero, MTC has pledged to take steps to implement these Seven Core Safety Principles:

1. Prioritized Safety – We will prioritize safety and equity in all plans, designs, funding allocations, and operations. We will prioritize addressing safety issues on the top corridors and intersections in the Bay Area first.

2. Safe Speeds – We will lower speed limits, reconstruct roads to discourage speeding, vigorously enforce speed limits, and educate drivers on the dangers of speeding to slow vehicle speeds everywhere in the city.

3. Safe Streets – We will construct new streets and retrofit existing streets with the safest configurations possible.

4. Safe Intersections – We will construct new intersections and retrofit existing intersections with the safest configurations possible.

5. Safe Multimodal Networks – We will construct new streets and retrofit existing streets to provide a safe and convenient network of protected bike lanes, sidewalks, and trails and support expanded transit service.

6. Safe Users – We will provide educational opportunities for drivers on the dangers of speeding and driving while intoxicated.

7. Equitable Law Enforcement – We will enforce traffic laws based on a data-driven, performance based, and equitable program to support traffic safety.

Top Crash Countermeasures

Creating an effective program of countermeasures for streets or neighborhoods is a multi-faceted approach which must keep equitable solutions and accurate reporting in mind. The program should focus on infrastructure that is designed to improve safety for all users of the road, but also prioritize addressing the most severe safety issues in that area. Top countermeasures include:

- **Road Diets** – Road diets, or roadway reconfigurations, can improve safety, calm traffic, provide better mobility and access for all road users, and enhance overall quality of life. A road diet typically involves converting an existing four-lane undivided roadway to a three-lane roadway consisting of two through lanes and a center two-way left-turn lane (TWLTL) but can involve any amount of vehicle drive lane reduction/repurposing. The application of this strategy usually reduces the roadway segment speeds and can address many crash types. In many cases the extra pavement width can be used for the installation of bicycle or pedestrian infrastructure. **Caltrans Crash Reduction Factor = 30%**

- **Road Safety Audits** – Road Safety Audits (RSAs) are a formal safety performance examination of an existing or future road or intersection by an independent, multidisciplinary team. RSAs seek to find what elements of the roadway present safety concerns and to find what opportunities there are to remedy the problem. It both reports on possible road safety issues and finds opportunities for enhancements in safety. **FHWA Crash Reduction Factor = 60%**

- **Road Diets** – Road diets, or roadway reconfigurations, can improve safety, calm traffic, provide better mobility and access for all road users, and enhance overall quality of life. A road diet typically involves converting an existing four-lane undivided roadway to a three-lane roadway consisting of two through lanes and a center two-way left-turn lane (TWLTL) but can involve any amount of vehicle drive lane reduction/repurposing. The application of this strategy usually reduces the roadway segment speeds and can address many crash types. In many cases the extra pavement width can be used for the installation of bicycle or pedestrian infrastructure. **Caltrans Crash Reduction Factor = 30%**

- **Roundabouts –** Intersections that have a significant crash problem, in particular signalized intersections, can benefit dramatically from conversion to a roundabout. Roundabouts can also be very effective at intersections with complex geometry and intersections with frequent left-turn movements. Roundabouts are safer for drivers, pedestrians, and cyclists and often improve the operations of the intersection as well. They can be successfully implemented in all roadway contexts, including rural and urban areas. **Caltrans Crash Reduction Factor = 67%**

- **Sidewalks and Walkways** – Sidewalks and walkways provide people with space to travel within the public right-of-way that is separated from roadway vehicles. The presence of sidewalks on both sides of the street has been found to be related to significant reductions in the "walking along roadway" pedestrian crash risk compared to locations where no sidewalks or walkways exist. For areas noted as not having adequate or no sidewalks and a history of walking along roadway pedestrian crashes. In rural areas utilizing the roadway shoulder for pedestrians may be appropriate, especially with physical barrier protection for walkways or trail separation from vehicles adjacent to roadways. **Caltrans Crash Reduction Factor = 80% (Pedestrian Crashes)**

- **Dedicated Bicycle Infrastructure** - Dedicated bicycle facilities separate bicycle traffic from vehicle traffic and pedestrian traffic. Bicycle lanes provide marked areas for bicyclist to travel along the roadway and provide for more predictable movements for both bicyclist and motorist. Separated bike lanes provide increased safety and comfort for bicyclists beyond conventional bicycle lanes. By physically separating bicyclists from motor traffic, "protected" or physically separated bike lanes can offer a higher level of safety and comfort and are attractive to a wider spectrum of the public. **Caltrans Crash Reduction Factor = 45% (Bicycle Crashes)**

Eliminating traffic deaths and serious injuries will require everyone involved in the transportation system to focus all our efforts on achieving this goal. This means elected officials, planners, engineers, emergency responders, and drivers, walkers, and bicyclists on our roads all have a critical role to play. If any of these groups fail to act, achieving Vision Zero is not possible. **If we can do this, we can achieve Vision Zero.**

Introduction

The Metropolitan Transportation Commission (MTC) began the process to develop a Regional Safety Data System and Bay Area Vision Zero Action Plan in 2021. The Bay Area Vision Zero Data System (BAYVIZ) will provide an important resource for local jurisdictions to analyze, identify, and correct transportation safety problems when developing safety plans. The system will integrate information about crashes, infrastructure, equity, and demographics, as well as additional data that become available over time. The Bay Area Vision Zero Action Plan will leverage this data system to guide future traffic safety efforts in the area.

MTC recognizes an increasing focus on traffic safety at the federal and state levels and is taking initial steps to encourage more jurisdictions to prioritize safety by leading Vision Zero efforts in the Bay Area. The key objectives of this project are to:

1. Integrate key data sources into a comprehensive system that allows for easy access, synthesis, and analysis of safety data
2. Produce a "Vision Zero Action Plan," including a Regional High Injury Network
3. Proofing of the system, such that it may continue to be used well into the future as new and better data becomes available

As part of this effort, the team has developed this Vision Zero Action Plan. This document contains the complete and technical contents of this report. This report will serve as a basis for MTC and local jurisdictions to better understand current safety trends and issues in the Bay Area. This plan and the BAYVIZ system will also serve as the baseline to assist local jurisdictions to build upon to complete their own Vision Zero Action Plan process to move towards a future with zero traffic deaths.

Vision Zero Overview

MTC recognizes that as fatal and serious injury crashes increase in the region, policy changes are needed to reverse this trend. A regional approach to safety will help promote safety and reduce costs among cities and counties so that local governments can redirect limited funds toward implementing new safety projects and policies.

Vision Zero is a strategy to substantially reduce traffic fatalities and severe injuries, while increasing safe, healthy, equitable mobility for all with the ideal goal of eventually reducing traffic fatalities to 0. Vision Zero is rooted in the belief that everyone has the right to move safely in their communities, and that traffic deaths are preventable. Vision Zero takes a systems approach—to ensure that system designers and policymakers can improve the roadway environment—and a multidisciplinary approach—to acknowledge that many factors contribute to safety mobility, including roadway design, speeds, behaviors, technology, and policies. These two approaches set clear objectives to achieve the shared goal of zero fatalities and severe injuries.

Vision Zero Guiding Principles

To effectively implement Vision Zero, a number of guiding principles should be followed. These guiding principles are show in Table 1 below. If any one of these elements is excluded in the development of the Action Plan, the impact of the Action Plan will be severely limited.

Table 1: Fundamental Guiding Principles of Vision Zero

	Traditional/Prevailing	Vision Zero
Issue	Preventing all crashes	Preventing fatalities and serious injuries
Premise	Deaths are inevitable	Deaths are preventable
Focus	Perfecting human behavior	Designing a road system with a focus on reducing crashes by accounting for human error
Responsibility	Individual road users	Shared: road users and system designers

In addition to being focused on the Vision Zero guiding principles, a Vision Zero Action Plan must have the following key elements to be successful.

- **Data Driven** - In the past it was thought that fatal traffic crashes were random occurrences and could not be predicted or prevented. Modern analytical techniques have shown this premise to be false. Fatal and serious injury crashes are generally predictable and preventable more so than vehicle damage only crashes. Relying on data analysis—specifically the analysis of fatal and serious injury crashes—is the foundation of understanding traffic safety issues within a jurisdiction.
- **Actionable** – Once the data analysis has been completed, an action plan must be put in place with specific steps. A Vision Zero Action Plan should identify a series of specific tasks based on short-, medium-, and long-term timeframes, and should assign these tasks to specific individuals or departments.
- **Accountable** – Unless a mechanism is in place to track and report on the actionable steps from the Vision Zero action plan, it is difficult to continue progress towards achieving Vision Zero. Key Performance Indicators (KPIs) of success should be identified with desired targets in the Action Plan that can be tracked and used to improve accountability.

Safe System Approach

At the core of Vision Zero is the Safe System Approach. A Safe System Approach aims for human safety above all else and acknowledging the reality that people make mistakes. These mistakes on the roadway may lead to crashes. Preventing or minimizing the severity overall is key. Caltrans has pivoted to make safety a priority in its new four pillars approach, with implementing safe systems being a keystone.

The Safe System Approach is a data-driven, holistic, and equitable method to roadway safety that accounts for the needs of all users, acknowledges the possibility of errors by road users, and manages crash impact forces to levels tolerated by the human body. The Safe System Approach includes five elements: safe road users, safe vehicles, safe speeds, safe roads, and post-crash care. At the same time, the approach incorporates the 5 Es of traffic safety: equity, engineering, education, enforcement, and emergency medical services. It goes beyond the traditional approach to enlist designers, operators, and users of the transportation system to prevent fatal crashes and reduce crash severity. Figure 3 depicts FHWA's visualization of the Safe System Approach.



Figure 2: The Safe System Approach Principles and Elements (Source: FHWA)

The principle of safe road users means that all road users, including pedestrians, bicyclists, transit users, and drivers are accounted for on the roadway. Everyone deserves a safe transportation system, regardless of the mode they choose to travel. Interventions to encourage safe road users are both infrastructure and behavioral based. Examples of infrastructure-based countermeasures include sidewalks/multi-use paths, safe crossings, crosswalk visibility enhancements, rapid flashing/pedestrian hybrid beacons, and leading pedestrian intervals. Behavior countermeasures include public advocacy campaigns, seatbelt usage, and traffic laws.

Safe vehicles mean that the cars, trucks, SUVs, transit vehicles, or any other type are built to protect the driver, passengers, and all other roadway users they interact with. New technology advances have created systems within vehicles that mitigate some of the outcomes that could results from unsafe driving behaviors or error from the driver. These systems are either passive or active, meaning the vehicle simply alerts the driver to a possible danger or the vehicle takes control of the vehicle to avoid or mitigate a crash/conflict.

The third system with the Safe System approach is post-crash care. Even when improvements are made in all other facets of the system, crashes will still occur, and people will get injured. It is extremely important then to make sure emergency medical services (EMS) are available, notified, and responsive to minimize the human damage post-crash. Improvements to EMS systems, such as automated communication of crash location and severity, may can help reduce the deaths from traffic crashes that occur after the EMS arrive on scene.

Safe roads require infrastructure specific improvements to the roadway itself. These include countermeasures applied to both corridors and intersections. Improvements along corridor segments may include wider edge lines, horizontal curve enhancements, median barriers, and longitudinal rumble strips and stripes. Examples of intersection improvements include roundabouts, turn-lanes at stop-controlled intersections, access management, yellow change intervals, and signal backplates with reflective boarders.

The last system within the Safe System approach is safe speeds. Studies have shown that vehicles-pedestrian crashes where the vehicle is traveling over 30 mph result in approximately a 50% change that the pedestrian will be killed. If the vehicle is traveling over 40 mph, there is an 85% chance the pedestrian will die. It is critical to slow down vehicles to support a Safe System approach.

Vision Zero Action Plan Development

Integrating a Vision Zero mindset into road safety activities requires a long-term commitment from a range of stakeholders. Development of an action plan is recommended to serve as an overarching guide to inform the integration process and provide a framework to monitor and evaluate results.

In addition to identifying actions in this plan, this project is intended to assist MTC and local agencies in the MTC area in furthering safety analysis and Vision Zero efforts. Figure 4 depicts the key steps in the process to developing a Vision Zero Action Plan. More details on development best practices are included in the Appendix.



Figure 3: Vision Zero Action Plan Development Steps

The BAYVIZ System and Bay Area Vision Zero Action Plan will support the development of Vision Zero Action Plans by local agencies in supporting these key elements:

- Review of Current Road Safety Practice
- Literature Review (and Best Practices Review)
- Development of Road Injury Database (Regional Safety Data System)
- Data Analysis
- Strategy Development (Countermeasure Development)
- Implementation (Action Plan)
- Monitoring

This document will generally follow the framework of these elements and report on the results of the analysis and how this document can be utilized by MTC and local jurisdictions within the MTC area.

Federal Statutes Related to Crash Analyses and Legal Liability

Some concern may exist with local agencies to study and publish findings of their Vision Zero Action Plans. Broadly, states, counties, cities, and other agencies are protected from liability that could be associated with identifying crash issues and are encouraged to perform these studies to better understand traffic safety. There are several federal statutes which deal with highway safety and crash data that require agencies to conduct crash analyses and provide legal protections when conducting crash analyses.

23 U.S.C. 152 says that "Each state shall conduct and systematically maintain an engineering survey of all public roads to identify hazardous locations, sections, and elements, including roadside obstacles and unmarked or poorly marked roads, which may constitute a danger to motorists and pedestrians, assign priorities for the correction of such locations, sections, elements, and establish and implement a schedule of projects for their improvement."[1]

This implies that at the state level, there is a duty to understand facilities used by motorists and pedestrians with the goal being to identify locations and factors which may pose a hazard and require correction. States may delegate these duties to other entities (e.g., counties, cities, Metropolitan Planning Organizations, etc.).

With regards to the Highway Safety Improvement Program, it further states:

> "(2) IDENTIFICATION AND ANALYSIS OF HIGHWAY SAFETY PROBLEMS AND OPPORTUNITIES.—As part of the State strategic highway safety plan, a State shall—

[1] https://www.law.cornell.edu/uscode/text/23/152

(A) have in place a crash data system with the ability to perform safety problem identification and countermeasure analysis;

(B) based on the analysis required by subparagraph (A)—

(i) identify hazardous locations, sections, and elements (including roadside obstacles, railway-highway crossing needs, and unmarked or poorly marked roads) that constitute a danger to motorists (including motorcyclists), bicyclists, pedestrians, and other highway users;"

This directly ties the requirement to have a system to collect crash data, and analyze it to identify concerns and countermeasures, to each states' Strategic Highway Safety Plan (SHSP). As this applies to the system being developed by MTC, it is taking data already required to be collected and displaying it in a manner which will aid agencies in identifying and countering safety concerns on their transportation networks. Additionally, as per 23 U.S.C. 152 there needs to be a schedule of projects to make improvements. These are affirmative statements by which a state needs to comply.

Therefore, if a DOT (or other agency) is required to identify safety concerns and maintain a system which has the data needed to analyze and propose mitigations for these concerns, they need to do so openly and without fear of litigation. 23 U.S.C. 409 was codified to allay these concerns:

"Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 152(148)of this title or for the purpose of developing any highway safety construction improvements project which may be implemented using Federal-aid highway funds shall not be subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data. (As amended Nov. 28, 1995, P.L. 104-59, Title III, Sec.323, 109 Stat. 591.)"[2]

This means that Congress prohibited the introduction of the history of state/federal highway safety improvement projects into evidence in private litigation concerning crashes at these sites, prohibiting the introduction of these matters (studies, reports, petitions traffic counts correspondence, political demands, crash records, etc.) which have been "compiled or collected". When balancing competing interests, Congress determined that the public good is accomplished by prohibiting introduction of these matters into private litigation. Conversely the collection, monitoring, analysis, and reporting of this data will further benefit the public where and when safety improvements should occur.

Crashes are rare both temporally and spatially, single events may not be evidence of a safety concern which is correctable through an improvement. The varying nature of traffic, weather, and other factors are often not foreseeable. Therefore, Congress

[2] https://www.law.cornell.edu/uscode/text/23/409

decided that it should not be up to a judge or jury to second guess the decision to change a facility.

This helps foster the free flow of safety-related information by precluding the possibility that the information would later be admissible in civil suits. The statutes are clear that "all data collected or compiled for the purpose of planning any safety enhancement of potential accidents sites" or "for the purpose of developing any highway safety improvement project which may be implemented utilizing Federal-aid highway funds" is protected. Over time, any and every facility could be evaluated for improvements, whether as small as modifications to pavement markings or signing or as large as a reconstruction or reconfiguration, therefore all the data maintained to compare the need for improvement or identify specific concerns or countermeasures is protected.

These statutes do not say that the data should be shielded from view but rather that agencies should not fear to hold and maintain this data in support of their safety programs. If there is liability associated with collecting and distributing safety data, it may stem from the lack of identification of concerns rather than sharing it.

Review of Current Road Safety Practice in the Bay Area

When producing a Vision Zero Action Plan, it is important to benchmark against past and current safety activities. Being a regional plan, this section summarizes the current safety plans and strategies within the MTC region. Statewide safety programs are discussed as well as Bay Area Safety Plans, local roadway safety plans, and vision zero initiatives.

Statewide Safety Programs

Federal regulations require that each State have a Strategic Highway Safety Plan (SHSP). The SHSP is a statewide data-driven road safety plan to reduce crash fatalities and serious injuries. It works with the Highway Safety Improvement Program (HSIP), the Highway Safety Plan, and the Commercial Vehicle Safety Plan to improve traffic safety throughout the state of California. The goal of the SHSP is to move towards zero fatalities and serious injuries. It establishes goals, objectives, and emphasis areas (common crash types). Actions will be developed for focus areas within the high-priority area. The SHSP indicates strategies, actions within the 5 Es: Education, enforcement, engineering, emergency response, emerging technology, and evaluating progress. Caltrans has recently completed an update to the SHSP for 2020 – 2024.[3] Themes from the SHSP include:

- **Guiding Principles:**
    - **Integrate Equity** - The SHSP integrated equity into all aspects of the plan to address institutional and systemic biases. This will ensure that the processes, strategies, and outcomes of the SHSP serve all, but particularly vulnerable and traditionally underserved populations.
    - **Double Down on What Works** - The SHSP focuses on implementing proven safety countermeasures that are highly effective in reducing fatalities. These include the technical resources from the FHWA's Proven Safety Countermeasures as well as the NHTSA's Countermeasures That Work. See more at Caltrans webpage on Proven Safety Countermeasures.
    - **Accelerate Advanced Technology** - As technology development continues, the SHSP encourages advanced technology in and on our roadways by forming new partnerships with technology providers, health and safety groups, manufacturers, and government partners to prioritize safety.

[3] https://dot.ca.gov/programs/safety-programs/shsp

    - **Implement a Safe System Approach** - The Safe System Approach aims to eliminate fatal and serious injuries for all road users through a holistic view of the roadway system.
- **High Priority Challenge Areas**
    - Lane Departures
    - Impaired Driving
    - Speed Management / Aggressive Driving
    - Pedestrians and Bicyclists
    - Intersections

The focuses of the SHSP are guide the distribution of HSIP funding. HSIP is a federal funding program for infrastructure improvement along state highways and local roads with the goal of reducing fatalities and serious injuries. California's Local HSIP focuses on infrastructure projects based on historical crash data, crash potential, or other data-supported means. The program provides funding for preliminary engineering, right-of-way acquisition and construction using nationally recognized crash reduction factors (CRFs).

Distribution of HSIP funds traditionally followed the development of a safety plan by the local jurisdiction. Starting in 2022, the distribution of HSIP funding will require a safety plan to be completed. This safety plan could be a Local Road Safety Plan (LRSP), Strategic Safety Analysis Report (SSAR), or Vision Zero Action Plans (VZAP). Table 2 lists distinctions between the three types of safety plans.

Table 2: Safety Plan Distinctions

Vision Zero Action Plan	Local Road Safety Plan (LRSP)	Systemic Safety Analysis Report Program (SSARP)
• Vision Zero plans require using data to identify safety issues, but the principles of Vision Zero emphasize fatalities and serious injuries. • Vision Zero emphasizes that we should not accept even one fatal or serious crash, and a reduction of those crashes is paramount over all other safety goals. For example, minor crashes might increase if serious crashes are decreased. • Collaboration among staff and departments of an agency is a critical part of developing the VZ plan • Engagement with the community, particularly communities of concern, is a critical part of the VZ plan • VZ plans should be constantly reassessed, evaluating the effectiveness of countermeasures to build on the data available	• Generally follow state Strategic Highway Safety Plan but are tailored to a jurisdiction's concerns. • LRSPs do require analyzing safety data, but there is less detail regarding what specific data to use and how to analyze that data • LRSPs might still identify human factors or human error as the primary causes of crashes • LRSPs also focus on collaboration between internal stakeholders, and developing the LRSP should facilitate these partnerships • Although LRSPs also identify community engagement as important, it is much less emphasized than in a VZ plan • LRSPs are a "living document" that should be updated over time as trends change and new problems arise, or old problems subside	• SSARs specifically require certain data elements, including the most frequent crash types, high risk corridors and intersections, and specific countermeasures to address those areas. • SSARs might still identify human factors or human error as the primary causes of crashes • While SSARs may benefit from internal stakeholder collaboration, it is not a strict requirement of the SSAR • SSARs do not necessarily involve community engagement • SSARs are more of a point in time analysis that aims to identify the problems that exist in the present

Bay Area Safety Plans

Many counties and cities within the Bay Area have created their own safety plans. All nine Bay Area counties either have completed a safety plan or are in the progress of completing a safety plan. Additionally, 64 of the 101 Bay Area cities have completed a safety plan or are in the progress of completing a safety plan. Nine communities have both a Vision Zero resolution and a Vision Zero Action Plan.

This section highlights several of those plans and details their contents. A full reporting of safety plans in the Bay Area are included in the Appendix of this report.

Local Roadway Safety Plans

A local road safety plan (LRSP) provides a framework for identifying, analyzing, and prioritizing roadway safety improvements on local roads. The LRSP development process and content are tailored to local issues and needs. The process results in a prioritized list of issues, risks, actions, and improvements that can be used to reduce fatalities and serious injuries on local roads. LRSP is data-driven, tailored to the local conditions, and based on community engagement. The California Transportation Commission (CTC) allocated $10 million in 2019 and $8 million in 2020 to assist local agencies with developing LRSPs. Caltrans released the latest agencies funding list in March 2021.

In 2020, Sonoma County Transportation Authority procured seven LRSPs from the California SHSP. These LRSPs will have similar goals to the California SHSP and Sonoma County Vision Zero but will be tailored to the local roadway needs of each agency. Like Sonoma County, Santa Clara Valley and San Mateo Counties in the MTC region received funding for itself and local agencies to develop their LRSP. Also, a local agency directly applied for funding. Some ongoing LRSPs include Cities of Petaluma, Healdsburg, Cotati, Rohnert Park in Sonoma County, San Mateo County, Antioch in Contra Costa County. Two completed local LRSPs in Sonoma County are summarized below.

Petaluma, Sonoma County, LRSP 2021

The City of Petaluma LRSP sets five clear and achievable goals. The study includes crash data analysis, community engagement, implementation, and evaluation criteria. Data analysis included five-year crash data (2015-2019) of all injuries, incapacitating injures, and fatalities separated by bicycle and pedestrian transportation modes. Using the data analysis include five emphasis areas that include high-incident locations, intersection visibility/access management, speeding, DUI, and unsafe starting and backing. Within each emphasis area, systematic countermeasures that include engineering, education, enforcement, and emergency actions. Ten high crash intersections were identified, detailed safety analysis conducted, and specific countermeasures with crash modification factors (CMFs) recommended. The City of

Petaluma is expected to apply for HSIP funds for preliminary engineering and construction of the identified high crash locations.

Healdsburg, Sonoma County, LRSP 2021

The City of Healdsburg LRSP includes data analysis, community engagement, and countermeasure strategies, prioritized projects, and the evaluation progress. Data analysis included five-year crash data (2015-2019) and analyzed within emphasis area, as collisions related to bicyclists, pedestrians, districted, aggressive driving and intersections. Countermeasures were identified at the eight high-injury intersections and seven segments. Evaluation criteria were tied the identified goals, with clear targets for each goal. The LRSP is intended as a living document with updates every five-years.

Vision Zero Action Plans

Counties and other local agencies have Vision Zero action plans. While some agencies have a Vision Zero Action Plan instead of the LRSP, some agencies use the information in their Vision Zero action plan to inform the LRSP. Local agencies that have adopted Vision Zero resolution and have a Vision Zero action plan are:

- San Jose City, Santa Clara County
- San Francisco City and County
- Sonoma County and Cities
- Oakland, Alameda County,
- Fremont, Alameda County,
- Berkeley, Alameda County,
- San Mateo, San Mateo County
- Alameda, Alameda County,
- Piedmont, Alameda County, Piedmont Safer Streets 2021 is expected to be adopted in early 2022

Two comprehensive Vision Zero action plans are highlighted below.

Fremont Vision Zero 2025: Action Plan and Status Report

Fremont Vision Zero released on May 2021 and has two parts. The first part is a Vision Zero progress report since the City of Fremont adopted in 2015. The second part of the report sets the goals and strategies for the next phase until 2025. The City's safety accomplishments were analysis using qualitative and quantitative measures, with project spotlights, and included:

- Comparison of three-year crashes (2013-2015) before vision zero adoption with three-years after crashes (2018-2020),
- Its safe routes to school program, a three-year effort to implement safety improvements like new all-way stop signs, high visibility crosswalk, parking restrictions, tactical/paint & plastic bulb outs, along with, a citywide campaign

"drive slowly, be healthy" promoting 20 mph advisory speed on all residential streets,
- The number of safety improvements at intersections and segments,
- Reduction of fatal and severe crashes, correlated to speed management strategies, and better street lighting improvements.

The new action plan for 2025 uses a needs-based approach based on crash type, most vulnerable people- pedestrians, bicyclists, older and unhoused people, high-crash locations mostly along the fastest streets. Ten actions were identified in the next level action plan and organized under: 1) get state legislation for safer speeds; 2) continue local actions for safer speeds; and 3) encourage support from regional partners. The action plan also includes projects that must be prioritized for construction by 2022.

Vision Zero San Francisco Action Strategy 2021-2024

San Francisco adopted its Vision Zero plan in 2014. Vision Zero SF 2021-24 an updated action strategy was in released in November 2021. Like Fremont's Vision Zero 2025, the Vision Zero SF 2021-25 has two parts, one reports on progress made since 2014 and describes on new actions. The action strategy is anchored with five core principles, with an equity focus. Updated actions include:

- Investing in the quick-build program within the identified high-injury network,
- Developing an active transportation network,
- Advancing a comprehensive speed management plan that include reducing, speeds to 20 mph implemented along some streets,

These actions and improvements are expected to be implemented using an equity lens by:

- Strengthening community engagement with community leaders,
- Focusing on constructing complete safety projects within Communities of Concerns, and
- Using proven enforcement alternatives like speed cameras that can reduce bias.

Vision Zero SF regularly reports the progress every year. The Vision Zero SF measures progress with several metrics with specific targets for each of the strategies to quantify the impact and effectiveness of Vision Zero SF projects and programs.

Summary of Current State of Safety

State funding for developing LRSPs, then safety improvements funding from HSIP has encouraged local agencies to develop local safety plans. The local LRSP plans use the FHWA template that includes identifying high-injury locations and emphasis area using crash data, and comprehensive community engagement when developing strategies and countermeasures.

These state incentives have encouraged most counties, cities to develop a safety action plan (LSRP), if they don't have a Vision Zero Action plan. As of 2021, only 39 agencies out of 111 local counties and municipal agencies, do not have any safety plans funded or planned.

Table 3: Current Safety Plans in the Bay Area

Regional Safety Plan in the MTC Region	Priority Areas/Network
2020-24 Strategic Highway Safety Plan (SHSP), Caltrans	High Priority Areas: Active Transportation, Impaired Driving, Intersections, and Departures, Speed Management/Aggressive Driving. Focus Areas: Aging Driver (Equal to >65), Commercial Vehicles, Distracted Driving, Driver Licensing, Emergency Response, Emerging Technologies, motorcyclists, Occupant Protection, Work Zones, Young Driver (15-20)
Vision Zero Action Plan in local jurisdictions	
Contra Costa Countywide Transportation Safety Policy and Implementation Guide	Safety Priority Locations (fatal and severe injury crashes separated by mode-pedestrians, biking, motor vehicles)
Eliminating Traffic Deaths in San Francisco	High-Injury Network, Community of Concern
Fremont Vision Zero 2020	Safety Priority Streets (fatal & severe collusions)
Berkeley Vision Zero Action Plan	High-Injury Streets (fatal & severe collusions), Equity Priority Community
Vision Zero San Jose. Action Plan 2017 & 2018	Priority Safety Corridors (PCSC), Communities of Concern
Daly City Action Plan 2020	High-Injury Network (fatal & severe injury crashes), Emphasis Areas: Crashes on arterials, pedestrian-involved crashes, nighttime crashes, crashes while impaired, and broadside crashes at intersection.
Safe Oakland Streets Initiative	High-Injury Network severe and fatal crashes separated by mode- multimodal, pedestrian, bicycle, and motor vehicle, Community of Concern (low, medium, high)
Alameda Vision Zero Action Plan 2021	High-injury corridors (killed & severely injured) separated by pedestrian, bicycle, motorcycle, and automobile High Social Vulnerability Area

Literature and Best Practices Review

As part of this report a literature review was conducted to understand the state of practice of analytical approaches to traffic safety and Vision Zero and ensure adherence to best practice. The team conducted a search for the most recent and relevant literature, including journal articles and reports, through the Transport Research International Documentation (TRID) and the University of California, Berkeley (UC Berkeley) Safe Transportation Research and Education Center (SafeTrec) databases.

In addition to the literature review, an analysis has been made of the current best practices with a sampling of example Vision Zero action plans from California, nationally, and internationally. An outline of the steps to move towards implementation of Vision Zero are covered in addition to identifying the key elements of a comprehensive Vision Zero action plan.

The full Literature and Best Practices Review is included as Appendix C to this report. This section summarizes the key takeaways from the findings of that review. These key takeaways were identified as most relevant to the Safety Data System and State of Safety in the Region Report development and were used in the development of this report.

Overall Key Takeaways

- Road safety should focus on eliminating fatalities and serious injuries.
- A data-driven analysis approach will narrow the focus to areas with the greatest need or impact.
- Quality data is vital to understanding safety issues and should be obtained from multiple sources.
- Current analysis methods and data are not as robust for vulnerable road users.
- Visualization tools may help practitioners make more informed decisions using data.
- Data helps decision-makers identify both emphasis areas as well as effective countermeasures.
- A comprehensive analysis approach allows for both spot and systemic improvements based on data availability or potential changes.
- A High Injury Network (HIN) should be developed to help prioritize and target countermeasures
- Setting and monitoring performance targets is necessary to help track and communicate progress towards safety goals.
- Vision Zero requires a long-term commitment from a range of stakeholders

- Development of a Vision Zero action plan is recommended to serve as an overarching guide.

Data Collection Key Takeaways

- Quality data is vital to understanding safety issues.
- Effective data collection will lead to high-quality, timely, and accessible data.
- Safety data should come from multiple sources.
- Understand that police crash data is often incomplete, especially for bicycle and pedestrian crashes and in equity priority communities.
- Integrating public health/hospital/trauma data can help fill gaps.
- Self-Reported crashes in certain instances can help fill gaps in public data

Data Analysis Key Takeaways

- Analysis should focus on KSI crashes (crashes with people killed or seriously injured).
- Analysis should study contributing factors to KSI crashes such as:
    - Speed
    - Vulnerable Users
    - Equity
    - Ride Mode Share
    - Impaired Users
- Analysis should be done with multiple approaches:
    - Hot spot analysis
        - Schools
        - Transit Hubs
        - Commercial Areas
    - Systemic/predictive analysis
- Data requirements should vary based on the level of analysis; broader screenings should require fewer inputs than a narrow analysis at a specific location.
- Practitioners must understand the possibility of bias when attempting to estimate risks using available crash data. Methods to understand and counteract this bias include:
    - Utilizing anecdotal data through public engagement to understand issues beyond what is seen in the data
    - Understanding implications of small sample sizes in areas with low population/low crash frequencies
    - Prioritizing vulnerable users by either introducing weights into a formula-based approach or limiting the data analysis to emphasize a priority user

Data Outputs Key Takeaways

- Leverage safety data analysis outputs to create visualizations to identify patterns, develop countermeasures, develop policies, and evaluate performance

- Develop internal and public facing visualization outputs
- Summarize analysis results in a meaningful using tools such as
    - High-injury or crash network maps
    - Data reports that describe crash frequency, crash averages, crash trends, and crash rates
- Use analysis to identify countermeasures using various approaches:
    - Spot Location
    - Systemic approach
    - Comprehensive approach combining spot and systemic

Vision Zero Best Practices Key Takeaways

- Integrating a Vision Zero mindset into road safety activities requires a long-term commitment from a range of stakeholders
- Development of a Vision Zero action plan is recommended to serve as an overarching guide
- Vision Zero Action Plan must have the following characteristics elements to be successful
    - Data Driven
    - Actionable
    - Accountable
- A complete Vision Zero Action Plan is an involved document that requires a substantial amount of work by practitioners and outreach to community members, public agency staff, and other stakeholders
- A High Injury Network (HIN) should be developed to help prioritize and target countermeasures. HIN should consider:
    - Years of data
    - Intersection or corridor focused analysis
    - Roadway facility types included
    - Consideration of transportation modes
    - Weight assignment, such as assigning more weight to collisions involving certain populations or types of injury severity
    - Normalization
    - Overall threshold, which determines a potential cut-off for including a portion of a roadway on the high injury network

Bay Area Vision Zero System Development Overview

Vision Zero is a data-driven approach to road safety. A centralized, comprehensive, and georeferenced crash database helps provide a full picture of current road safety performance, enabling in-depth analysis. This project has identified existing road safety databases including the SWITRS and TIMS systems and identified data needs beyond these existing systems. An extensive survey of users was conducted to identify use cases and tailor the regional safety data system to the needs of Bay Area users. This system has been dubbed the Bay Area Vision Zero System (BAYVIZ). This section details the data sources, system architecture, access, and other features of the system.

Data Sources

To gain a complete picture of traffic safety issues in an area, multiple data sources are needed. To develop the BAYVIZ system, these data sources generally fell into three categories:

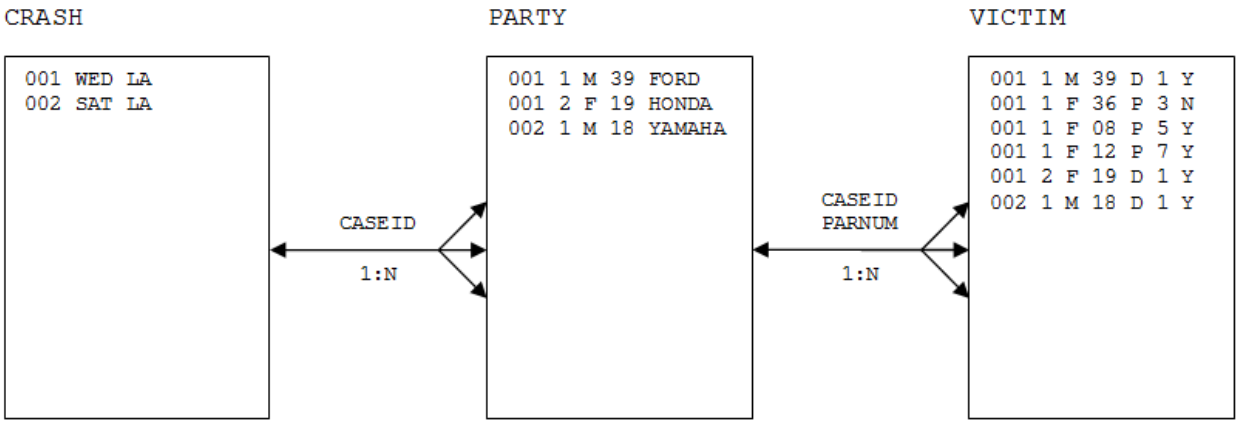
- Crash Data
- Infrastructure Data
- Demographic Data

A fourth set of hospital trauma data was considered. However, the ongoing COVID-19 pandemic made it impractical to coordinate with epidemiologists to collect this data at the time of developing the BAYVIZ system. This data should be assessed for inclusion in the BAYVIZ system in the future.

Crash Data

Crash data was obtained primarily from the Statewide Integrated Traffic Records System (SWITRS) maintained by the California Highway Patrol. The data was accessed using the Transportation Injury Mapping System (TIMS) maintained by SafeTREC.

SWITRS is a relational database containing three primary data tables—Crashes, Parties, and Victims—as shown in Figure 4. The Crash table contains one crash for each line and includes information related to location, crash type, weather, and more. There are typically multiple parties per crash and information about the parties involved are contained in the Party table. The Party tables contain information about the major parties involved in the crash event including drivers, pedestrians, cyclists, and parked vehicles. The data is related to demographics, vehicle type, and other information. Each of the parties may have multiple victims and information about these victims are in the Victim table. A victim may be a party such as the driver of a car or a non-party such as a passenger in the car. The Victim table contains information on individuals including demographics and injury severity.



JOINED TABLE

```
001 1 M 39 D 1 Y M 39 FORD    001 WED LA
001 1 F 36 P 3 N M 39 FORD    001 WED LA
001 1 F 08 P 5 Y M 39 FORD    001 WED LA
001 1 F 12 P 7 Y M 39 FORD    001 WED LA
001 2 F 19 D 1 Y F 19 HONDA   001 WED LA
002 1 M 18 D 1 Y M 18 YAMAHA  002 SAT LA
```

Figure 4: SWITRS Relational Database Structure Example (Source: https://tims.berkeley.edu/help/SWITRS.php)

Data from all three of the data tables was utilized in various forms throughout the BAYVIZ system development and development of this plan. For all summary statistics, systemic analyses, and development of the High Injury Network, the date range utilized of crashes included the five years of 2015 – 2019. The exception to this is the trend data, which included the ten years of 2010 – 2019.

The analysis conducted in this plan only utilizes crashes were someone was killed or seriously injured (KSI crashes). KSI crashes were identified using the SWITRS designation of Fatal, Severe Injury, and Suspected Serious Injury crashes. Note that the Severe Injury crash definition was changed to the new Suspected Serious Injury crash definition, first introduced in the Bay Area in 2017. Both definitions are still in use across the region and are considered to be equivalent for the purposes of analysis in this document. The term "serious injury" is used to denote both severe injury and suspected serious injury crashes. These crashes typically involve the following types of injuries:

- Severe laceration resulting in exposure of underlying tissues/muscle/organs or resulting in significant loss of blood
- Broken or distorted extremity (arm or leg)
- Crush injuries

- Suspected skull, chest, or abdominal injury other than bruises or minor lacerations
- Significant burns (second and third degree burns over 10% or more of the body)
- Unconsciousness when taken from the crash scene
- Paralysis[4]

Demographic Data

Demographic data for the BAYVIZ system was obtained from the United States Census Bureau data sets, primarily the American Community Survey averages for 2015 – 2019. Demographic data obtained includes information on population, race, sex, employment, poverty, and other similar data. This data was utilized to display general demographic trends for the various analyses, and also utilized to calculate rates of crashes per 100,000 residents where rates were calculated.

Physical and Operational Data

To better understand the characteristics of crashes, infrastructure and operational data was obtained to conduct the systemic analysis. The systemic analysis relates crash rates to various physical and operational characteristics of the roadways where the crashes happen. The features obtained include:

- Roadway characteristics
  - Number of Lanes
  - One-Way/Two-Way Traffic
  - Divided or undivided
  - Signalization of intersection
  - Presence of sidewalk
  - Location and type of crosswalk
  - Presence and type of bicycle facility
  - AADT
- Speeds
  - Posted speed limits
  - Prevailing speeds of drivers
- Traffic Volumes (AADT)
- Points of Interest
  - Schools/Childcare Facilities
  - H
  - Transit Stops
  - Parks

The sources for the features are shown in Table 4 and the MIRE FDE Elements are shown in Table 5.

Table 4: Potential Sources of Desired Features

[4] https://safety.fhwa.dot.gov/hsip/spm/docs/factsheet-mmucc-4edition.pdf

Potential Source	Feature
	Divided or Undivided
	Paved or Unpaved Surface
	Presence, Width of Shoulder
	Signalization of Intersection
Aerial Imagery Extraction	Presence of Sidewalk
	Presence, Type of Crosswalk
	Presence of ADA Ramp
MTC Active Transportation Plan	Presence, Type, Width of Bicycle Facility
MTC TravelModel2	Vehicle Traffic Volumes & Capacity
	Bike/Ped Activity or Volumes
Inrix	Typical Vehicle Speed Data

Table 5: MIRE FDE Elements

	Unpaved	Local Paved	Non-Local Paved		
Element	**Roadway Segment**	**Roadway Segment**	**Roadway Segment**	**Intersection**	**Interchange/Ramp**
AADT (79)		x	x	x	
AADT Year (80)			x	x	
Access Control (22)			x		
Begin Point Segment Descriptor (10)	x	x	x		
End Point Segment Descriptor (11)	x	x	x		
Direction of Inventory (18)			x		
Federal Aid/Route Type (21)			x		
Functional Class (19)	x	x	x		x
Interchange Type (182)					x
Intersection/Junction Geometry (126)				x	
Intersection/Junction Traffic Control (131)				x	
Location Identifier for Road 1 Crossing Point (122)				x	
Location Identifier for Road 2 Crossing Point (123)				x	
Location Identifier for Roadway Beginning Ramp Terminal (197)					x
Location Identifier for Roadway Ending Ramp Terminal (201)					x
Median Type (54)			x		
Number of Through Lanes (31)		x	x		
One/Two-Way Operations (91)			x		
Ramp AADT (191)					x
Ramp Length (187)					x
Roadway Type at Beginning Ramp Terminal (195))					x
Roadway Type at Ending Ramp Terminal (199)					x
Route Number (8)			x		
Route/Street Name (9)			x		
Rural/Urban Designation (20)		x	x		
Segment Identifier (12)	x	x	x		
Surface Type (23)		x	x		
Type of Govermental Ownership (4)	x	x	x		x
Unique Approach Identifier (139)				x	
Unique Interchange Identifier (178)					x
Unique Junction Identifier (120)				x	
Year of Ramp AADT (192)					x

User Profiles

The functionality of the BAYVIZ System was developed based on the need of a broad range of potential users in the Bay Area. Consultant and MTC staff worked with the Data Technical Advisory Committee to identify potential user types and understand their roles and contributions to traffic safety. These users include:

- Planner
- Staff or consulting engineer
- Grant writer
- Safe Routes to School Coordinator
- GIS administrator
- Journalist
- Advocate
- Parent

	Collect Data	Analyze Data	Develop Strategic Plan	Safety Project & Policy Development				Measure Outcomes
				Identify	Prioritize	Fund	Implement	
Law Enforcement Officers	Lead		Support	Support			Support	
Elected Official			Support	Support	Support	Lead		
Planner		Lead	Lead	Lead	Lead	Support	Support	Lead
Engineer		Support	Support	Support	Support	Support	Lead	
Advocate			Support	Support	Support	Support	Support	
Journalist	Support	Support		Support		Support		Support
SRTS Coordinator			Support	Support	Support		Support	
Data Scientist	Support	Support			Support			Support

Figure 5: Potential Safety Data System Users and their Role in Traffic Safety

Several profiles for various user types were created to better understand the needs of potential data system users. These profiles were used to develop use cases for the data system.

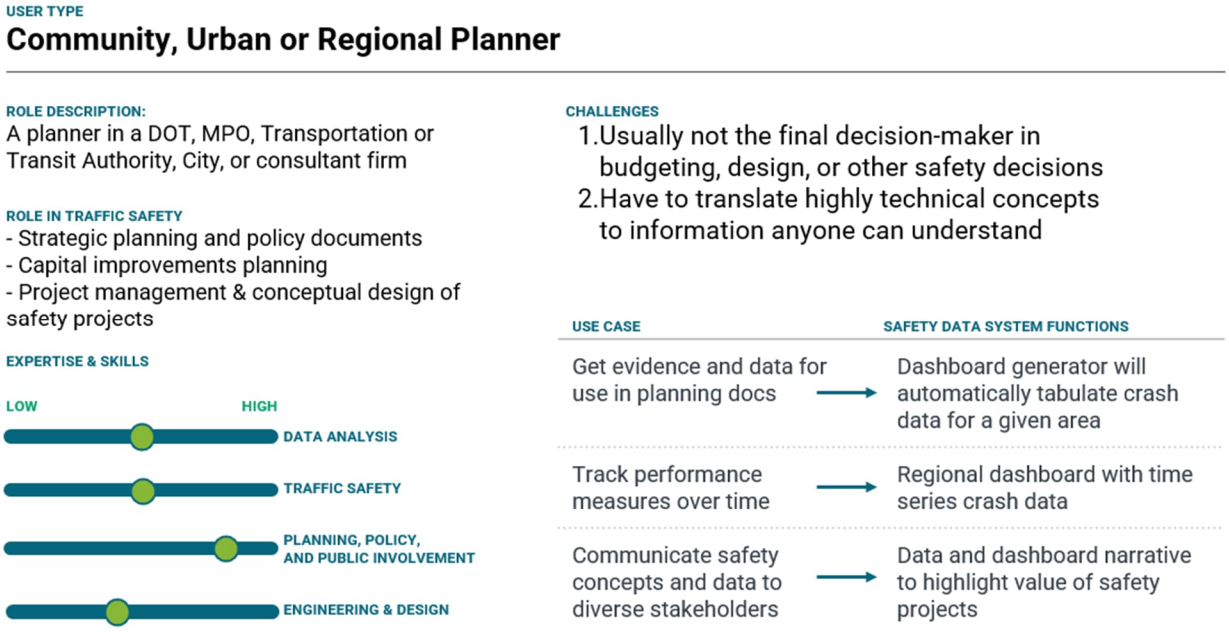


Figure 6: Sample user profile

This system appeals to a broad range of users, it can also be used for many tasks. The below:

- Apply for a grant
- Understand their community
- Budget for street improvements
- Redesign a street, intersection, or other facility
- Testify at a City Council meeting or State Assembly meeting
- Measure VZ progress each year
- Write a journal article
- Plan a walking or biking route
- Prioritizing funding within a jurisdiction
- Long range comprehensive planning
- Prioritizing maintenance
- Communicating with stakeholders and the public

BAYVIZ System and Dashboard Generator

The BAYVIZ System and dashboard generator were developed simultaneously. They were informed by research into traffic safety literature in this report, user interviews, evaluation of existing software solutions, and anticipated analytical needs for this study. The technology solution consists of a relational database that conflates multiple disparate datasets into a single, convenient source and a dynamic user interface that aggregates and summarizes data for a user-determined area of interest. The data visualizations and other information are arranged to mirror the Vision Zero Action Plan framework, enabling end users to make informed decisions about safety in the selected area.

1. BAYVIZ System Database

    a. **Powers dashboard generator** and much of the analysis for the regional report

    b. Can also be used by **MTC & Stakeholders for custom analysis**

    c. Provides data wrangling & conflation of multiple sources to a common point of reference

    d. Incorporates 3rd party infrastructure data for sidewalks & crosswalks

    e. Leverages existing MTC data sources & subscriptions for safety purposes

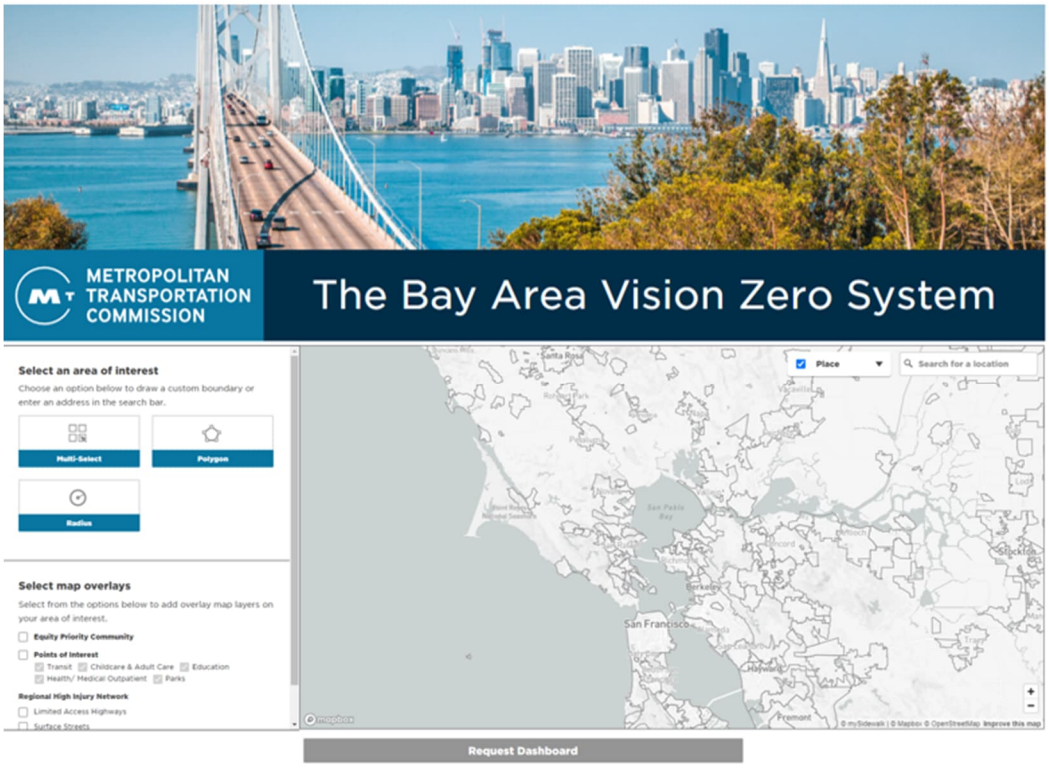
    f. Provides access to community-level indicators (i.e., equity data) from mySidewalk

Specific data sources are listed in the previous section.

2. Data Tool for Local Analysis
    a. Allows report creation for a custom area-of-interest (AOI) with a standard comprehensive template, built with and for the DTAC
    b. Includes resources a community would need to begin a Vision Zero Action Plan
    c. Provides on-the-fly aggregate statistics that automatically pull together multiple sources
    d. Provides context about place, equity, and road characteristics to accompany crash data
    e. Creates comparisons between County and Region the AOI falls within
    f. Generates High Injury Networks for the selected AOI
    g. Highlights appropriate crash countermeasures based on costliest crash types in AOI

Dashboard Generator Overview

Users can draw their own AOI by selecting Census Tracts, Cities/Places, or Counties; drawing a custom polygon; or drawing a radius around a point. Informational overlays, such as the High Injury Network or Equity Priority Communities, can be toggled on or off. Users must submit their name and email address and will receive a link to the interactive dashboard in their email inbox.



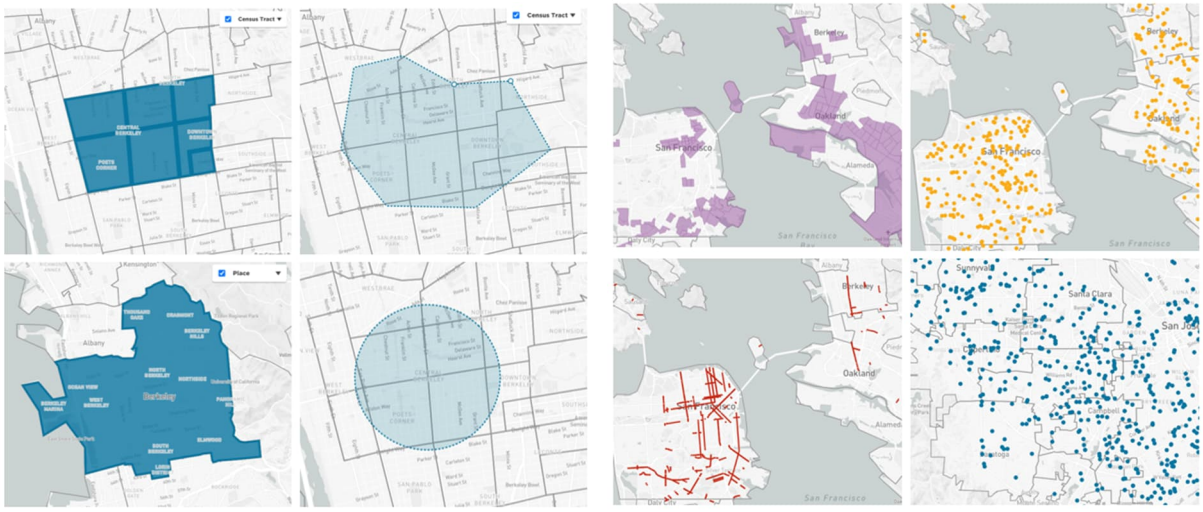


Figure 7: Selection Options (Left) and Overlays (Right)

The dashboard includes the following primary sections:

Crash Summaries: Summary statistics on crashes within the selected Area of Interest, as well as comparisons to the County the AOI falls within and the entire region.

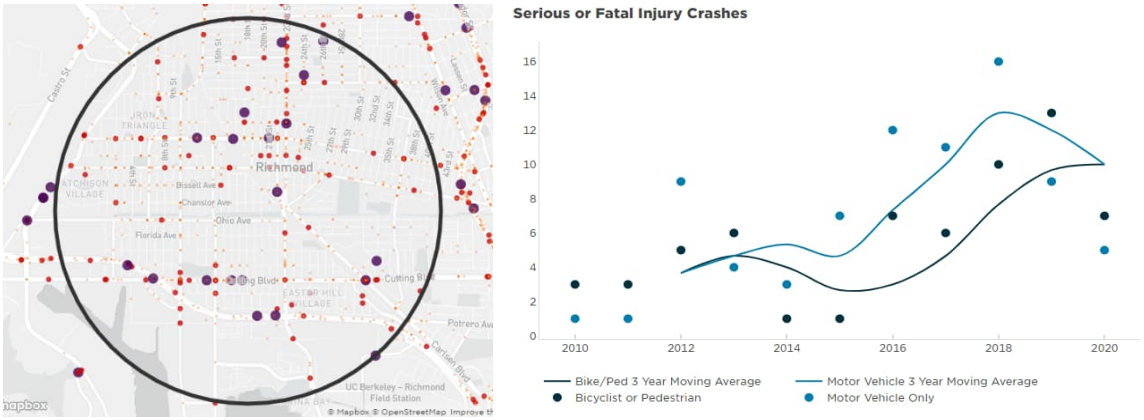


Figure 8: Maps and Time Series Trends for the AOI

Maps show the location of fatal, serious injury, and other injury crashes in the area of interest. A time series visualization compares the actual and moving-average fatal/serious injury (KSI) crash trend for motor vehicles and vulnerable road users in the area of interest. Major crash types are compared between the AOI, County, and Region. The Highest injury segments and intersections for the AOI are displayed to aid in the creation of a local High Injury Network.

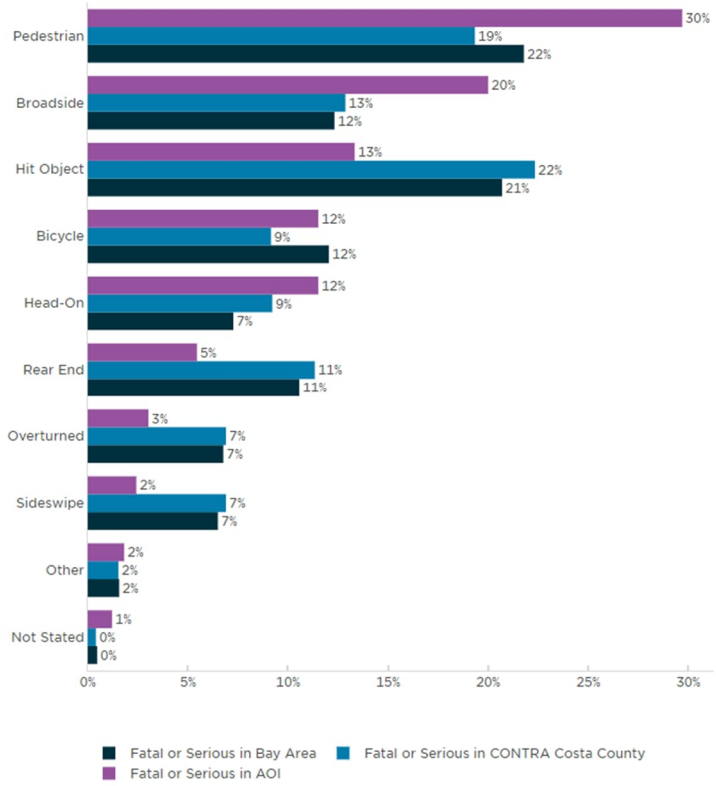


Figure 9: Crash Type Comparison between AOI, County, and Metro

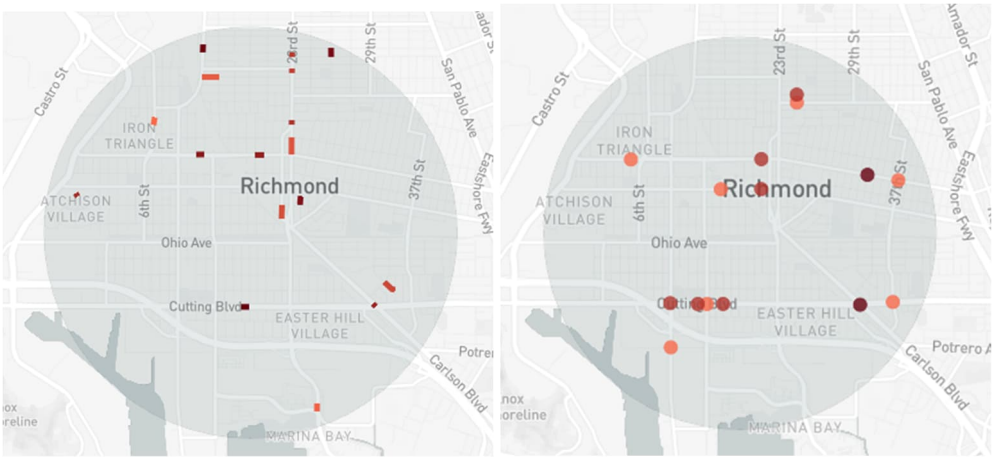


Figure 10: High Injury Segments and Intersections in the AOI

Our Community: Information about the people who live, work, and visit the Area of Interest (in other words, the road users in this area). This includes demographic data from the Census/ACS and various points of interest in the region.

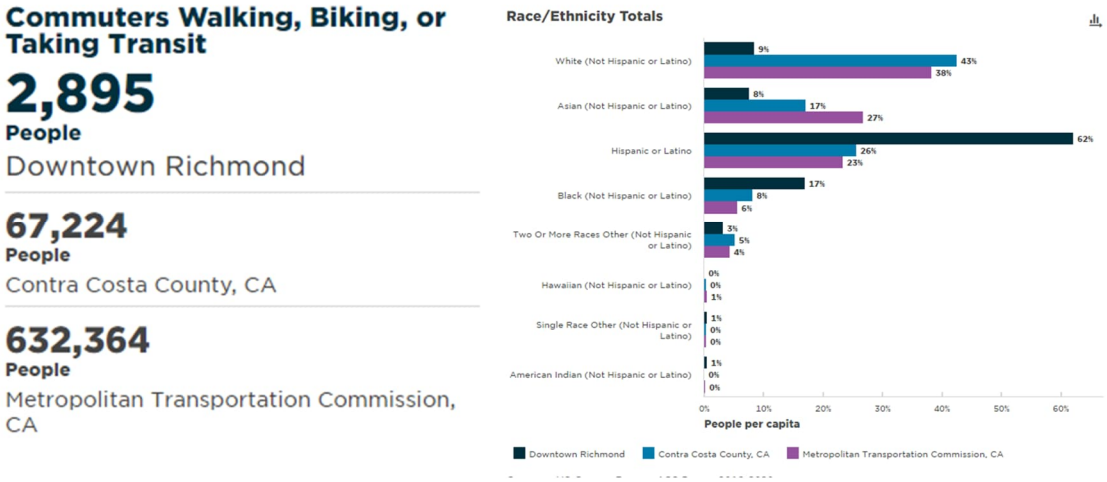


Figure 11: Total non-driving commuters and race/ethnicity totals are shown for the AOI, County, and Bay Area.

Our Streets: As crashes are mapped to roadway attributes, it is possible to compare the relative share of those roadway attributes to the proportion of crashes associated with those attributes.

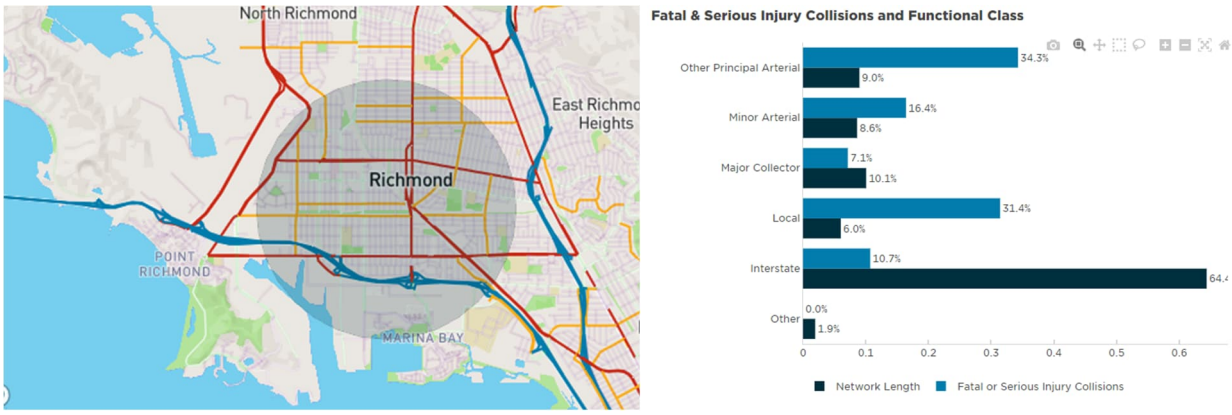
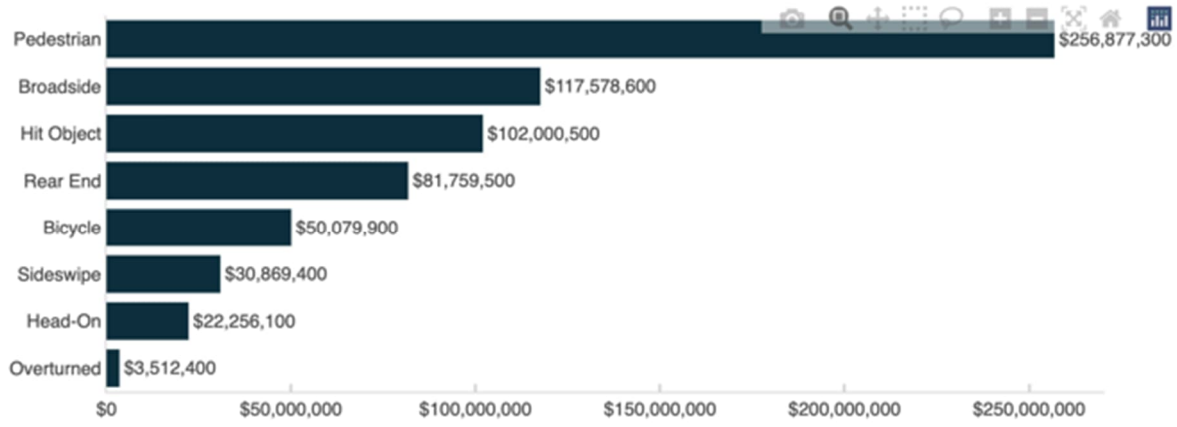


Figure 12: Map and Bar Chart Comparing Functional Class Network Length & KSI Crash Proportions

Toward Vision Zero: This section is organized by major crash type and contains information on the location, severity, and overall cost to society of these crashes in the area of interest. Information on relevant countermeasures is provided, with links and resources to Caltrans' Local Road Safety Manual, FHWA's Proven Safety Countermeasures, and other relevant resources.



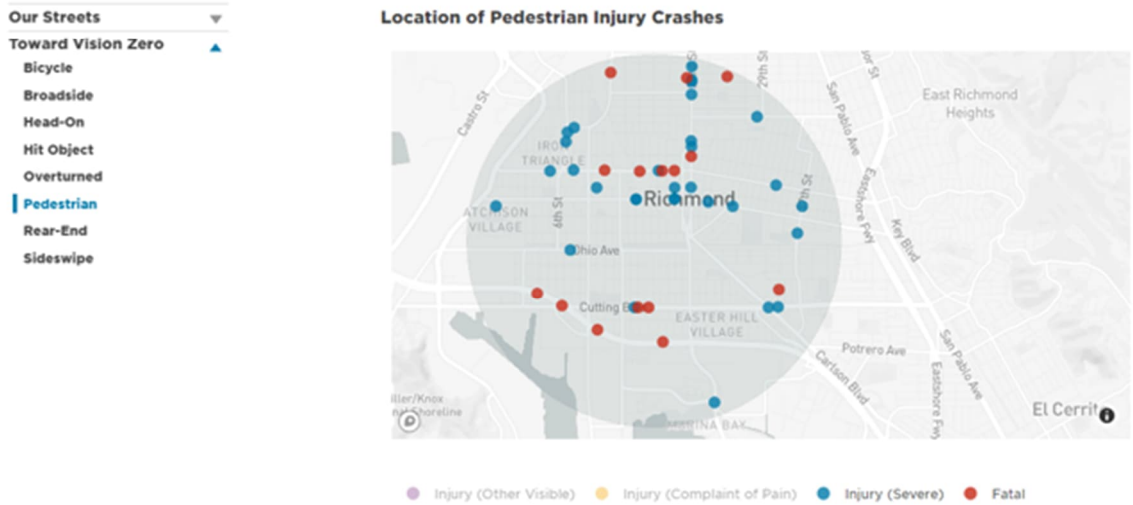
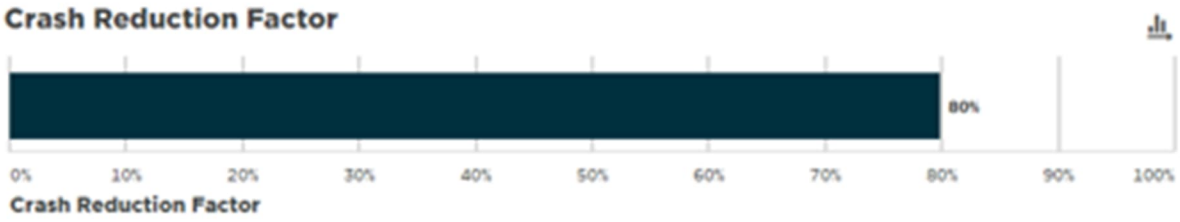


Figure 13: Crash Type Summaries and Maps



Caltrans Countermeasure IDs

R34PB

Sidewalks and walkways provide people with space to travel within the public right-of-way that is separated from roadway vehicles. The presence of sidewalks on both sides of the street has been found to be related to significant reductions in the "walking along roadway" pedestrian crash risk compared to locations where no sidewalks or walkways exist. For areas noted as not having adequate or no sidewalks and a history of walking along roadway pedestrian crashes. In rural areas asphalt curbs and/or separated walkways may be appropriate.

See more: **FHWA Countermeasures: Walkways**, **NACTO: Sidewalks**, **Rural Design Guide**

Appropriate Contexts

Urban | Suburban | Rural

Cost

$ | **$$** | $$$

HSIP Funding Eligibility %

90%

Expected Life of Improvement

20 years

Figure 14: Countermeasure Descriptions

State of Safety in the Bay Area

Using the BAYVIZ System, a comprehensive data analysis was conducted focusing on crashes where people were killed or seriously injured (KSI crashes). The intention of this data analysis was to provide a baseline analysis for the entire Bay Area and sub-areas within the Bay Area. These sub-areas include an analysis of Equity Priority Communities and different land use area types. Crashes have also been mapped by user type so that trend locations can be identified. Additionally, a systemic safety analysis is included. This analysis compares the number of crashes on a given roadway segment to that roadway segment's characteristics such as speed limit, number of lanes, presence of bicycle or pedestrian facilities. This systemic analysis provides a method for evaluating relative risk of KSI crashes based on various roadway characteristics.

Regional KSI Crash Trend

Crashes in the Bay Area are a serious problem resulting in thousands of people killed and seriously injured. And the issue is becoming worse. An initial crash analysis was completed for a 10-year period, from 2010 to 2019. During this 10-year period, there were approximately 4,000 fatal crashes and 18,200 serious injury crash events. Approximately 4,230 people died and 20,300 people were seriously injured in the Bay Area during this period.

The USDOT provides guidance to monetize the economic cost to society of fatalities and injury crashes. According to the 2021 FHWA guidance, a fatal crash has a cost to society of $10,900,000 and a serious injury crash of $521,300[5]. Using these figures, the total societal impact of fatal and serious injury crashes within the Bay Area is approximately $53.05 billion from 2010 to 2019.

From 2010 to 2019, 4,230 people died and 20,300 were seriously injured in traffic crashes in the Bay Area. These crashes resulted in a societal economic cost of $53 Billion. Fatal crashes increased 48% and serious injury crashes increased 60% during this time.

An overview of the trend of KSI crashes over this 10-year period is shown in Figure 15 and Figure 16. In 2019, there were approximately 451 fatal and 2,400 severe injury vehicle crashes annually. Between 2010 and 2019, fatal crashes have increased 48% and serious injury crashes have increased by 60%.

[5] https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-guidance-discretionary-grant-programs-0

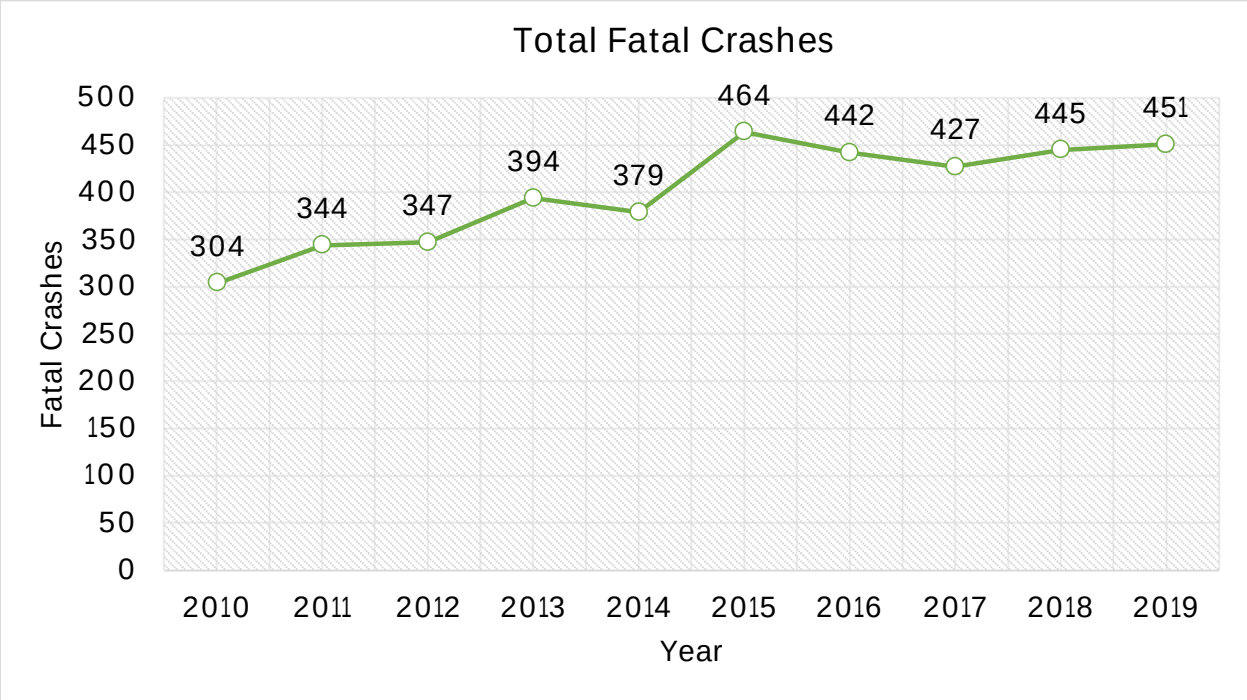


Figure 15: Fatal Crash Trend 2010 - 2019

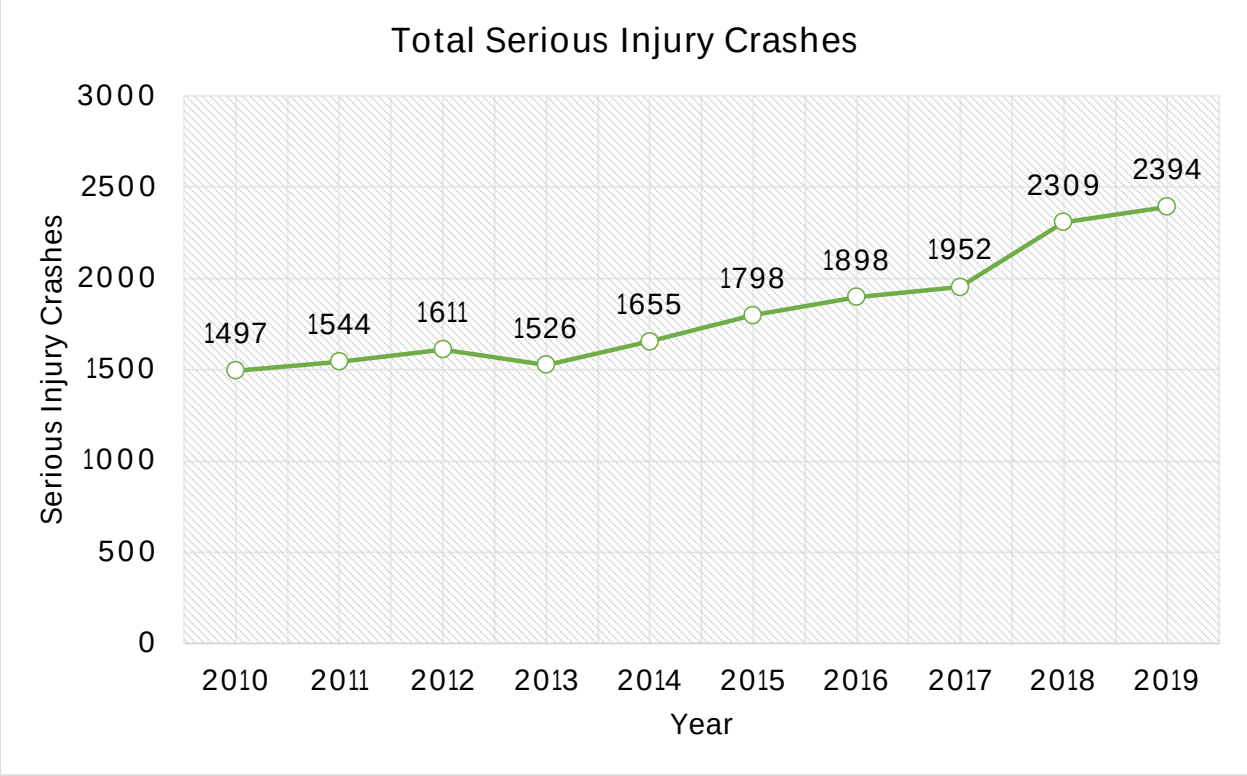


Figure 16: Serious Injury Crashes by Year

The following sections provide a detailed look at crash summary statistics and crash locations across the Bay Area. They examine who is involved in KSI crashes, the types of transportation modes most affected, crash types, and contributing circumstances. This

is subdivided into controlled access highways and local access roads. Controlled access highways were based on Caltrans' functional class roads "Interstate" and "Other Freeway or Expressway". Local access roads were defined as all other streets not identified as controlled access highways. Crash trends are also subdivided into different land use contexts including rural, suburban, urban, and dense urban. Crash data range used for this analysis covers the five years of 2015 – 2019 with the exception of the 10-year trend charts.

Roadway Type and Jurisdiction

Local access roads and local jurisdiction streets account for the majority of KSI crashes in the Bay Area. However, controlled access highways and state and county roads also have a substantial share of KSI crashes including vehicle, pedestrian, and bicycle crashes. To achieve Vision Zero, all roadways and all jurisdictions must be considered for developing countermeasures and prioritizing projects.

When looking at roadway type, local access roads have a much greater share than controlled access highways. Controlled access highways have a higher share of fatal crashes (27%) compared to serious injury crashes (21%). When looking at roadway jurisdiction, local streets account for approximately half of the KSI crashes, state roads approximately one-third, and county roads around one-seventh. Like the roadway type, the state routes have a greater proportion of fatal crashes compared to serious injury crashes. This data can be seen in Figure 17 and Figure 18.

Pedestrian and bicycle users have unique needs to create safe transportation systems for them. Typically, pedestrian and bicycle users are restricted from utilizing controlled access highways, but many bicycle and pedestrian fatalities occur on those facilities. Figure 19 and Figure 20 show the bicycle and pedestrian fatal crashes by roadway type and jurisdiction. 20% of fatal pedestrian crashes and 6% of fatal bicycle crashes occurred on controlled access highways. The majority of pedestrian and bicycle crashes happened on local jurisdiction streets, but nearly a quarter of them occurred on state and county roads.

The following sections will provide more detail on where these KSI crashes occurred on controlled access highways and local access roads and details on contributing circumstances.

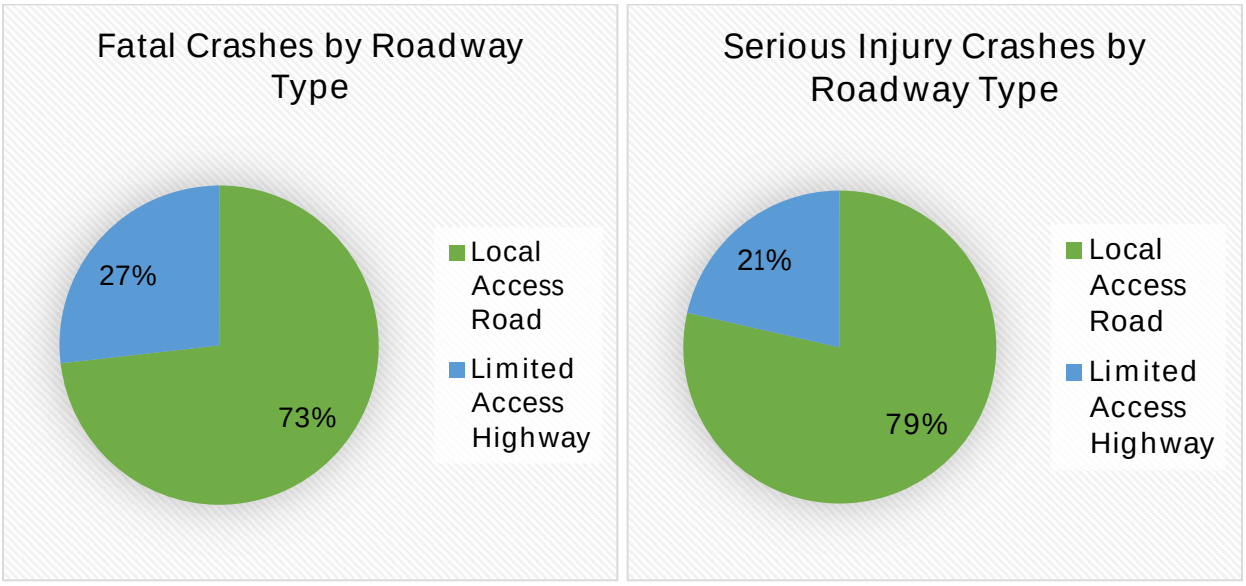


Figure 17: Fatal and Serious Injury Crashes by Roadway Type

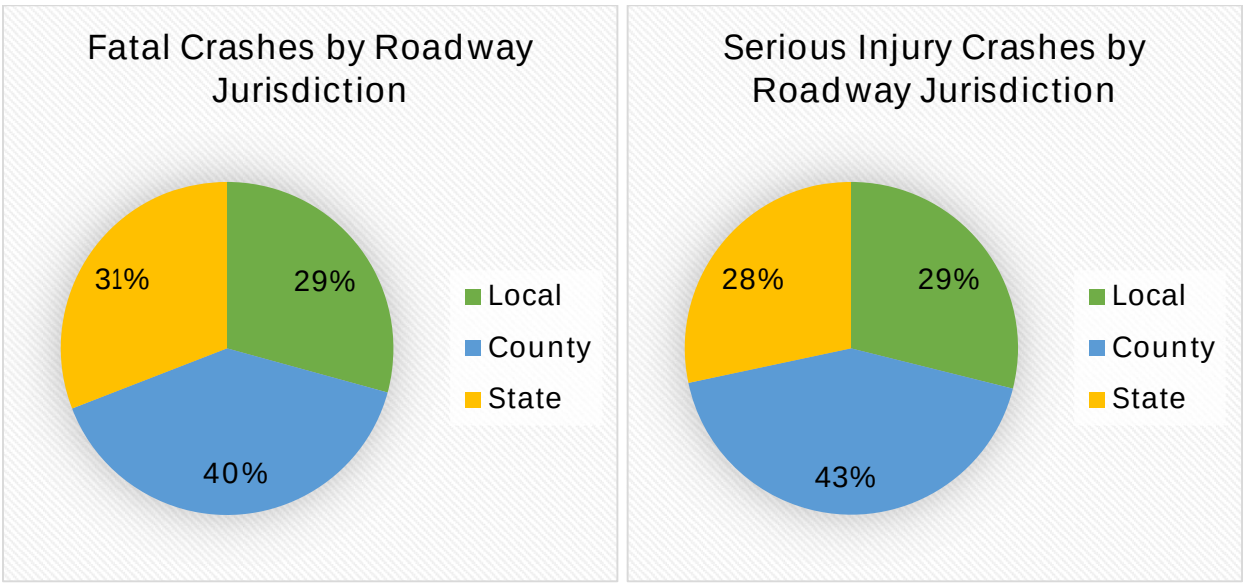


Figure 18: Fatal and Serious Injury Crashes by Roadway Jurisdiction

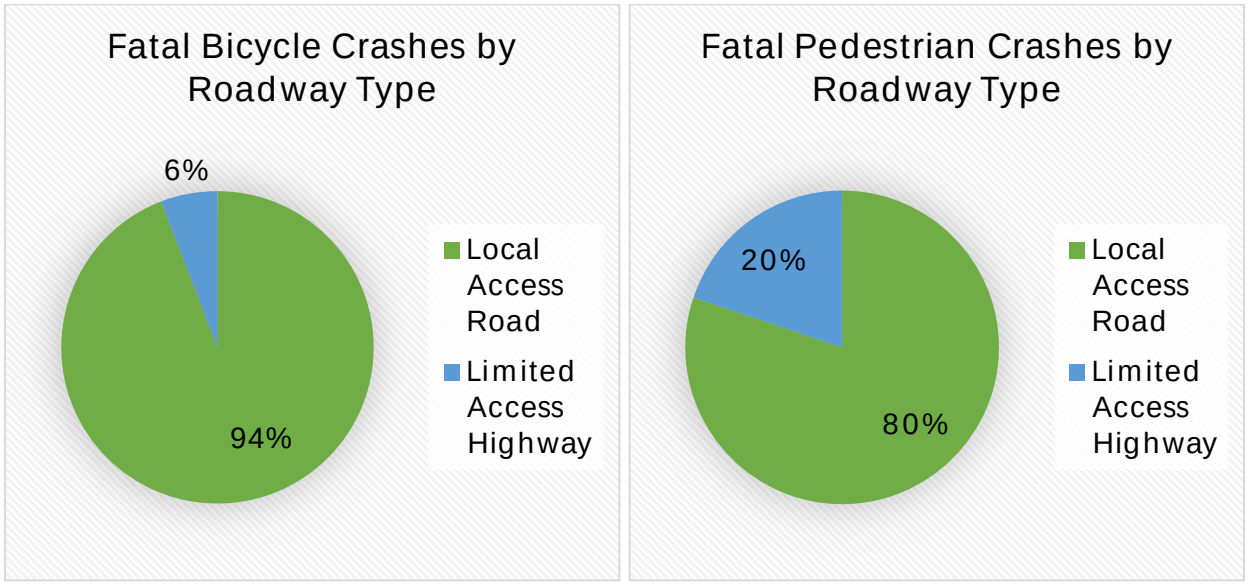


Figure 19: Fatal Pedestrian and Bicycle Crashes by Roadway Type

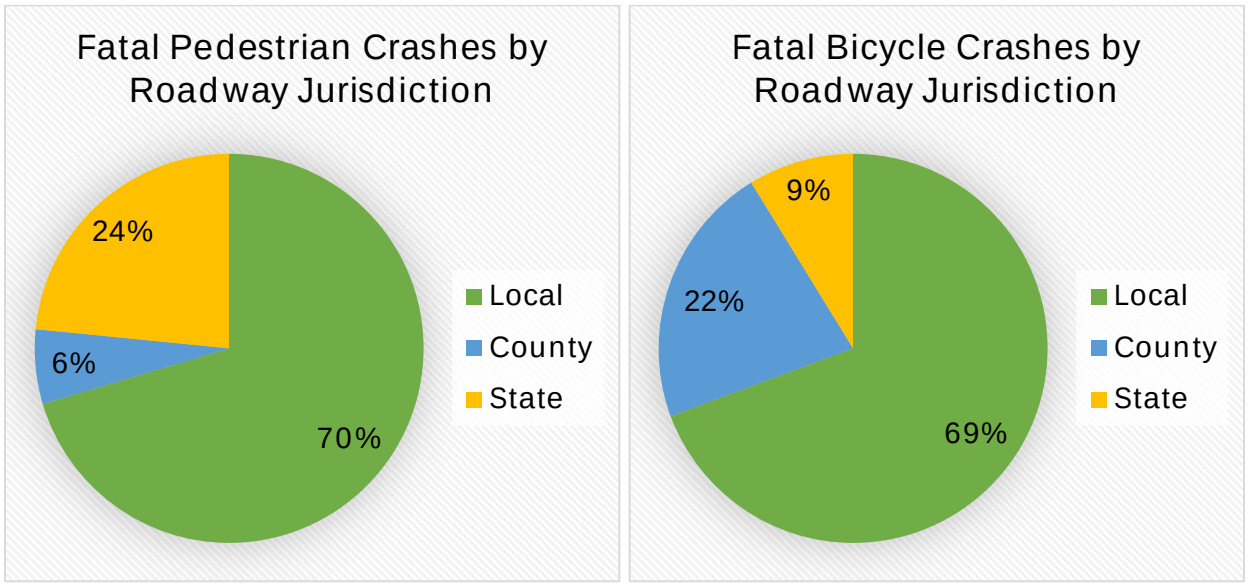


Figure 20: Fatal Pedestrian and Bicycle Crashes by Roadway Jurisdiction

High Injury Network Development

High Injury Networks (HINs) are an important analytic tool of the Vision Zero approach to better understand existing conditions in an area of study. HINs use roadway, vehicle, and speed data to localize crash data. Crash types, locations, times, and user demographics are associated to specific corridors so that causes, and specific solutions may be identified.

The following sections include maps of all of the HINs developed for the Bay Area. All of those maps can also be viewed online as well using this link: https://reports.mysidewalk.com/b5ef0ba311

High Injury Network Development Methodology

Since November 2020, a multi-jurisdictional HIN subgroup reviewed existing HINs among California cities, counties, and metropolitan planning organizations. Based on extensive review, the subgroup identified the core components common to HINs shown in Table 6. The information from the report contains a set of potential options that local jurisdictions can use to create their HIN. This process and additional local information were used to guide HIN development for the Bay Area. Discussions were conducted with stakeholders including the DTAC to identify the most appropriate methodology for the BAYVIZ system. The methodology and core components used to develop the HIN is shown in Table 6.

Table 6: Core Components of High Injury Network Development

Core Component	Considerations	BAYVIZ Methodology
Data Sources	• Statewide Integrated Traffic Records System (California Highway Patrol) • Transportation Injury Mapping System (SafeTREC) • Jurisdictionally specific police departments	The HIN utilizes the BAYVIZ system which incorporates crash data from SWITRS/TIMS and infrastructure data from a variety of other sources. Caltrans All Roads Linear Referencing System (LRS) network utilized for roadway location and segmentation.
Years of Data	Three to five years of collision data, with a median and average of four	The HIN uses five years of crash data utilized. Ten years is available, but stakeholders felt that five years would provide proper level of data without looking too far back into past with different driving/roadway considerations.
Collision by Intersection or Corridor	• Most High Injury Networks are analyzed at the corridor level • High-Injury intersections may warrant special study, and specific countermeasures	The HIN is developed at corridor level only. Automating process for both the entire Bay Area and sub-regions selected with the Dashboard Generator lends itself to corridor level analysis better.
Collision by Roadway Facility	Depending on geography, it may be appropriate to include freeway mainlines and ramps in addition to local streets. However, many localities lack authority to change freeway speed limits	Two HINs have been developed based on roadway type: • Controlled Access Highways • Local access roads (i.e., all other streets besides controlled access highways regardless of ownership) Local jurisdictions have limited control over roads maintained by other jurisdictions within their boundaries (e.g., state or county owned roads located in a municipality), but the local jurisdiction often still provides police enforcement and educational efforts targeted to these non-jurisdictional roads. This is typically not the case on controlled access freeways (such as Interstate Highways) which are typically patrolled by

Core Component	Considerations	BAYVIZ Methodology
		California Highway Patrol and educational activities targeted to these roads are conducted by Caltrans. For this reason, the HIN development was separated into these two separate HINs.
Collision by Mode	Collisions may include users of different modes such as automobile, bicycle, and pedestrian. It may be helpful to distinguish between types of collisions such as auto-auto, auto-pedestrian, etc.	Four separate HINs have been developed by user mode: • All Users • Vehicle-Pedestrian Crashes • Vehicle-Bicycle Crashes • Vehicle crashes not involving pedestrians/cyclists These HINs will be created for the "Local access roads" HIN noted above and not for the "Controlled Access Highways" HIN. The "Controlled Access Highways" will be created using "All Crashes." The stakeholders felt that crash locations, crash patterns, and countermeasures are different enough for the various user modes, that separating them into their own HINs was necessary. This is consistent with several HINs already created in the Bay Area. Separating HINs into individual modes also helps avoid issues surrounding under-reporting of crashes among bicycle and pedestrian users compared to vehicle only crashes.
Collision Weights	Weighting allows for prioritization according to specific priority goals by more strongly assigning weight to collisions that involve vulnerable populations such as children or older adults, different injury severities, or equity considerations	Collision weights for BAYVIZ was separated into two separate discussion: • Weighting by crash severity—only fatal and serious injury crashes will be used, and fatal crashes will have a 3 times higher weight than serious injury crashes • Weighting by equity factors—no additional weighting applied based on equity factors **Weighting by Crash Severity:** It was decided that only fatal and serious injury crashes would be used for the HIN development, which is consistent with most HIN

Core Component	Considerations	BAYVIZ Methodology
		development. Some stakeholders noted a relative lack of KSI crashes in their jurisdiction which may make the use of minor injury crashes useful. However, to keep a consistent methodology across the region, the decision was made to utilize only KSI crashes. Fatal crashes have more impact than serious injury crashes. The USDOT has measured economic impact of a fatal crash to be ~21 times higher than a serious injury crash. However, weighting fatal crashes this high can give the relatively rare fatal crashes an outsized influence on the location of HIN segments, when often serious injury crashes have similar contributing circumstances to fatal crashes. For this reason, it was decided to weight fatal crashes 3 times higher than serious injury crashes. **Weighting by Equity Factors:** Equity is an important issue in traffic safety and Vision Zero implementation. The issues surrounding equity and safety are complex, and difficult to directly measure and data is not readily available to assess the relationship. Because of this, a special weighting factor for equity considerations was not applied to the HIN development, which was supported by the stakeholders. This is consistent with other HIN development in the Bay Area. Equity Priority Communities defined by MTC will be shown on all HIN maps and jurisdictions will be encouraged to utilize equity factors and equity priority communities in prioritizing projects relating from the HIN.
Normalization	The number of collisions may be divided by other factors such as facility length or population to better compare road segments or intersections for inclusion in the High Injury Network	Crashes are normalized by number of weighted crashes per mile on the HIN. This was supported by the stakeholders and consistent with other HIN development in the Bay Area.

Core Component	Considerations	BAYVIZ Methodology
Thresholds	For prioritization purposes, it may be helpful to include thresholds for inclusion based on factors like a certain number of serious injuries or fatalities per unit distance, or the top 15% of roadways with serious injuries	The HIN has been created based on roadway segments that are in the highest percentiles of weighted crashes. This has been done at the regional level for the Bay Area HIN, but also is calculated on-demand with the dashboard generator for the sub-area selected. Both methods are based on the highest percentiles, but the HIN for the sub-area is different because the highest percentile segments are calculated based on the number of crashes and length of segments in that smaller area. This allows a HIN to be created at the regional level (which concentrates most HIN segments in the highest density in the region) and create a meaningful HIN in lower density areas in the region through the dashboard generator. This method was supported by the stakeholders to provide meaningful HINs in various areas and contexts in the Bay Area.

High Injury Network Maps

The High Injury Networks have been created for the Bay Area. These HINs include:

- Controlled Access Highway HIN
- Local Access Road All Users HIN
- Local Access Road Pedestrian HIN
- Local Access Road Bicycle HIN
- Local Access Road Vehicle HIN

These maps are shown on Figure 21 through Figure 25. In addition to these maps, HIN maps can be created dynamically for any sub-area using the dashboard generator. These maps can also be viewed online using this link: https://reports.mysidewalk.com/b5ef0ba311

Table 7 and Table 8 show statistics related to the High Injury Networks. Overall, one-third of all KSI crashes in the Bay Area happen on just 1.9% of the roads. These 1.9% of roads constitute nearly 550 miles of Bay Area Roads and 3,090 KSI crashes. HIN segments are highly concentrated in equity priority communities, especially for non-motorized users. When looking at all modes, 29% of HIN corridors are in EPCs, but just 12% of Bay Area roads are in EPCs. For pedestrians it is even worse—38% of pedestrian HIN segments are in EPCs with only 12% of Bay Area roads in EPCs.

Table 7: High Injury Network Statistics

Road Users	HIN KSI	Region KSI	HIN Miles	% of Crashes	% of Miles
All Modes				33.9%	1.9%
Vehicle	1,365	5,531	623.4	24.7%	2.1%
Pedestrian	707	2,373	255.3	29.8%	0.9%
Bicyclists	533	1,227	357.6	43.4%	1.2%

Table 8: High Injury Network Statistics Related to Equity

Road Users	Miles in EPCs	HIN Miles	% HIN Miles in EPCs	% of Overall Centerline Miles in EPCs
All Modes				
Vehicle	99.2	623.4	15.9%	
Pedestrian	96.5	255.3	37.8%	
Bicyclists	81.2	357.6	22.7%	



Figure 21: Controlled Access Highway High Injury Network Map (https://reports.mysidewalk.com/b5ef0ba311)

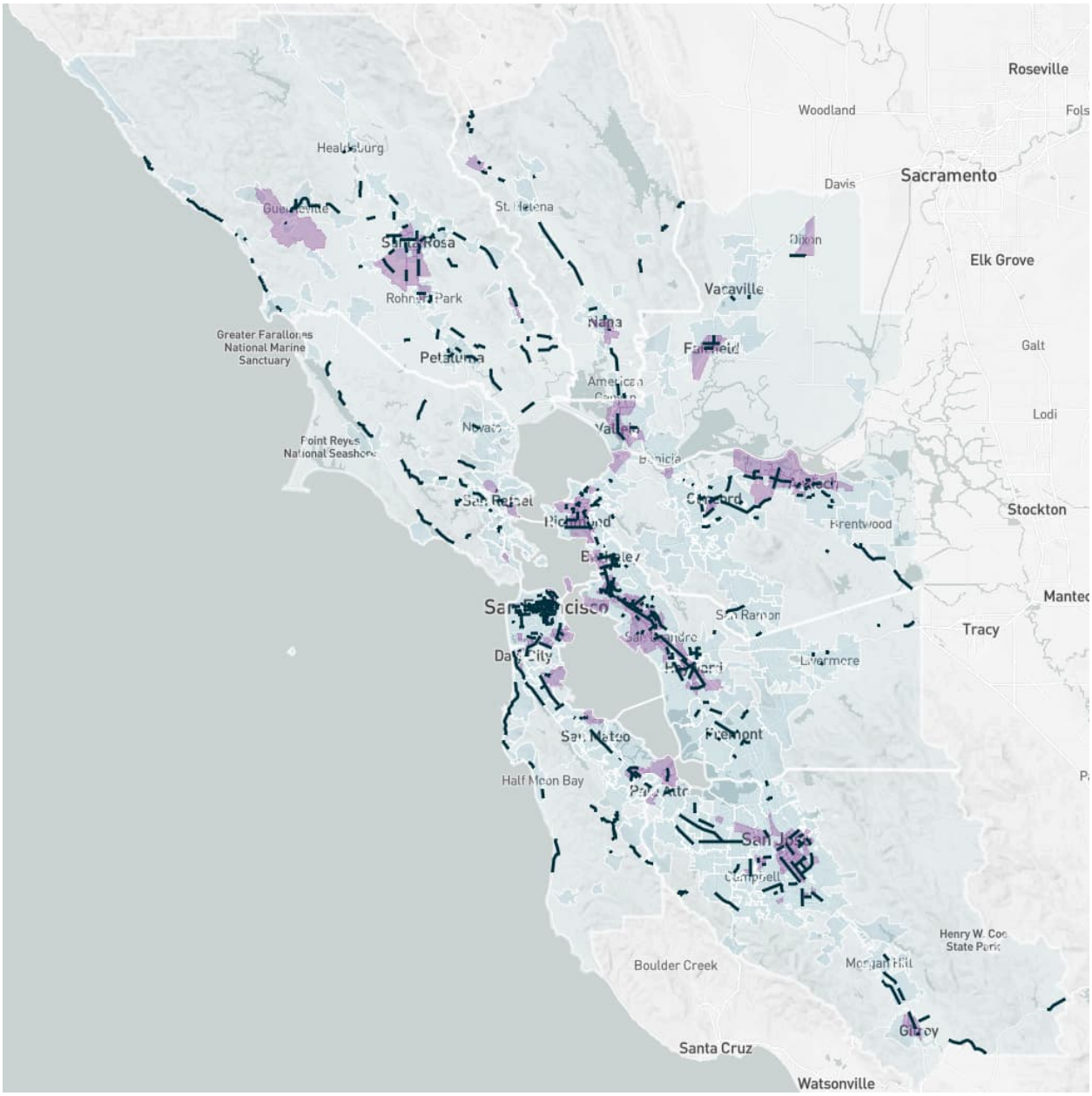


Figure 22: Local Access Road All Users High Injury Network Map
(https://reports.mysidewalk.com/b5ef0ba311)

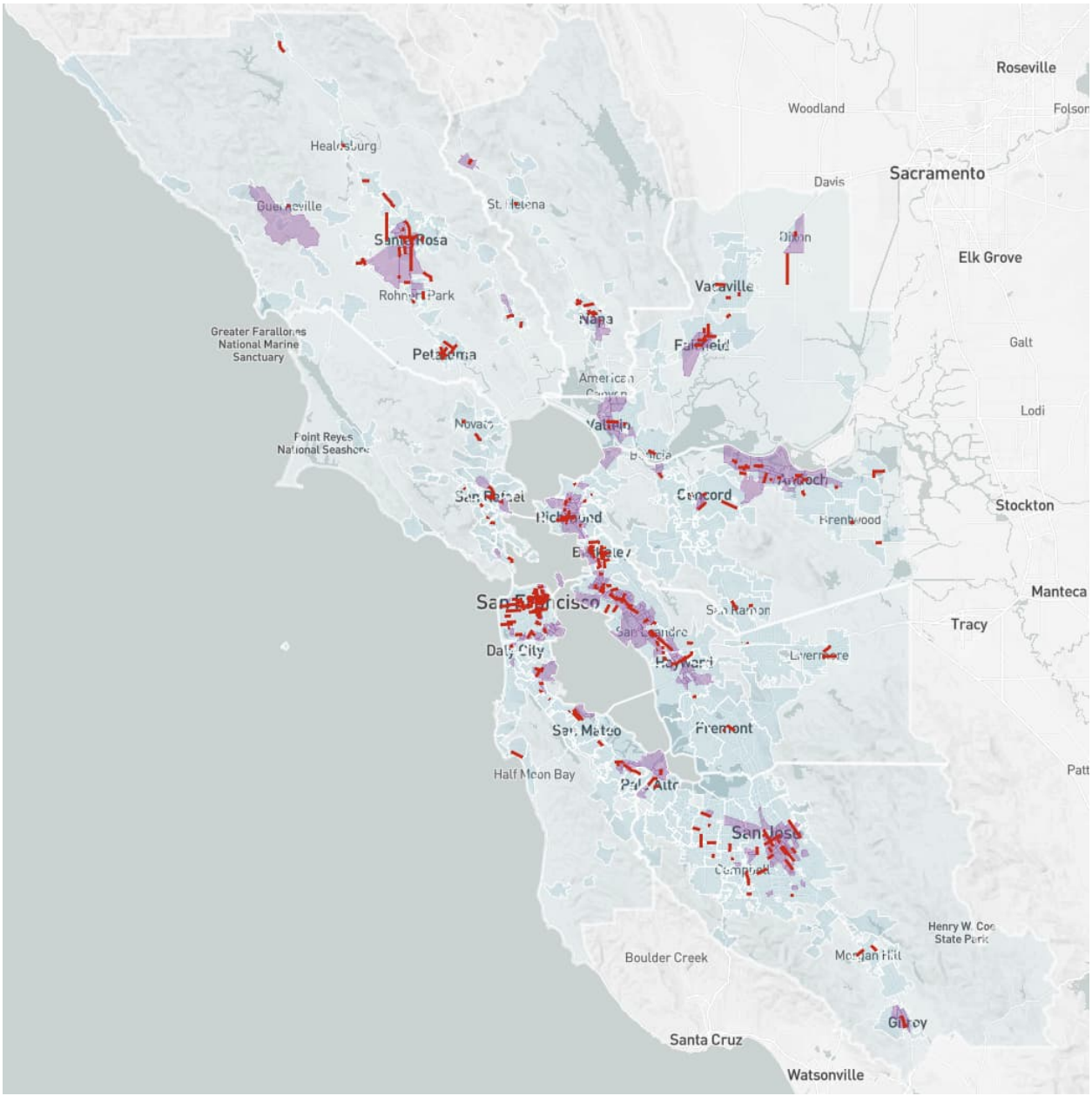


Figure 23: Local Access Road Pedestrian High Injury Network Map
(https://reports.mysidewalk.com/b5ef0ba311)

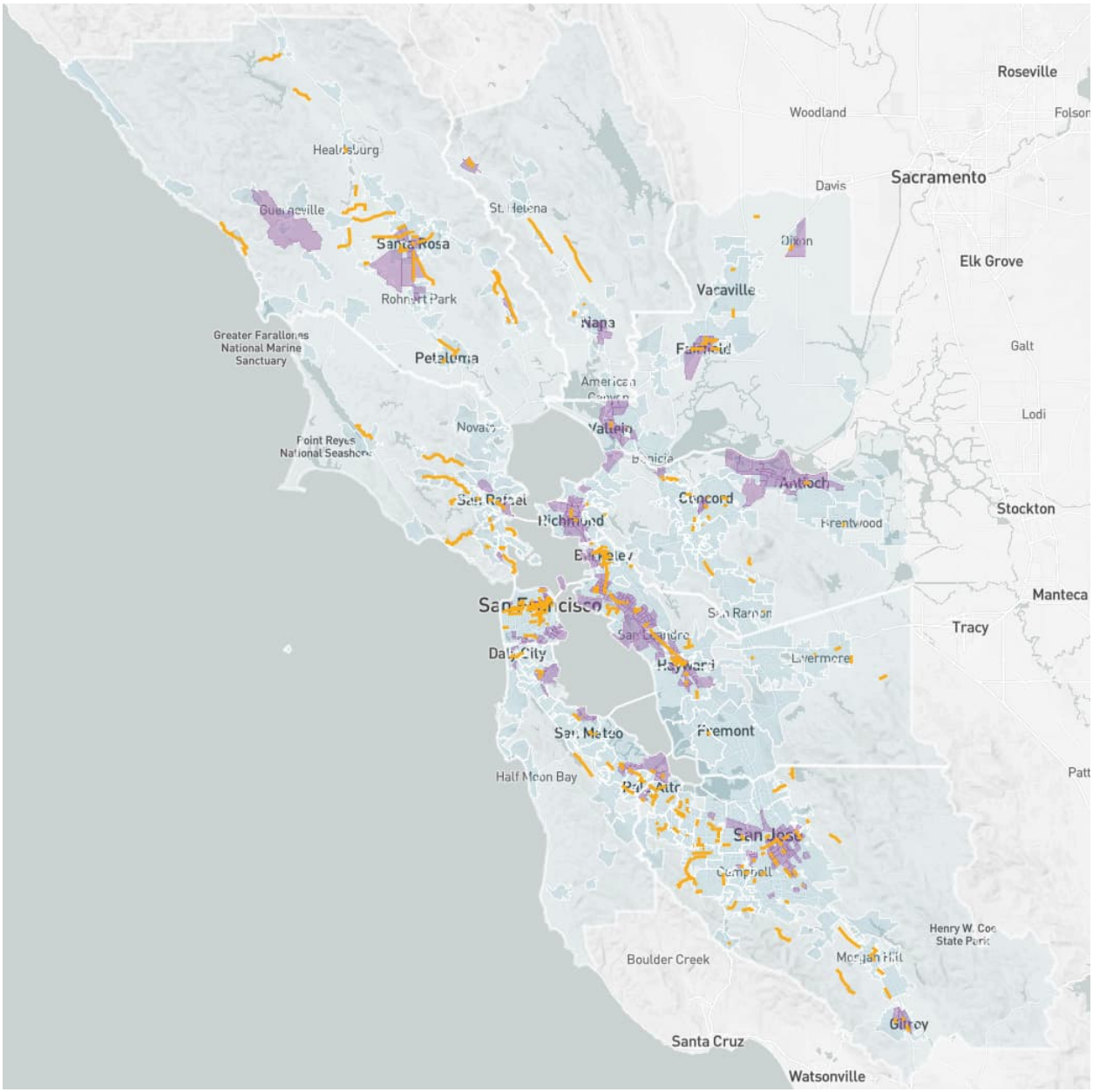


Figure 24: Local Access Road Bicycle High Injury Network Map
(https://reports.mysidewalk.com/b5ef0ba311)

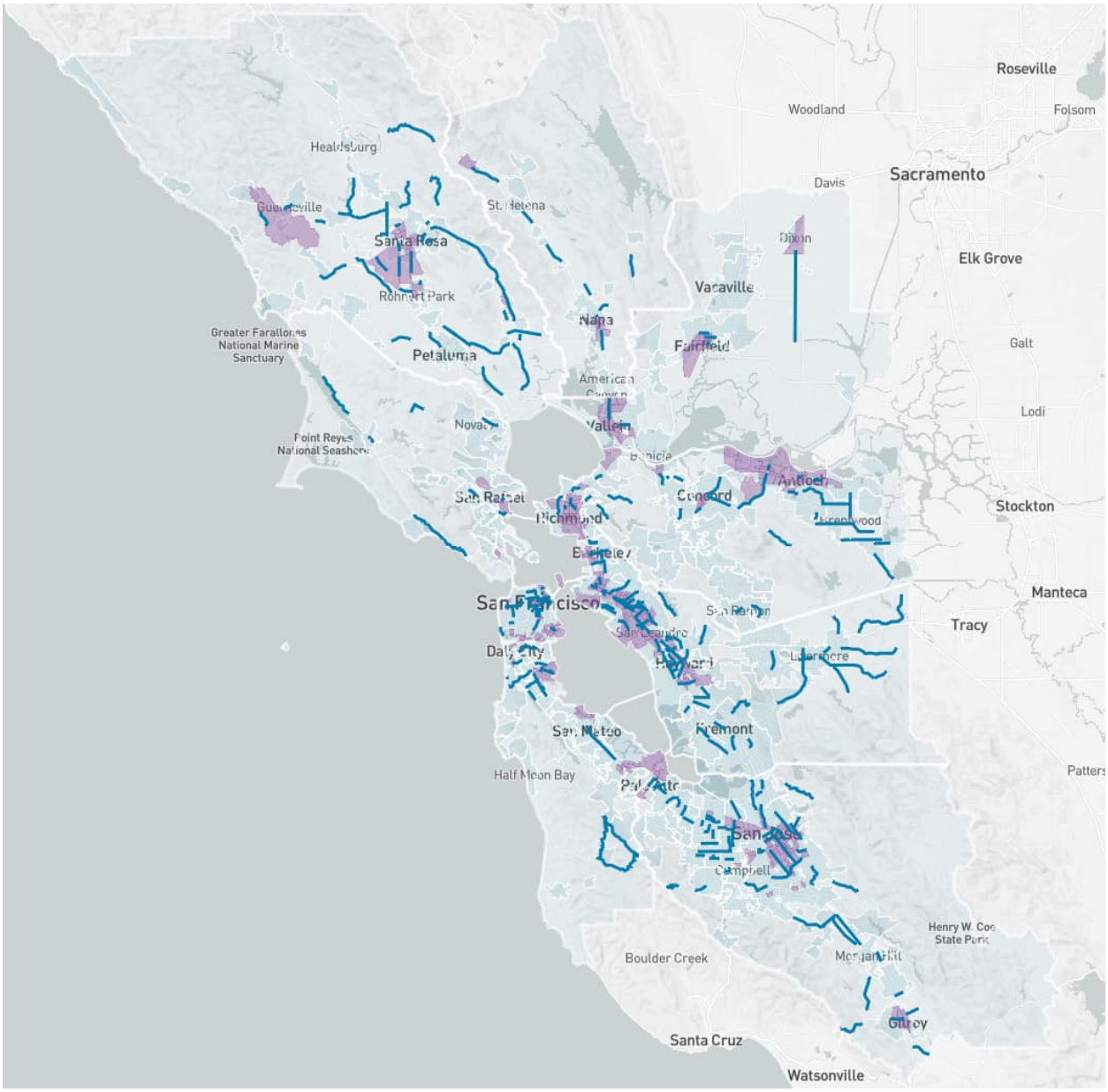


Figure 25: Local Access Road Vehicle High Injury Network Map
(https://reports.mysidewalk.com/b5ef0ba311)

Regional Controlled Access Highways KSI Crash Summary

Controlled access highways account for 27% of the fatal crashes and 21% of the serious injury crashes in the Bay Area. Approximately 120 people are killed and 550 are seriously injured on controlled access highways in the Bay Area every year and increasing. To properly address this trend, it needs to be done at a systemic level. Roadway deaths are a result of road design and poor user consideration. For this analysis, a controlled access highway was defined as Caltrans functional class roads

"Interstate" and "Other Freeway or Expressway." The crash data time range used for this analysis covers the five years of 2015 – 2019 except for the 10-year trend charts. Note that not all charts total to the same number of crashes due to gaps in data. All statistics are shown for crash records where the relevant data exists, and null values are not included.

Trends

KSI crashes on controlled access highways in the Bay Area have increased over the 10-year period from 2010 – 2019. Fatal crashes on controlled access highways have increased 33% and serious injury crashes have increased 69%. Some increase in serious injury crashes may be from the change of definition of "severe injury" to "suspected serious injury" in 2017. You can see a jump in serious injury crashes starting in 2017. However, even considering the definition change, the serious injury crash rates have continued to rise. Serious injuries increased 33% between 2017 and 2019. Fatal and serious injury crash trends from 2010 to 2019 are shown in Figure 26 and Figure 27.

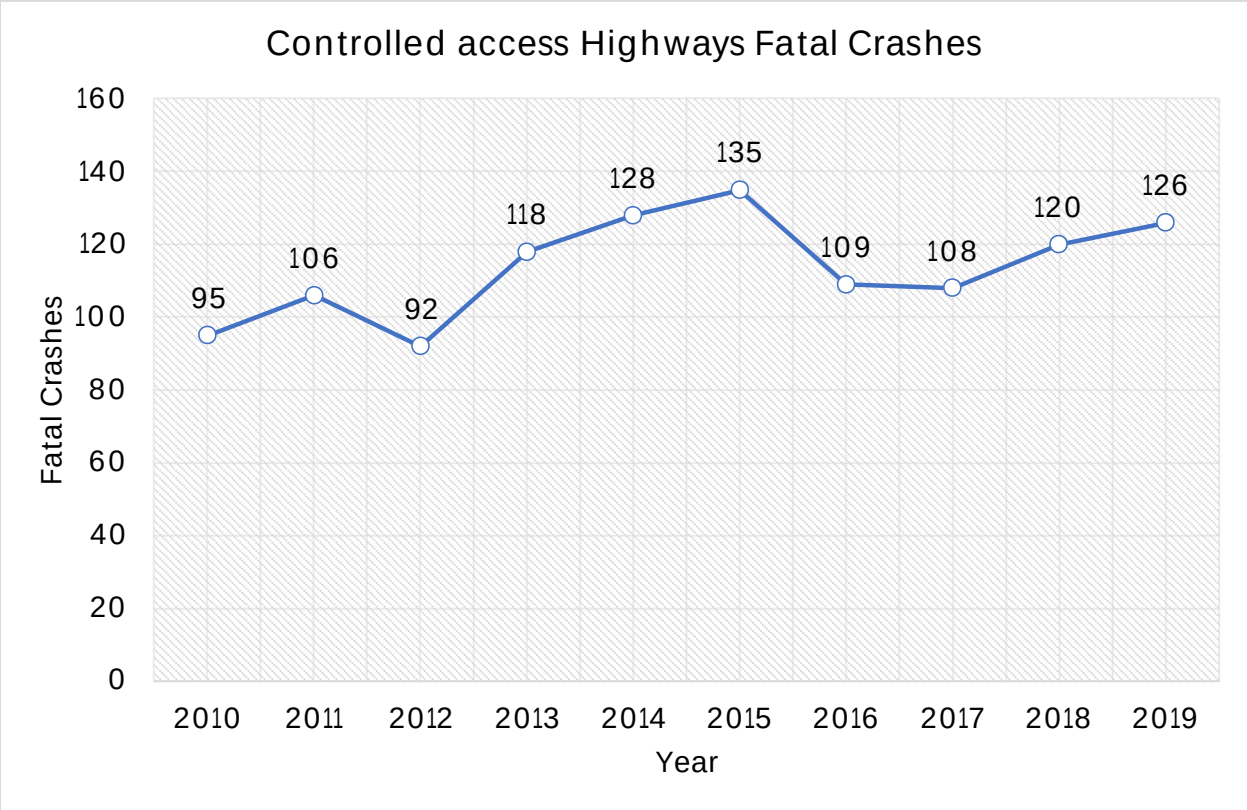


Figure 26: Controlled Access Highway Fatal Crash Trend 2010 - 2019

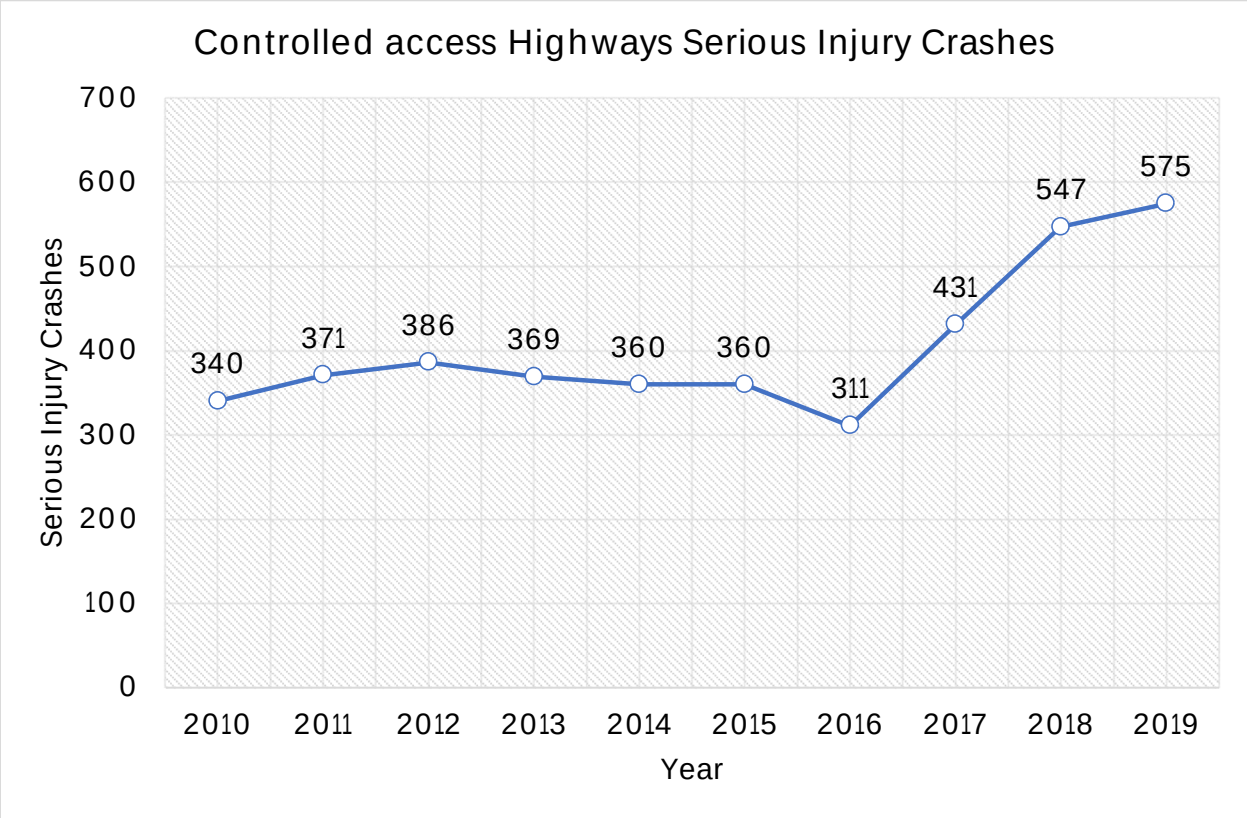


Figure 27: Controlled Access Highway Serious Injury Crash Trend 2010 - 2019

Transportation Modes

Controlled access highways are designed for high-speed motor vehicle travel. Pedestrians and cyclists are prohibited from traveling on these highways, which provide little to no facilities for pedestrians and cyclists. It is no surprise that vehicle crashes constitute the majority, 88%, of the KSI crashes on these roads. However, controlled access highways act as major barriers to walking and bicycling through neighborhoods. Pedestrians and cyclists are forced to cross these highways whether at interchanges or even directly across the highway to navigate their environment. This presents a structural danger to both pedestrians and vehicles alike. In some locations the highway is the only practical route through an area, especially in rural areas. This contributes to pedestrians and cyclists still constituting 12% of the KSI crashes out of 272 crashes. This is shown in Figure 28

Vehicle crashes on controlled access highways in the Bay Area have increased 70% between 2010 and 2019. Pedestrian KSI crashes have increased 25% and bicycle crashes have remained relatively consistent over the same period.

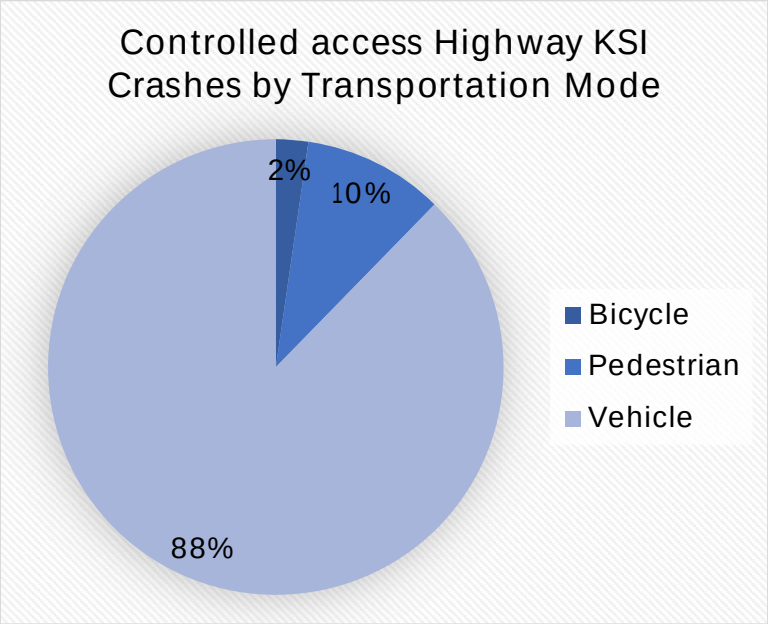


Figure 28: Controlled Access Highway KSI Crashes by Transportation Mode

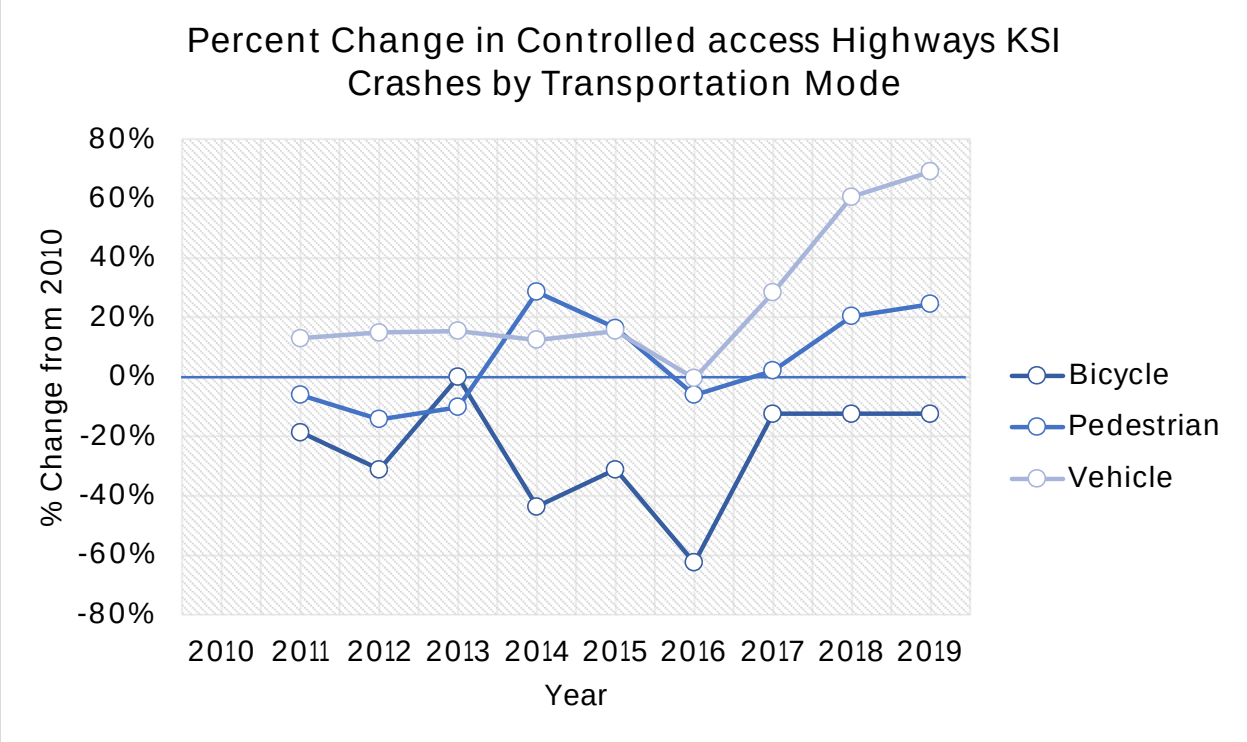


Figure 29: Percent Change in Controlled Access Highway KSI Crashes by Transportation Mode

Users and Equity

At controlled access highways black users and "other" users, which primarily consists of indigenous peoples, account for a disproportional proportion of crashes. Both groups

are over-represented by more than double when normalized for population proportion.

Equity priority communities (EPC), defined by MTC, were also examined for KSI crashes. These areas are of special focus as they are areas affected disproportionally by safety issues affecting roadways. 32% of all crashes occur in equity priority communities; however, when adjusted for population proportion, there is a 1.7 times higher chance of a KSI crash happening in an equity priority community than elsewhere. It is important that any steps taken towards safety improvements keep equity as a key consideration.

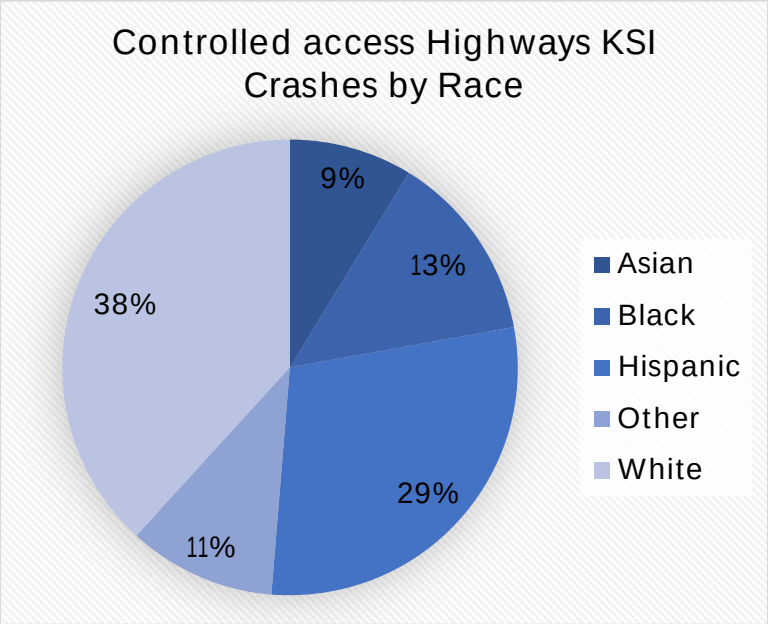


Figure 30: Controlled Access highways KSI Crashes by Race

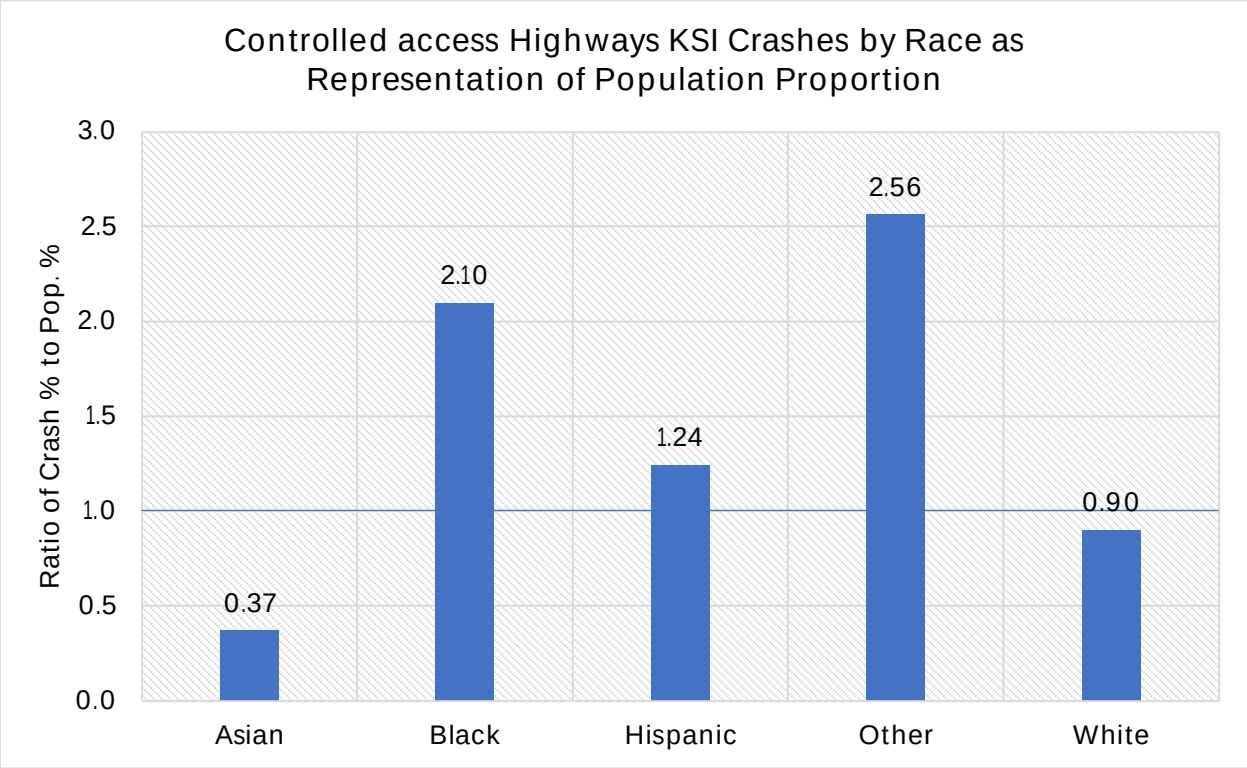


Figure 31: Controlled Access highways KSI Crashes by Race as a representation of population (>1.0 = Over-Representation)

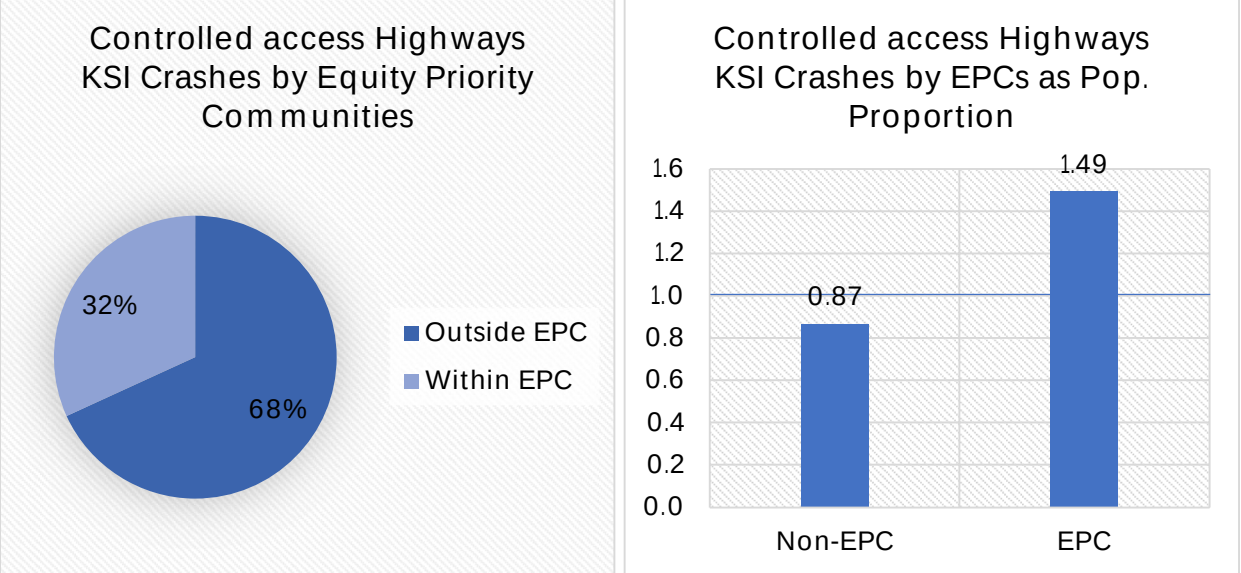


Figure 32: Controlled Access Highways KSI Crashes by Equity Priority Communities and as a Representation of Population (>1.0 = Over-Representation)

Age

Crashes on controlled access highways do not occur evenly across age groups. The groups that account for the largest number of crashes is those in their 20s, with 20–24 year-olds accounting for 490 KSI crashes and 25-29 year-olds accounting for 507 KSI

crashes. Normalizing for population, users in their 20s are highly over-represented. Users in the age group of 20-24 are 2.7 times more likely to be involved in a KSI crash than the average roadway user.

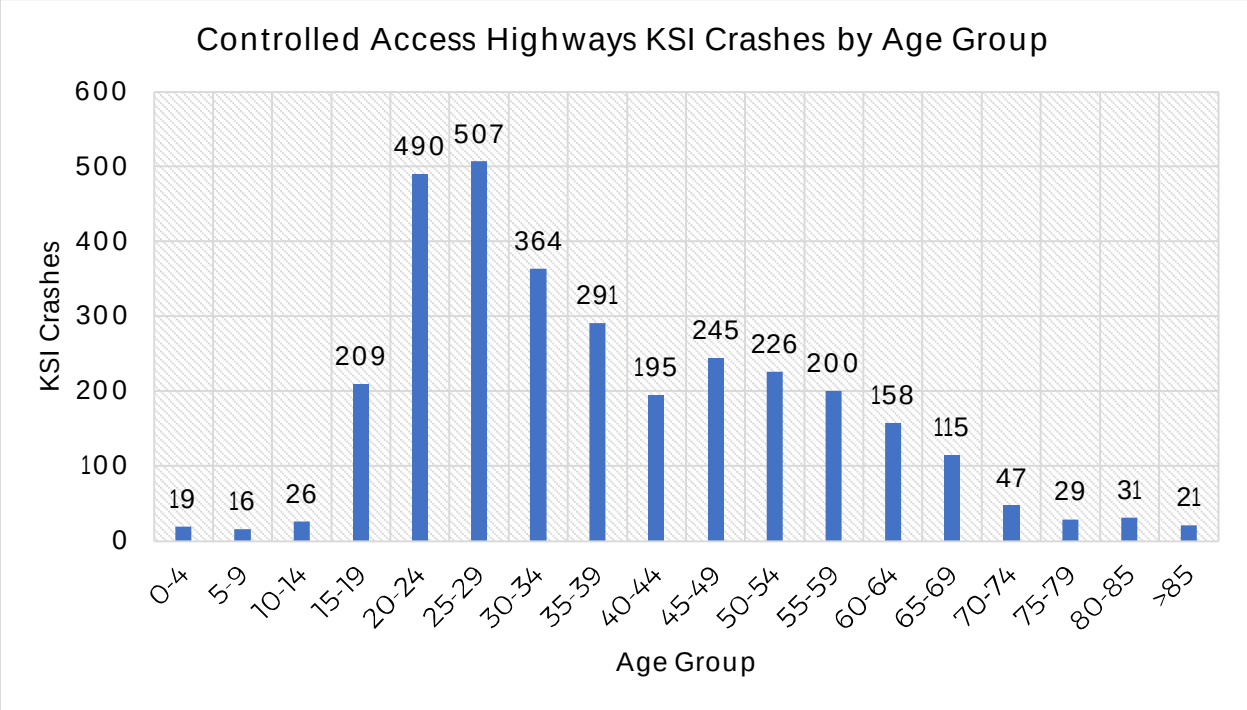


Figure 33: Controlled Access highways KSI Crashes by Age Group

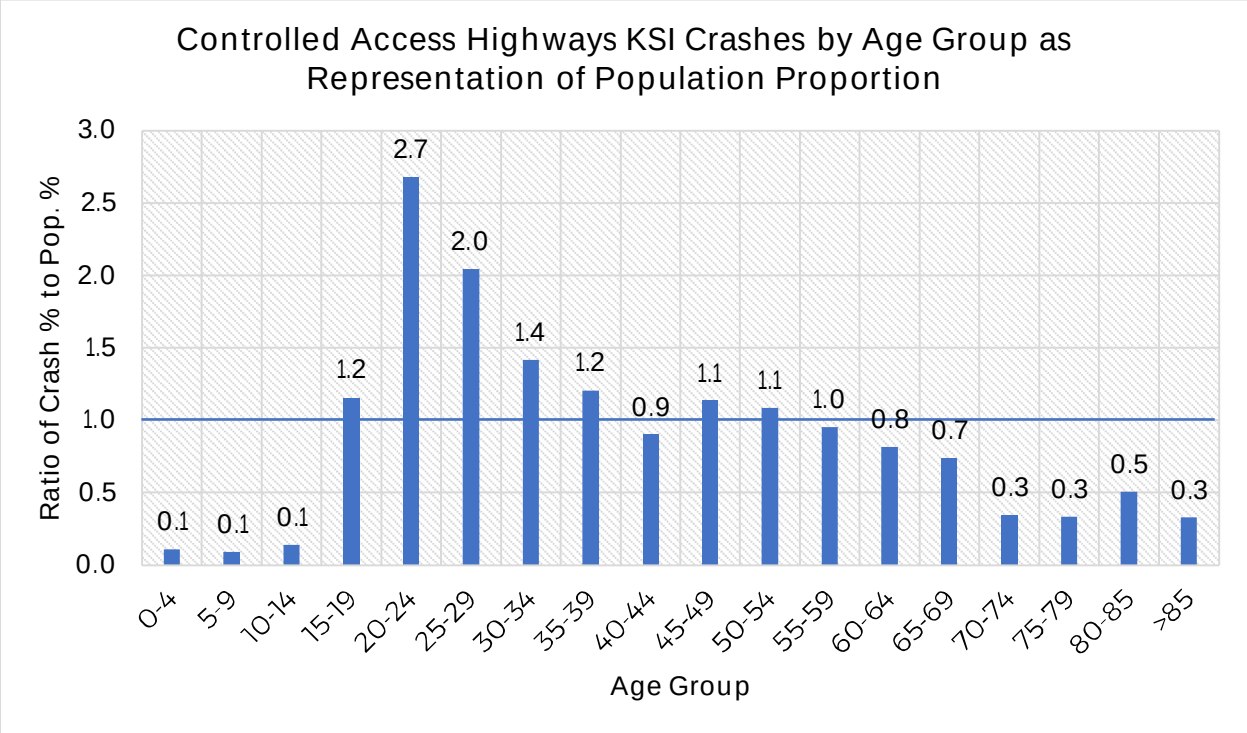


Figure 34: Controlled Access highways KSI Crashes by Age Group as a Representation of Population (>1.0 = Over-Representation)

Sex

Males currently account for 72% of crashes and are nearly 2.5 times as likely to be involved in a KSI crash compared to females on controlled access highways.

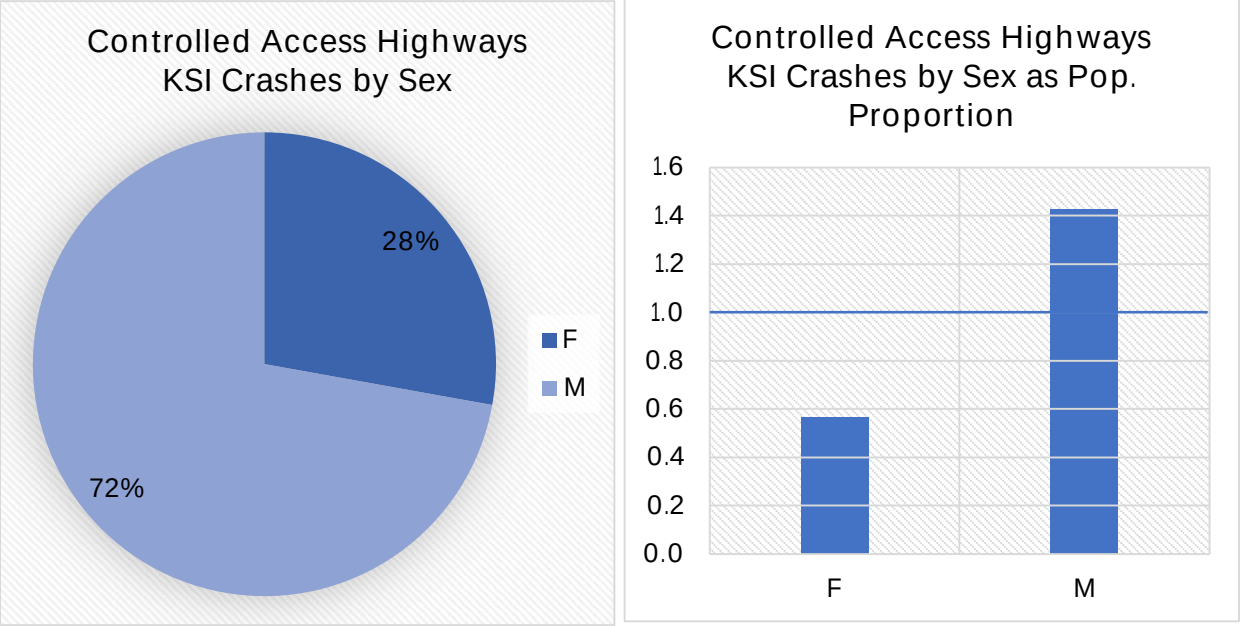


Figure 35: Controlled Access Highways KSI Crashes by Sex and as a Representation of Population (>1.0 = Over-Representation)

Crash Locations and Types

The majority of KSI crashes on controlled access highways occur at non-intersection locations and non-ramp locations. Most of the non-intersection crashes are fixed object (31%), rear-end (30%) and sideswipe (15%) crashes. Although pedestrians are legally prohibited from traveling on controlled access highways, there were still a substantial amount of pedestrian KSI crashes at non-intersection locations.

At intersection locations, pedestrian (21%) and bicycle (14%) crashes were the second and third most common types of crashes on controlled access highways following broadside crashes (39%).

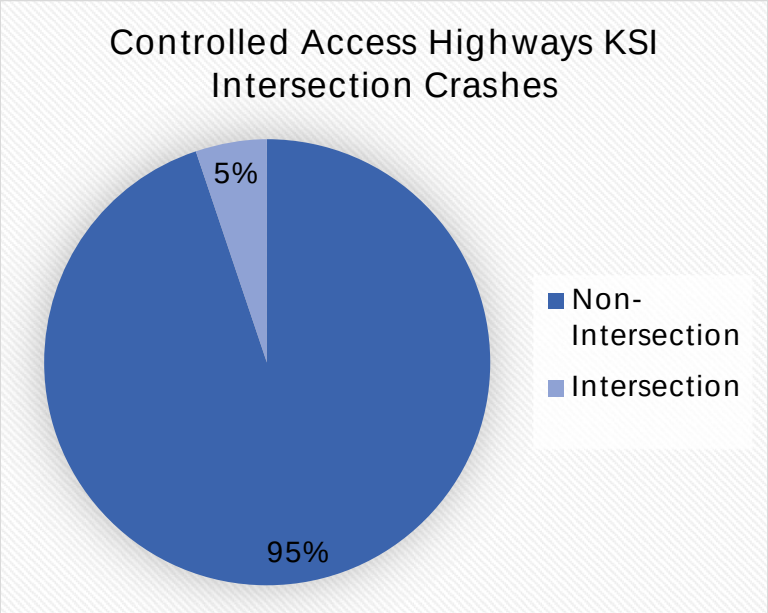


Figure 36: Controlled Access Highways KSI Intersection vs Non-Intersection Crashes

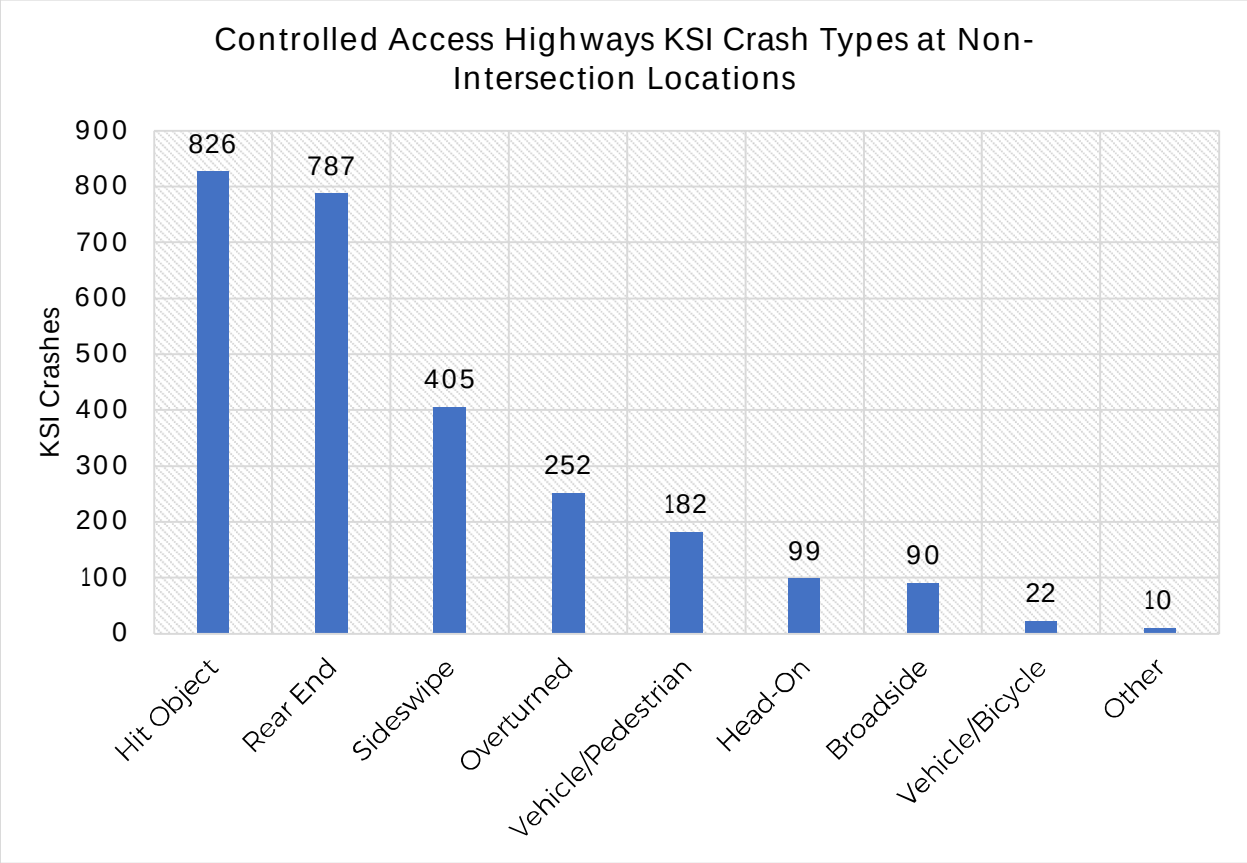


Figure 37: Controlled Access Highways KSI Crash Types at Non-Intersection Locations

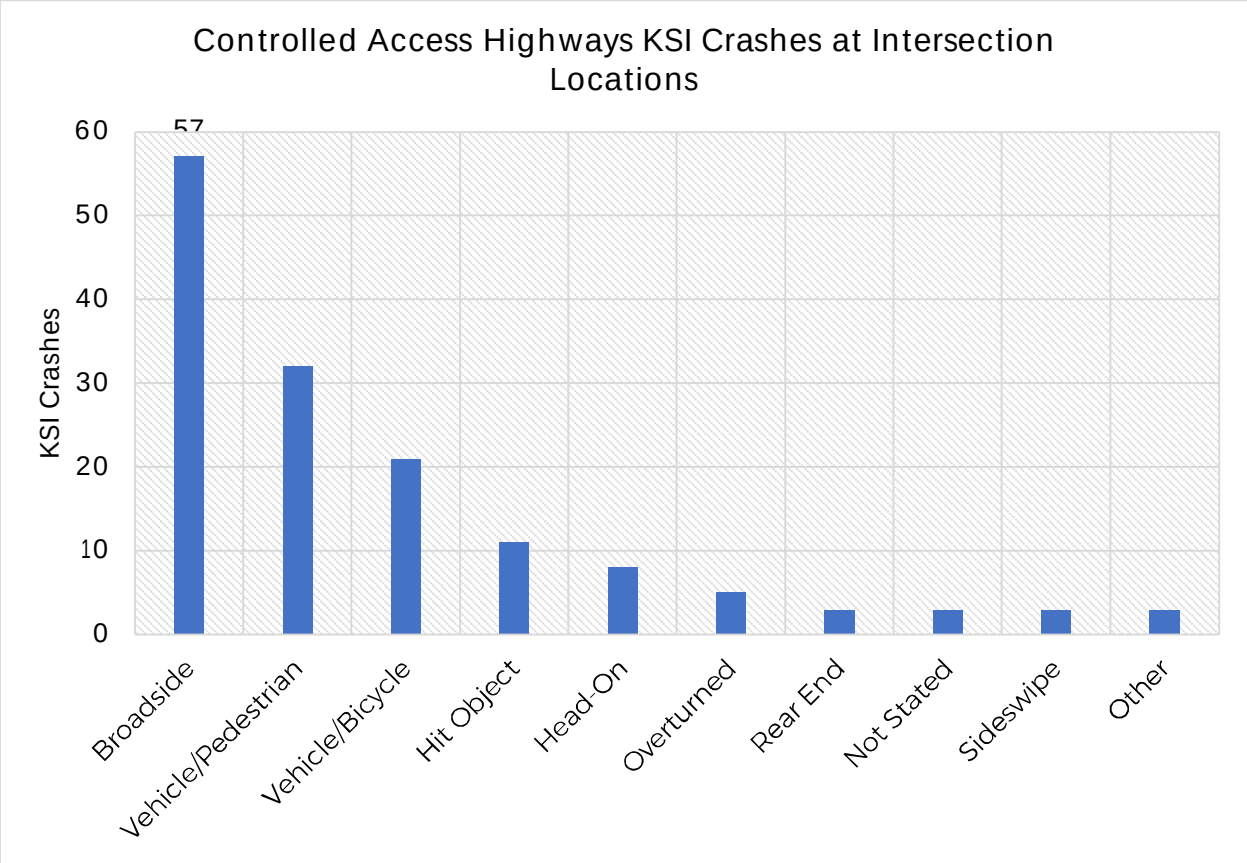


Figure 38: Controlled Access Highways KSI Crash Types at Intersection Locations

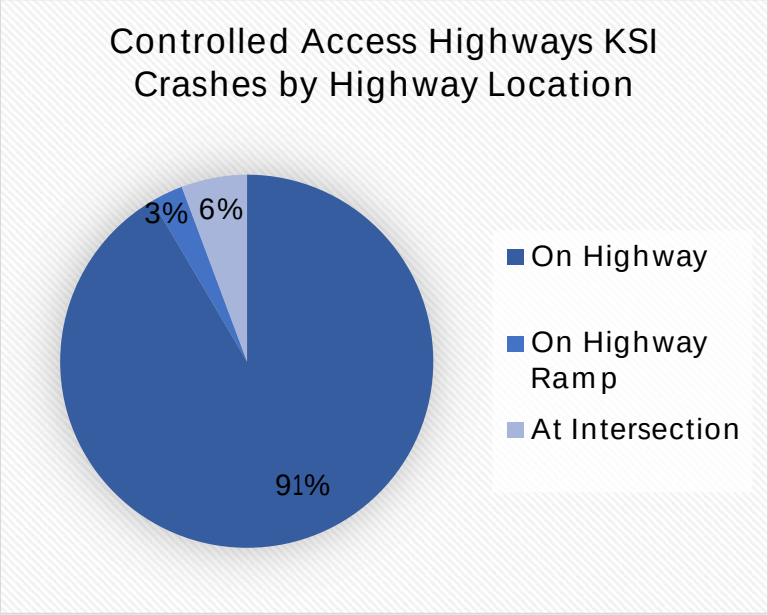


Figure 39: Controlled Access Highways KSI Crashes by Highway Location

Pedestrian and Bicycle Crash Locations and Types

Pedestrians and cyclists are prohibited from traveling along Controlled access highways. Regardless of this, there is a substantial amount of pedestrian and cyclist KSI crashes on these facilities. Most of these crashes occur at non-intersection locations and not on highway ramps. This is likely a result of pedestrian and cyclists attempting to cross controlled access highways, but the data necessary to determine this is not currently available.

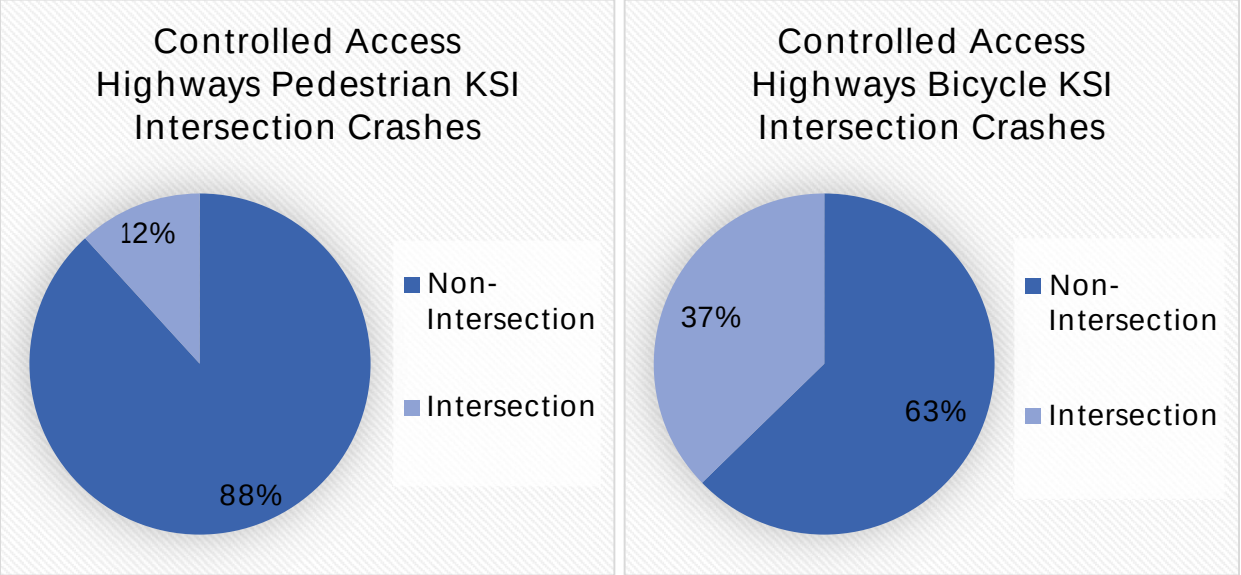


Figure 40: Controlled Access Highways Pedestrian and Bicycle KSI Intersection Crashes

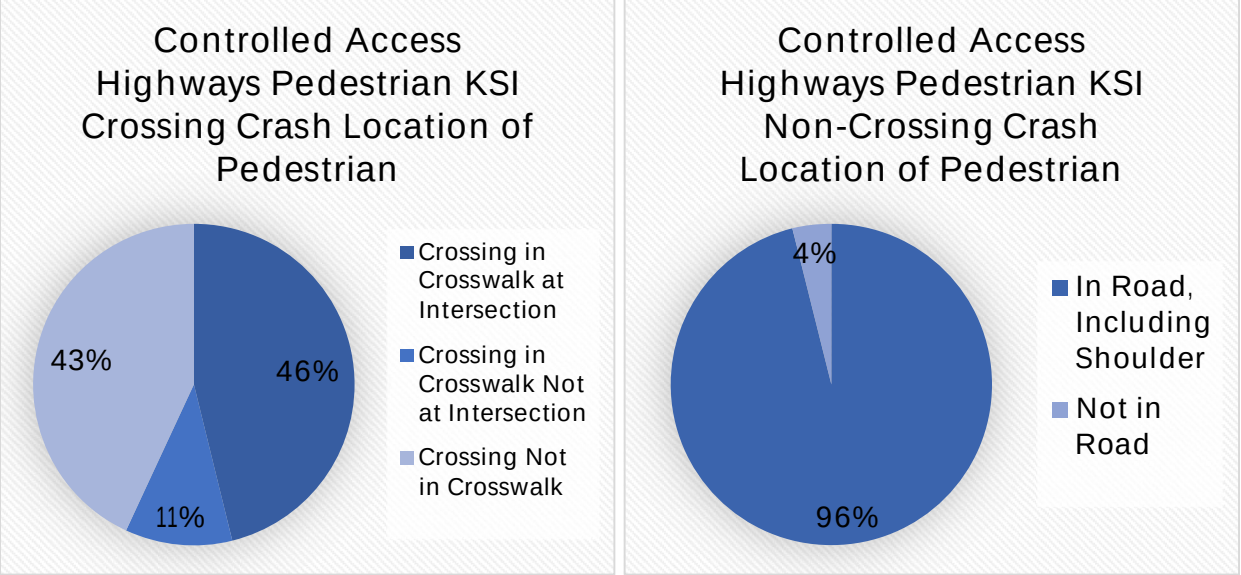


Figure 41: Controlled Access Highways Pedestrian KSI Crash Location of Pedestrian for Crossing Crashes and Non-Crossing Crashes

Contributing Circumstances

Contributing circumstances are the immediate identifiable causes of a crash as noted by the reporting law enforcement officer. These can include driver behavior, weather, and pavement conditions. The contributing circumstances also note the party at fault in a crash as determined by the reporting law enforcement officer.

Driver Actions and Designation of Fault

The most cited driver violations include unsafe speed, driving under the influence, and improper turning. Unsafe speed is often used as a "catch all" by law enforcement officers if no other obvious violation exists. This category accounts for nearly one-third of all crashes. By far the most common party noted as at-fault by reporting law enforcement officers is "passenger car/station wagon" (61%) followed by "motorcycle/scooter" and "pickup or panel truck." These three categories account for 90% of the at-fault users.

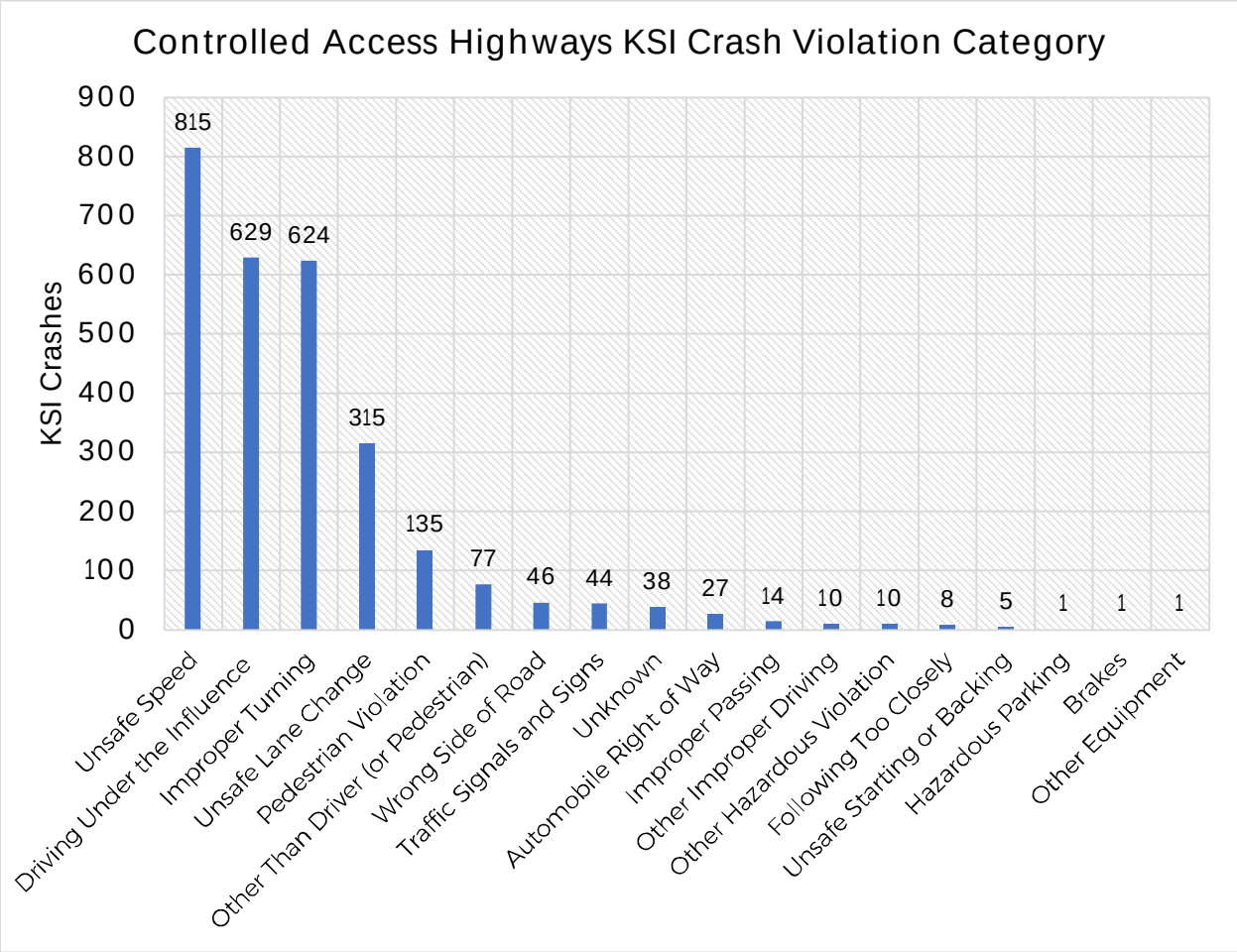


Figure 42: Controlled Access Highways KSI Crash Violation Category

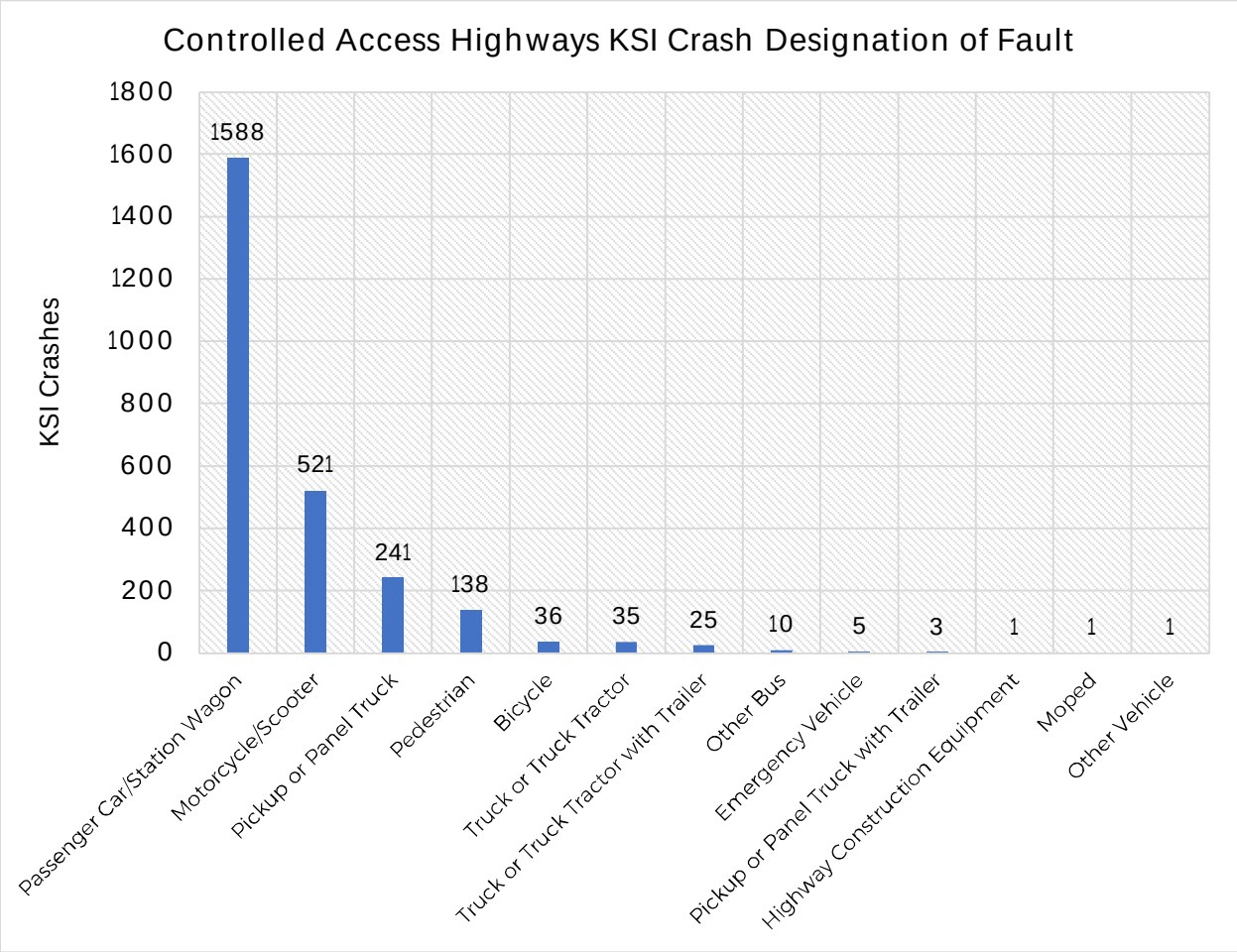


Figure 43: Controlled Access Highways KSI Crash Designation of Fault

Occupant Protection

89% of KSI crashes were found to have been wearing seatbelts and in 69% percent of KSI crashes the airbags deploy. Motorcyclist behavior was also examined and found that 97% of all motorcycle KSI crashes, the motorcycle user was wearing their helmets. It is undoubtedly that wearing proper equipment is essential for safety on roadways. While helmets and seatbelts help reduce the amount KSI crashes from the rate of usage they are only a small piece in the safety puzzle and that systemic changes to road designs with a vision zero and complete streets approach is needed. This data clearly shows that utilizing all proper occupant protection equipment in a vehicle will not stop fatal and serious injury crashes from occurring.

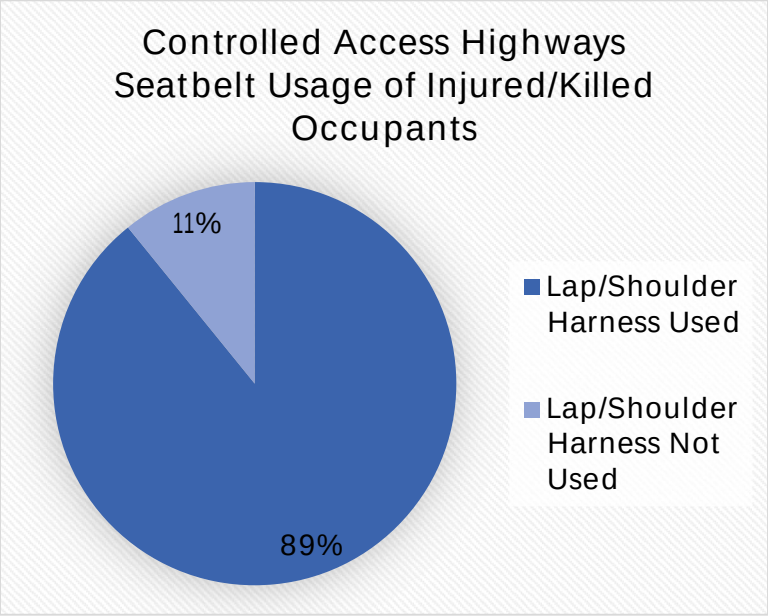


Figure 44: Controlled Access Highways KSI Crash Seatbelt Usage

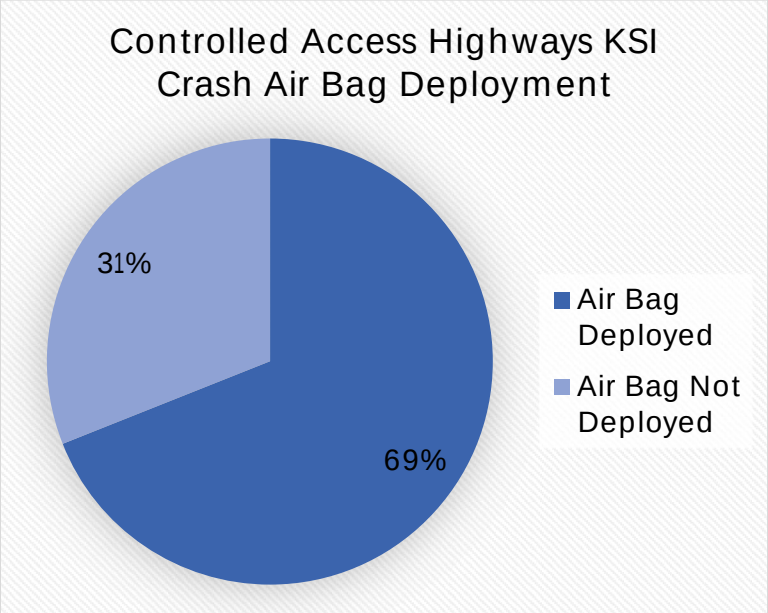


Figure 45: Controlled Access Highways KSI Crash Air Bag Deployment

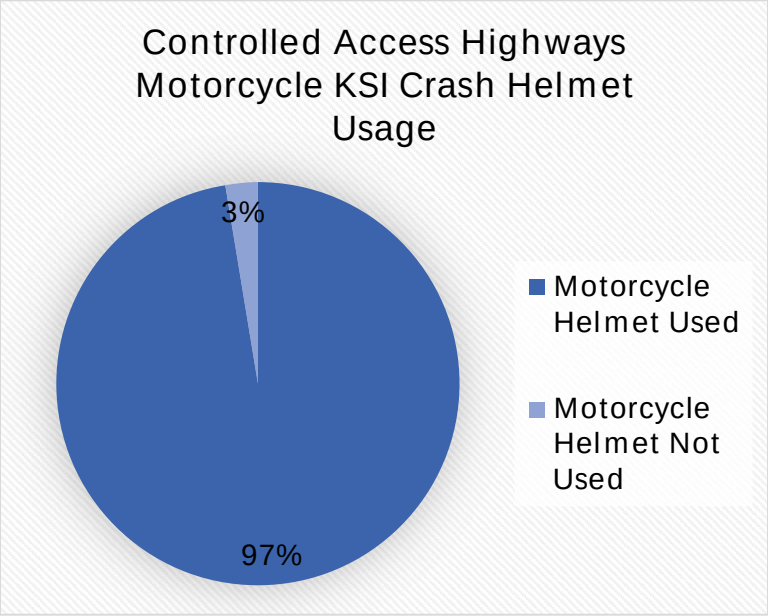


Figure 46: Controlled Access Highways KSI Motorcycle Crash Helmet Usage

Time and Day

Crash trends throughout the week tend to correspond to traffic pattern trends with higher numbers of crashes happening in the morning and afternoon peak periods of traffic. The exception to this rule is on Friday night/Saturday morning and Saturday night/Sunday morning between 10:00 pm and 3:00 am. This increase is attributed to increased alcohol use. Pedestrian and bicycle crashes show a trend like vehicle crashes, but the relatively small number of these crashes spread throughout the day creates difficulty in drawing conclusions from the data.

Controlled Access Highways KSI Crashes per Hour							
	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
Midnight	1.50%	0.50%	0.46%	0.50%	0.64%	0.68%	1.10%
1:00am	1.60%	0.29%	0.32%	0.39%	0.78%	0.43%	1.39%
2:00am	1.85%	0.57%	0.29%	0.68%	0.21%	0.46%	1.57%
3:00am	1.03%	0.39%	0.14%	0.43%	0.46%	0.39%	0.93%
4:00am	0.89%	0.43%	0.25%	0.57%	0.32%	0.18%	0.68%
5:00am	0.75%	0.57%	0.68%	0.68%	0.43%	0.43%	0.61%
6:00am	0.32%	0.53%	0.46%	0.75%	0.78%	0.29%	0.50%
7:00am	0.32%	0.71%	0.61%	0.75%	0.50%	0.36%	0.46%
8:00am	0.39%	0.53%	0.29%	0.53%	0.53%	0.53%	0.39%
9:00am	0.25%	0.43%	0.36%	0.32%	0.29%	0.29%	0.36%
10:00am	0.39%	0.61%	0.43%	0.21%	0.43%	0.39%	0.46%
11:00am	0.50%	0.36%	0.36%	0.32%	0.43%	0.61%	0.68%
Noon	0.75%	0.43%	0.43%	0.29%	0.32%	0.57%	0.68%
1:00pm	0.53%	0.43%	0.39%	0.43%	0.39%	0.43%	0.75%
2:00pm	0.64%	0.57%	0.36%	0.46%	0.57%	0.68%	0.93%
3:00pm	0.46%	0.71%	0.43%	0.75%	0.53%	1.07%	0.53%
4:00pm	0.61%	0.68%	0.57%	0.68%	0.46%	1.18%	0.71%
5:00pm	0.57%	0.46%	0.71%	0.93%	1.10%	1.10%	0.68%
6:00pm	0.78%	0.61%	0.64%	0.64%	0.93%	0.78%	0.82%
7:00pm	0.82%	0.61%	0.61%	0.57%	0.46%	0.50%	0.57%
8:00pm	0.50%	0.43%	0.53%	0.43%	0.39%	0.82%	0.61%
9:00pm	0.86%	0.64%	0.50%	0.57%	0.68%	0.71%	0.43%
10:00pm	0.71%	0.75%	0.68%	0.46%	0.57%	0.71%	1.07%
11:00pm	0.64%	0.39%	0.46%	0.64%	0.78%	1.25%	1.07%

Figure 47: Controlled Access Highways KSI Crashes per Hour

Controlled Access Highways Pedestrian KSI Crashes per Hour							
	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
Midnight	2.56%	0.73%	0.37%	0.00%	1.10%	0.37%	1.10%
1:00am	2.20%	0.00%	0.73%	0.37%	1.47%	0.00%	2.20%
2:00am	2.56%	0.73%	0.73%	1.10%	0.00%	0.00%	1.83%
3:00am	1.47%	0.73%	0.37%	0.00%	0.37%	1.83%	0.73%
4:00am	1.10%	1.10%	0.00%	1.47%	0.00%	0.37%	1.10%
5:00am	2.93%	1.10%	0.37%	1.83%	0.73%	0.37%	1.10%
6:00am	0.37%	0.37%	0.37%	1.10%	0.73%	0.37%	1.10%
7:00am	0.00%	0.37%	1.10%	0.37%	0.00%	0.37%	0.37%
8:00am	0.00%	0.73%	0.37%	0.00%	0.73%	0.37%	0.00%
9:00am	0.73%	0.00%	0.37%	0.00%	0.00%	0.37%	0.73%
10:00am	0.00%	0.37%	0.00%	0.37%	0.00%	0.73%	0.37%
11:00am	0.00%	0.00%	0.37%	0.37%	0.00%	0.37%	0.37%
Noon	0.73%	0.00%	0.00%	0.37%	0.00%	0.73%	0.00%
1:00pm	0.37%	0.00%	0.00%	0.73%	0.00%	0.37%	0.00%
2:00pm	0.00%	0.00%	1.10%	0.00%	0.00%	0.00%	0.00%
3:00pm	0.37%	0.73%	0.00%	0.37%	0.00%	0.37%	0.00%
4:00pm	0.37%	0.00%	0.00%	0.00%	0.00%	0.37%	0.00%
5:00pm	0.37%	0.00%	0.37%	0.00%	0.73%	1.10%	1.10%
6:00pm	1.83%	0.00%	0.37%	0.37%	0.37%	0.00%	1.10%
7:00pm	0.00%	1.47%	0.00%	1.10%	0.73%	0.73%	0.73%
8:00pm	1.10%	0.37%	0.73%	0.37%	1.10%	1.47%	0.73%
9:00pm	0.73%	1.10%	1.47%	1.10%	1.83%	0.37%	0.37%
10:00pm	1.47%	1.47%	0.37%	1.10%	1.10%	1.83%	1.10%
11:00pm	1.10%	0.37%	0.37%	0.73%	1.10%	0.73%	1.10%

Figure 48: Controlled Access Highways Pedestrian KSI Crashes per Hour

Controlled Access Highways Bicycle KSI Crashes per Hour							
	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
Midnight	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1:00am	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2:00am	1.79%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3:00am	0.00%	1.79%	0.00%	0.00%	1.79%	0.00%	0.00%
4:00am	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5:00am	0.00%	0.00%	3.57%	1.79%	0.00%	0.00%	0.00%
6:00am	0.00%	0.00%	1.79%	0.00%	1.79%	0.00%	0.00%
7:00am	0.00%	0.00%	0.00%	0.00%	1.79%	3.57%	1.79%
8:00am	0.00%	1.79%	0.00%	0.00%	0.00%	1.79%	1.79%
9:00am	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.79%
10:00am	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.79%
11:00am	0.00%	0.00%	0.00%	0.00%	0.00%	1.79%	0.00%
Noon	1.79%	0.00%	1.79%	0.00%	0.00%	0.00%	3.57%
1:00pm	3.57%	0.00%	1.79%	0.00%	0.00%	0.00%	1.79%
2:00pm	3.57%	3.57%	0.00%	0.00%	1.79%	0.00%	0.00%
3:00pm	0.00%	0.00%	0.00%	0.00%	1.79%	0.00%	0.00%
4:00pm	0.00%	1.79%	0.00%	0.00%	1.79%	0.00%	0.00%
5:00pm	0.00%	0.00%	1.79%	1.79%	0.00%	1.79%	1.79%
6:00pm	0.00%	1.79%	0.00%	1.79%	0.00%	0.00%	0.00%
7:00pm	0.00%	1.79%	1.79%	0.00%	0.00%	1.79%	1.79%
8:00pm	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.79%
9:00pm	1.79%	0.00%	0.00%	3.57%	0.00%	3.57%	0.00%
10:00pm	3.57%	1.79%	1.79%	0.00%	0.00%	0.00%	0.00%
11:00pm	1.79%	0.00%	0.00%	1.79%	0.00%	0.00%	0.00%

Figure 49: Controlled Access Highways Bicycle KSI Crashes per Hour

Weather, Road, and Lighting Conditions

96% of KSI crashes occurred during clear or cloudy weather and only 4% of KSI crashes with rain or other weather condition. Similarly, 90% of KSI crashes occurred on dry pavement and 95% of KSI crashes occurred on well-maintained pavement. Lighting factors are also shown. The majority of KSI crashes happened in daylight hours, or at night with streetlights on. Only 26% of crashes occurred at night without streetlights. Adverse weather, wet pavement, poor pavement quality, and dark/unlit roadways do contribute some to KSI crash risk, they are overwhelmingly not the main factors involved in most crashes. Furthermore, better road design takes weather and lighting into account.

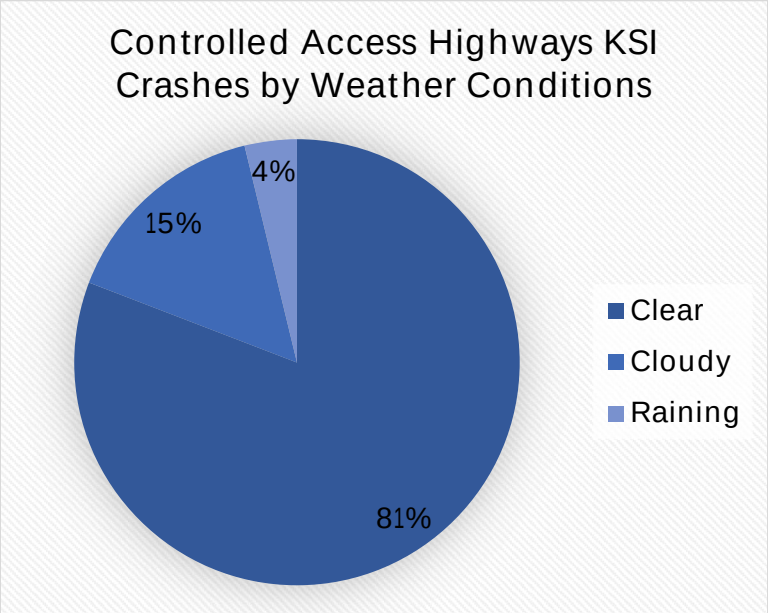


Figure 50: Controlled Access Highways KSI Crashes by Weather Conditions

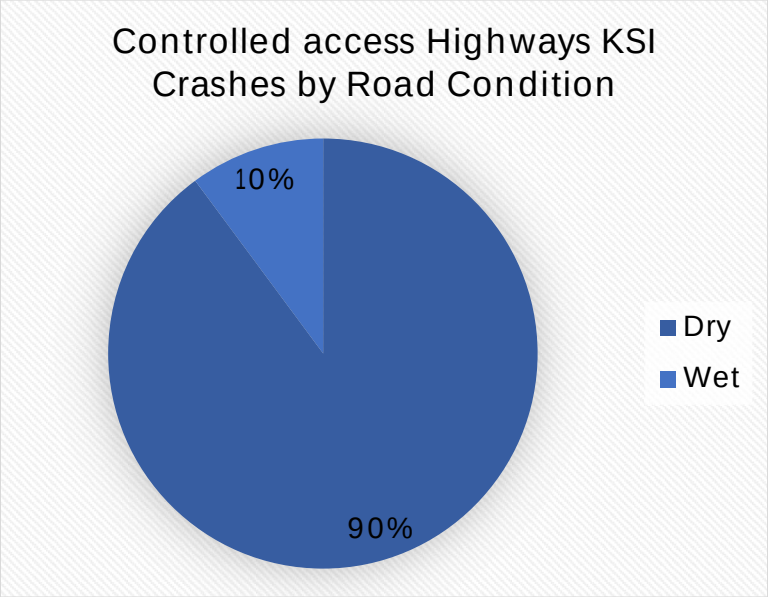


Figure 51: Controlled Access Highways KSI Crashes by Road Condition

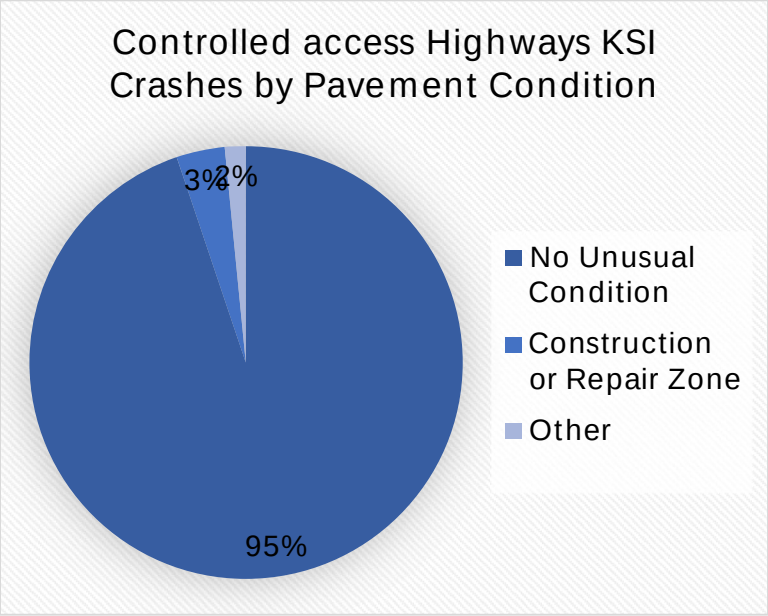


Figure 52: Controlled Access Highways KSI Crashes by Pavement Condition

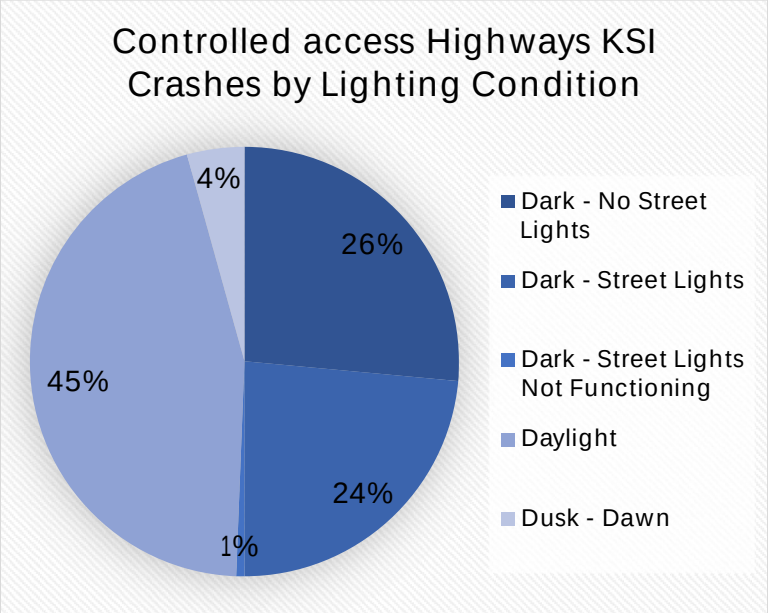


Figure 53: Controlled Access Highways KSI Crashes by Lighting Condition

Inattention and Impairment

Inattentive or "distracted" driving is often cited as an important contributing circumstance for crashes in common literature. However, the data shows that only 1% of drivers and less than 1% of bicyclists and pedestrians involved in KSI crashes in the Bay Area on controlled access highways were inattentive. More users are impaired, with 20% of drivers and 12% of cyclists and pedestrians impaired with either alcohol or drugs for KSI crashes. The majority of KSI crashes in the bay area involve non-impaired

and attentive drivers. In both cases of inattention and intoxication, drivers are more likely to be inattentive or intoxicated than pedestrians or cyclists.

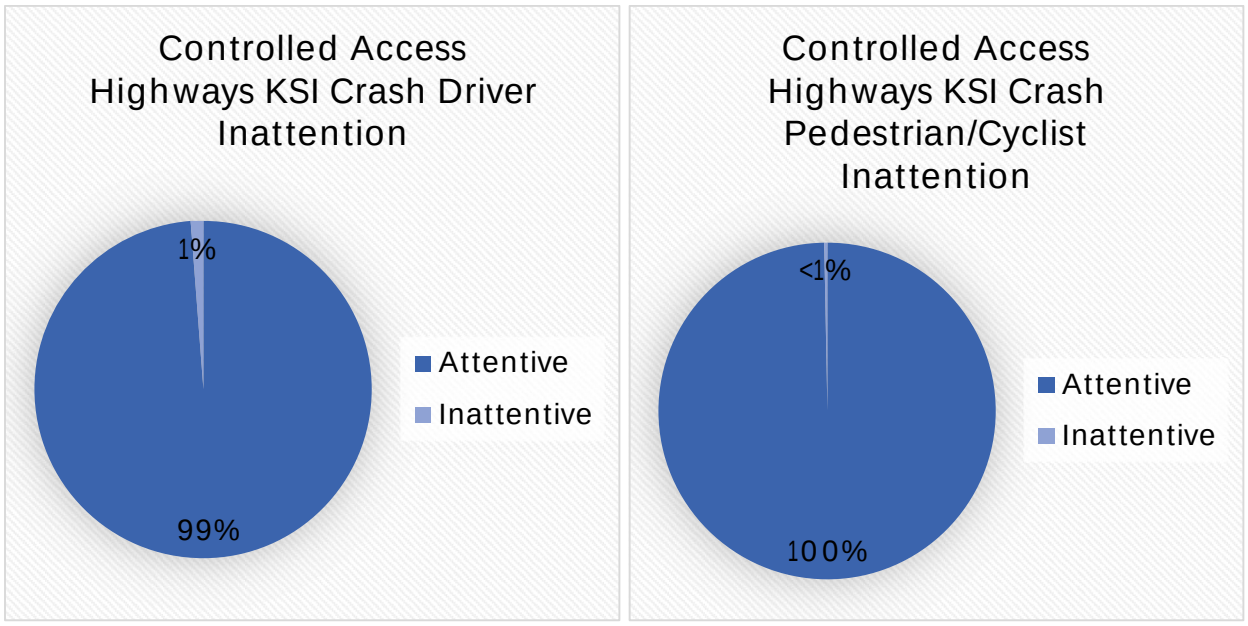


Figure 54: Controlled Access Highway KSI Crash Inattention Involvement

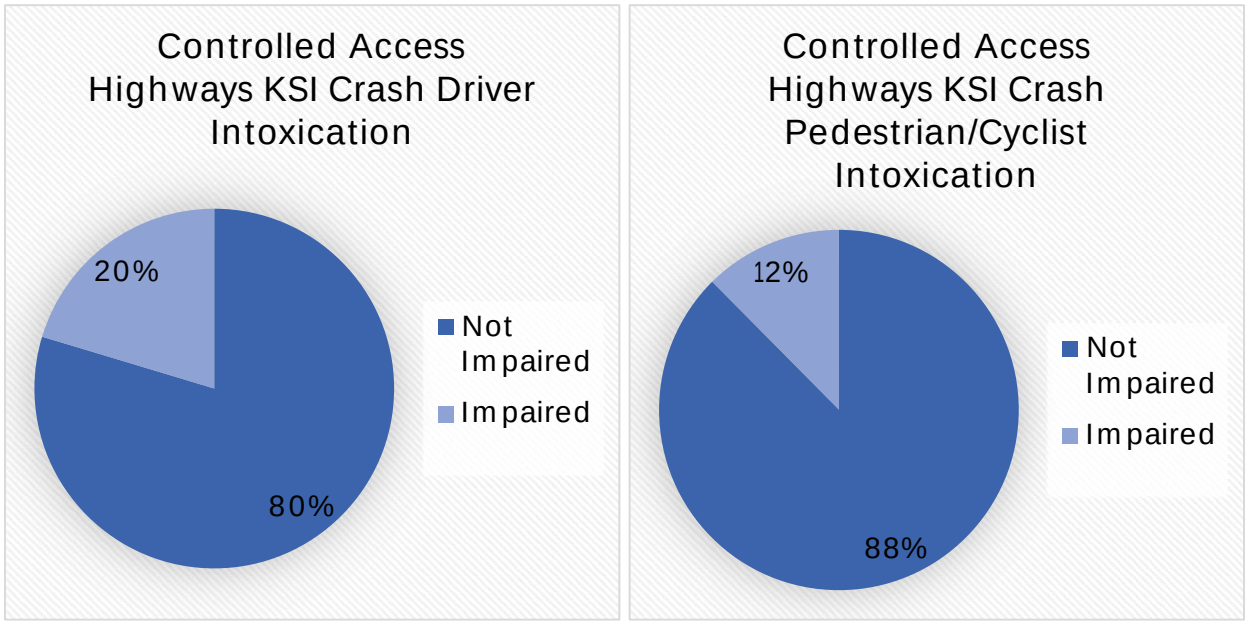


Figure 55: Controlled Access Highways KSI Crash Alcohol Intoxication Involvement

Regional Local Access Roads KSI Crash Summary

Local access roads account for 73% of the fatal crashes and 79% of the serious injury crashes in the Bay Area. Roughly 320 people die and 1,800 are seriously injured on local access roads in the Bay Area every year. The number of KSI crashes on these roads is increasing. For this analysis, a local access road was defined as all streets that are not classified by Caltrans as functional class roads "Interstate" and "Other Freeway or Expressway." This includes all streets that are not controlled access/grade separated roads in the Bay Area regardless of agency jurisdiction. Crash data ranges used for this analysis covers the five years of 2015 – 2019 and 2010-2019 for trend charts. Note that not all charts total to the same number of crashes due to gaps in data. All statistics are shown for crash records where the relevant data exists. Null values are not included.

Trends

KSI crashes on local access roads in the Bay Area have increased dramatically over the 10-year period of 2010 – 2019. Fatal crashes on local access roads have increased 56% and serious injury crashes have increased 57%. Some of the increase in serious injury crashes could be the result of the change of definition from "severe injury" to "suspected serious injury" in 2017. However, since the definition change, the serious injury crash rates have continued to rise, with a 20% increase between 2017 and 2019. Fatal and serious injury crash trends from 2010 to 2019 are shown in Figure 56 and Figure 57 respectively.

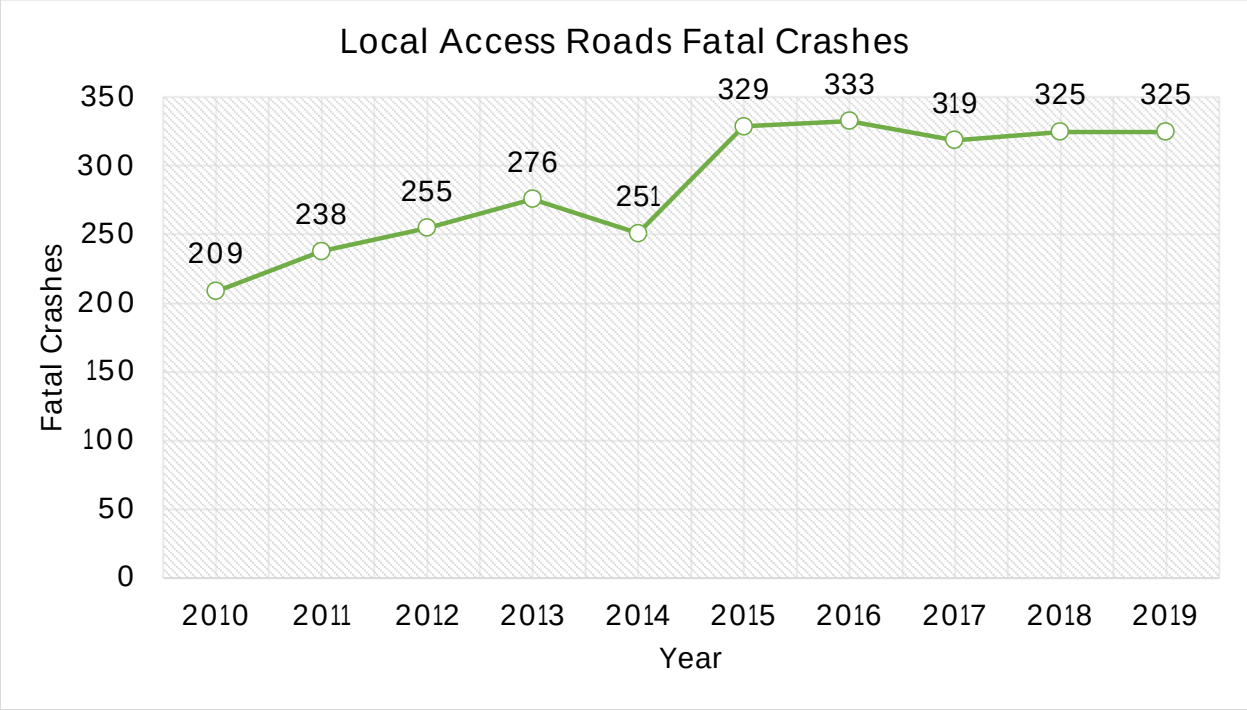


Figure 56: Local Access Roads Fatal Crash Trend 2010 - 2019

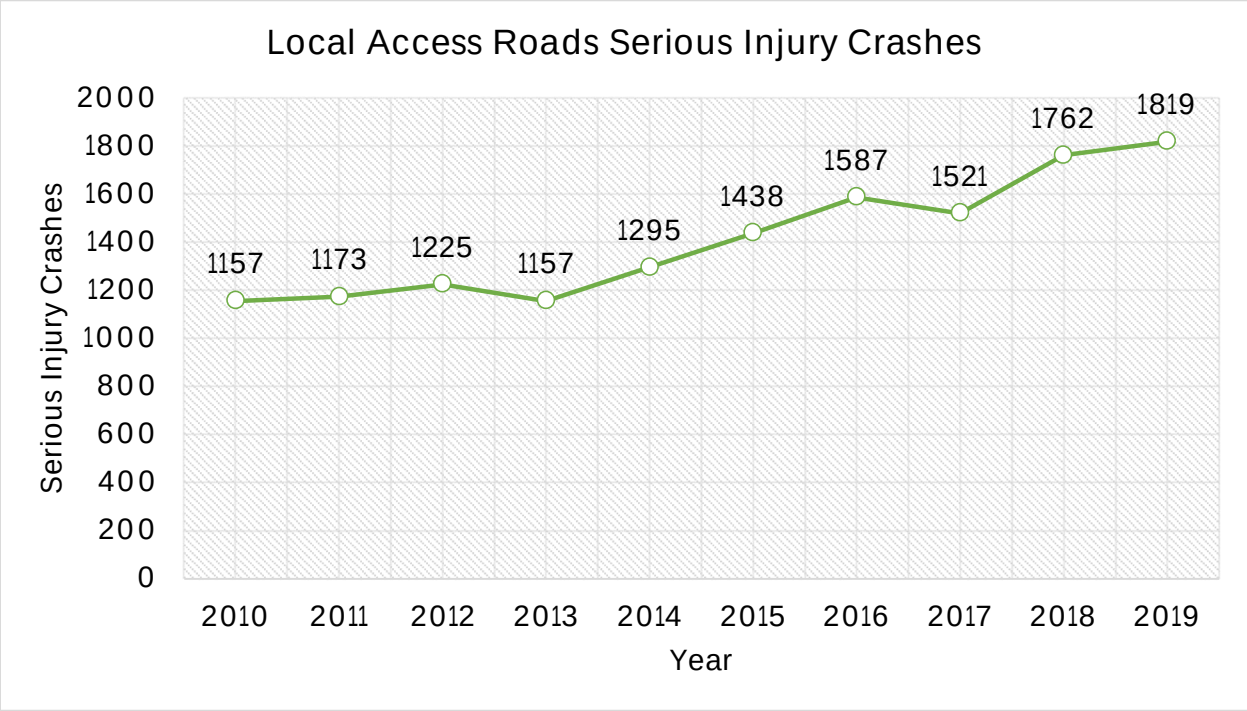


Figure 57: Local Access Roads Serious Injury Crash Trend 2010 - 2019

Transportation Modes

Local access roads provide mobility for all modes of transportation, primarily driving, walking, and biking. The majority of KSI crashes on local access roads are vehicle crashes that do not involve a pedestrian or cyclists. However, a large share involves pedestrians (26%) and cyclists (13%). The Bay Area has many walkable and bikeable neighborhoods; however, most Bay Area commuters drive. The commuting data from the 2015 – 2019 ACS 5-year estimate shows the following commuting patterns for the San Jose-San Francisco-Oakland, CA CSA:

- Car, truck, or van 76.9%
- Public transportation (excluding taxicab) 10.4%
- Walked 3.4%
- Bicycle 1.6%
- Taxicab, motorcycle, or other means 1.7%
- Worked from home 5.9%

Figure 58 and Figure 59 show the split between travel mode and relation to KSI crashes. Although biking and walking KSI crashes represent a smaller share of overall KSI crashes on local access roads, the relative risk is much higher than for driving.

Vehicle crashes on local access roads in the Bay Area have been increasing dramatically. Since 2010, vehicle KSI crashes have increased 63% between 2010 and 2019. Pedestrian KSI crashes have increased 64% and bicycle crashes have increased 23% between the years 2010 and 2019.

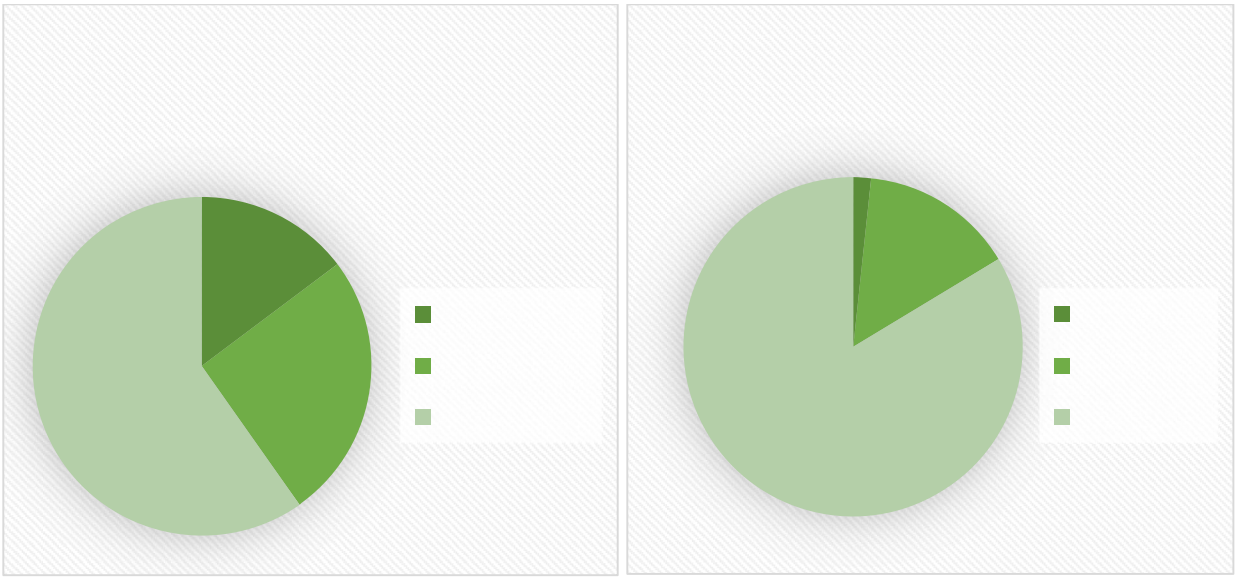


Figure 58: Local Access Roads KSI Crashes by Transportation Mode and Approximate Commute Mode Share for Traffic Crash Exposure.

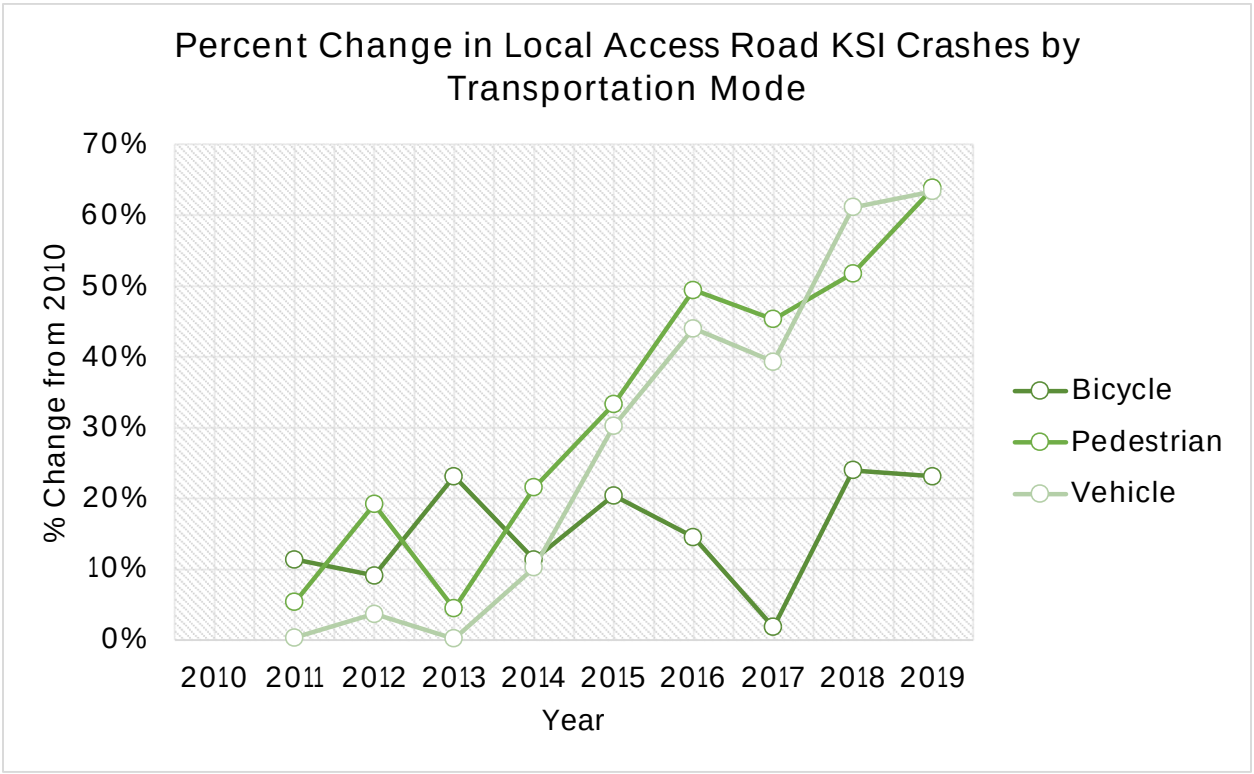


Figure 59: Percent Change in Local Access Roads KSI Crashes by Transportation Mode

Users and Equity

Local Access Roads also suffer from the effects of systemic racism. This manifests itself in crash data. Black users and Other users (which primarily consist of indigenous peoples) account for a disproportionally large proportion of crashes. Both groups are over-represented by nearly double when comparing crash proportion to population

proportion. Historical injustices have helped create conditions where their over-representation of KSI crashes in EPCs because the highways were predominantly built in EPCs because of low acquisition cost as well as less political fear of community retaliation.

Equity priority areas as defined by MTC were also examined for KSI crashes. These areas are of special focus as they are areas in which are affected disproportionally by safety issues affecting roadways and include the most vulnerable users. When looking at crashes in equity priority communities vs crashes not in equity priority communities, only 26% of all crashes occur in equity priority communities; however, when adjusted for population proportion, there is a 1.3 times higher chance of a KSI crash happening in an equity priority community than outside an equity priority community. As such, it is important that any steps taken towards safety improvements keep equity as a key consideration.

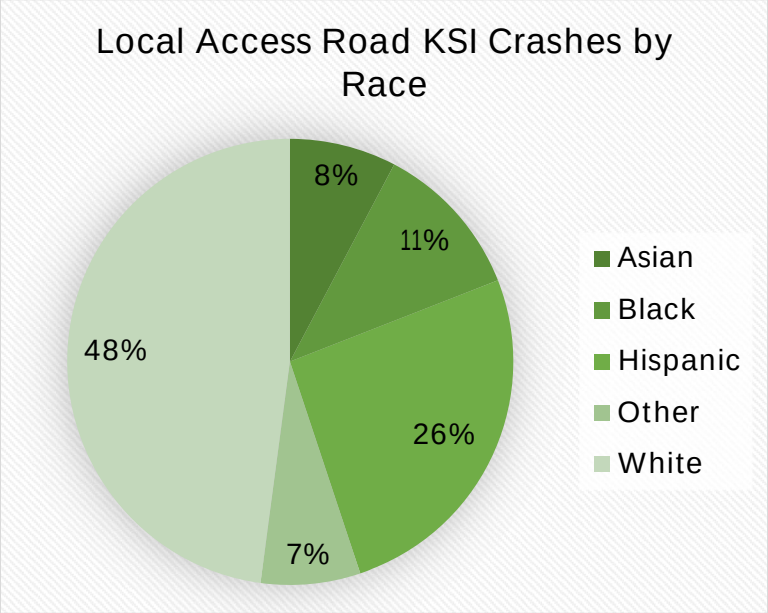


Figure 60: Local Access Roads KSI Crashes by Race

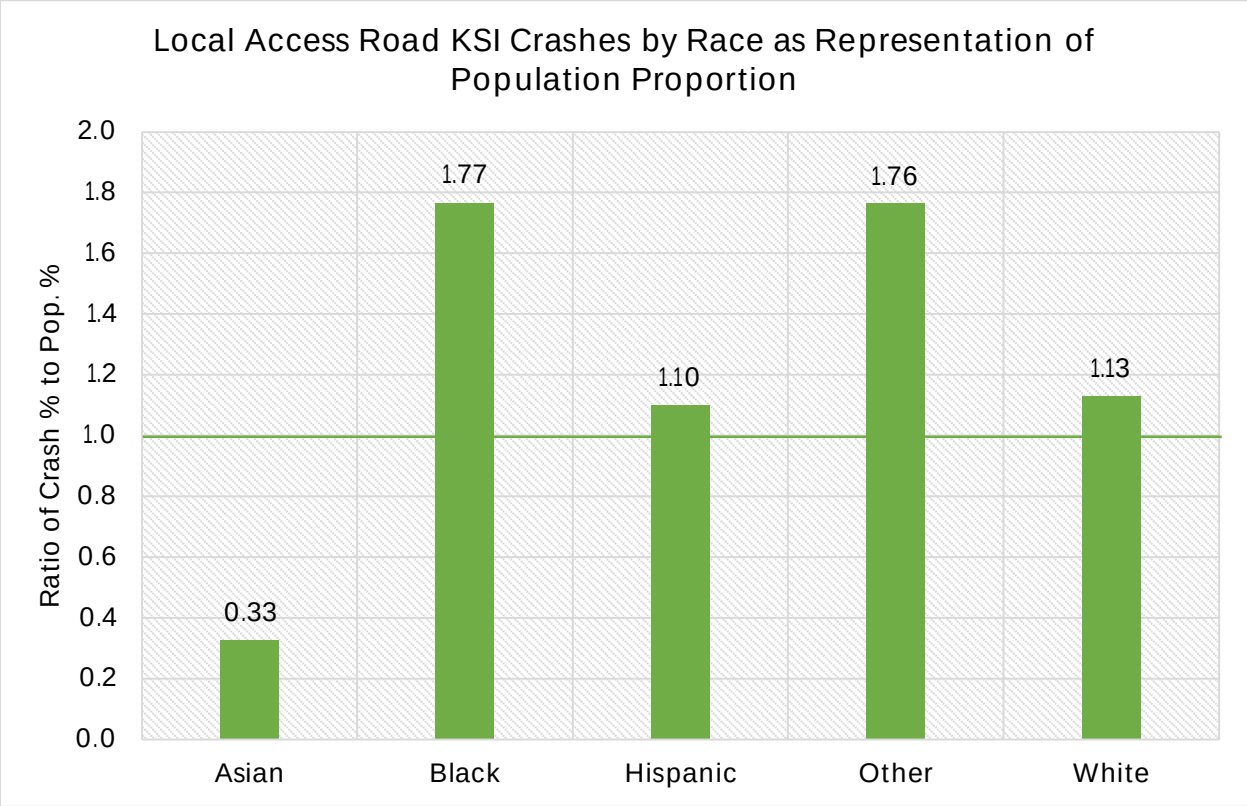


Figure 61: Local Access Roads KSI Crashes by Race as a Representation of Population (>1.0 = Over-Representation)

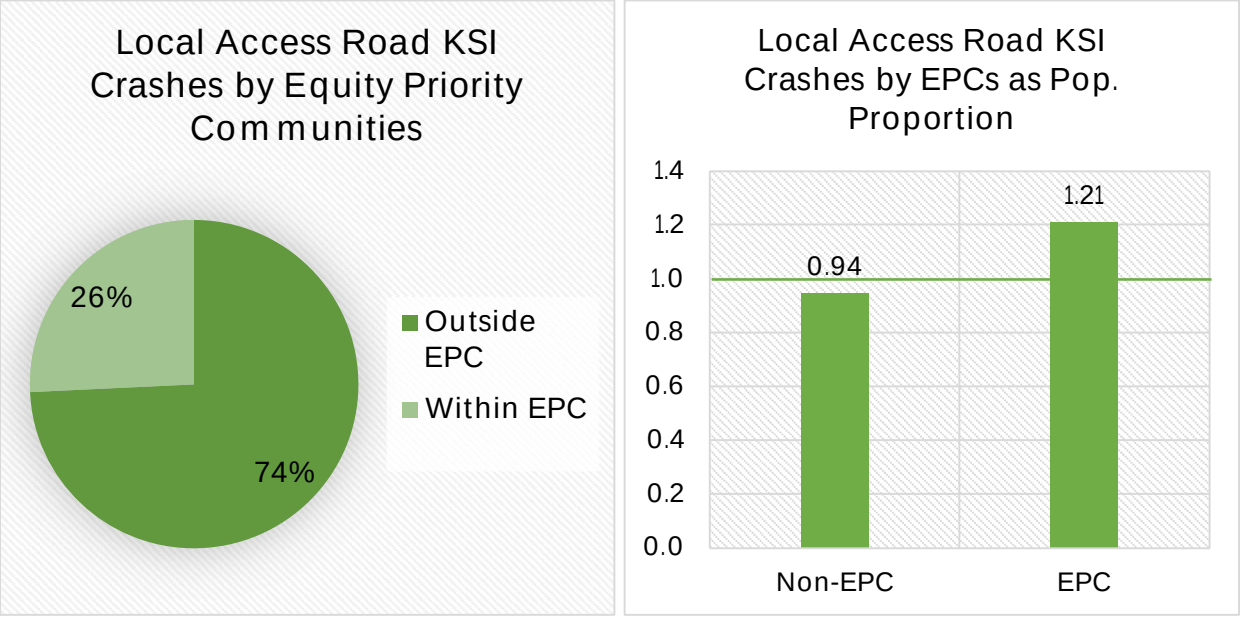


Figure 62: Local Access Roads KSI Crashes by Equity Priority Community and Crashes by Equity Priority Areas as a Representation of Population (>1.0 = Over-Representation)

Age

Crashes on local access roads do not occur evenly across age groups. The groups that account for the largest number of crashes is those in their 20s, with 20-24 accounting for 1,325 KSI crashes and 25-29 for 1199. Normalizing for population, users in their 20s not only are involved in a high frequency of KSI crashes, but that these users are also over-represented. Users in the age group of 20-24 are 2.2 times more likely to be involved in a KSI crash than average.

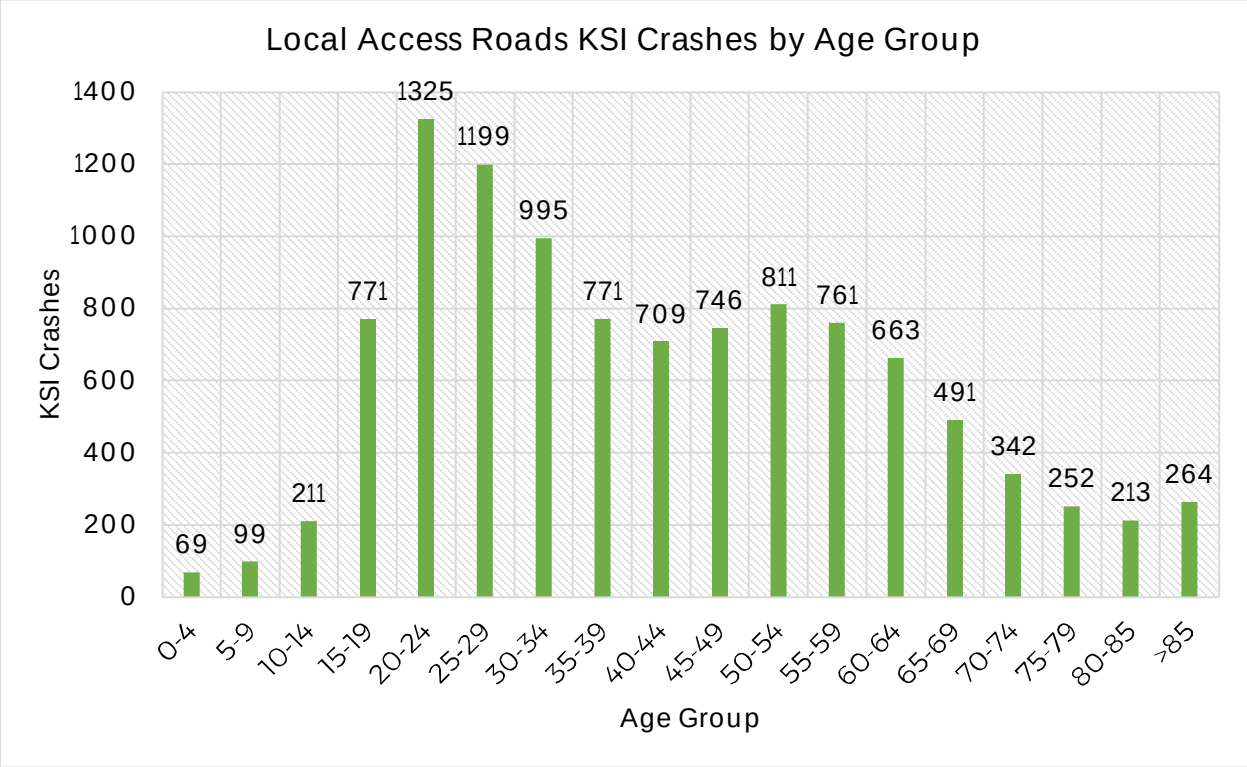


Figure 63: Local Access Roads KSI Crashes by Age Group

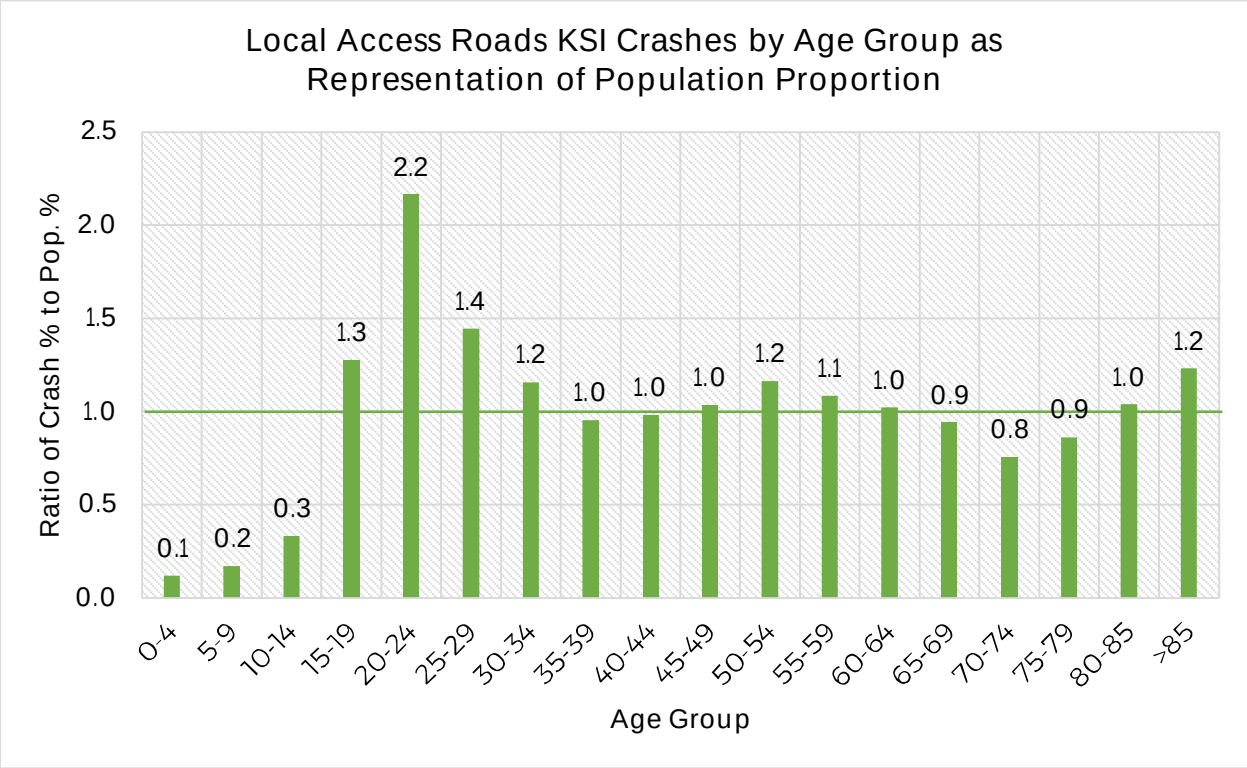
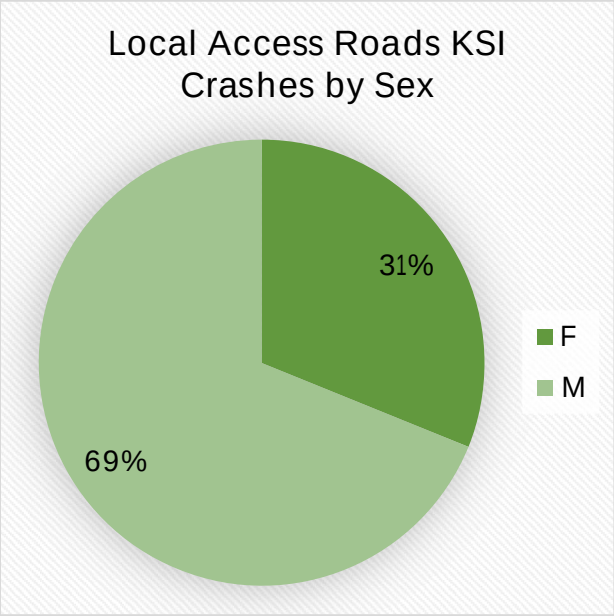


Figure 64: Local Access Roads KSI Crashes by Age Group as a Representation of Population (>1.0 = Over-Representation)

Sex

Males currently account for 69% of crashes and are nearly 2.3 times as likely to be involved in a KSI crash compared to females on local access roads.



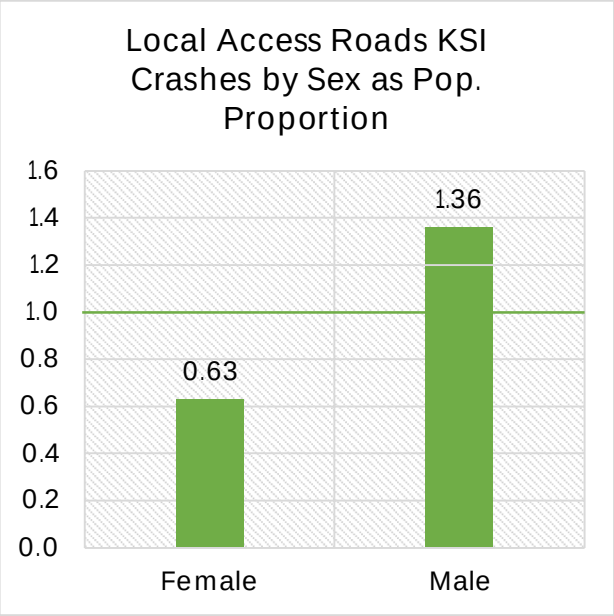


Figure 65: Local Access Roads KSI Crashes by Sex and Crashes by Sex as a Representation of Population (>1.0 = Over-Representation)

Crash Locations and Types

The majority of KSI crashes on local access roads occur at non-intersection locations. Most of the non-intersection crashes involve crashes with fixed objects (25%) and pedestrians (22%). Most of the crashes at intersections involve broadsides (31%), pedestrians (31%) and bicyclists (13%). The high number of bicycle and pedestrian crashes is notable and should be a focus of safety efforts on local access roads. Creating separated and safe facilities for cyclists and pedestrians via protected lanes or mixed-use trails. Additionally, fixed object and broadside crashes should be a focus of vehicle crashes.

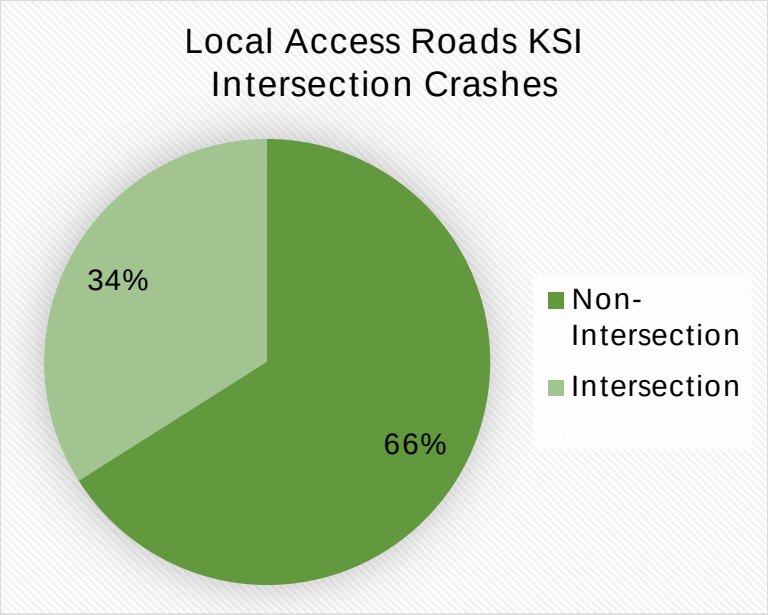


Figure 66: Local Access Roads KSI Intersection vs Non-Intersection Crashes

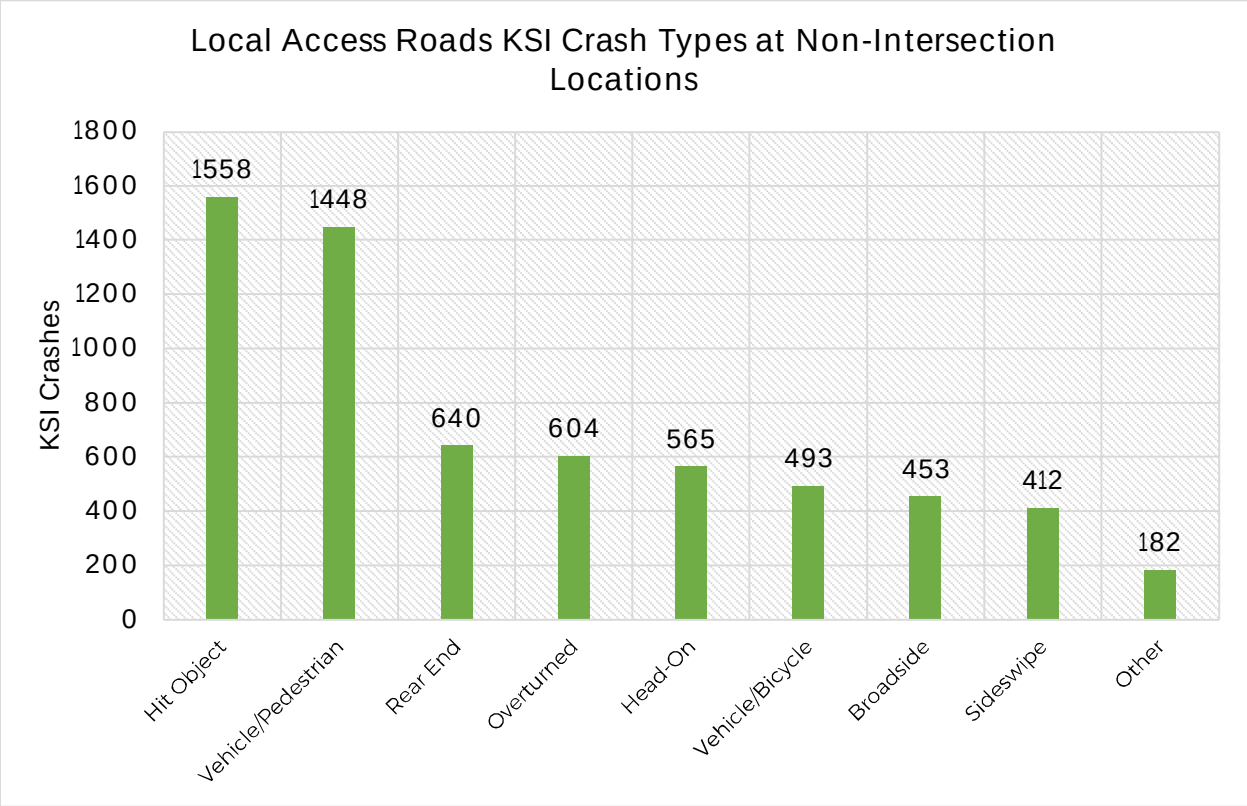


Figure 67: Local Access Roads KSI Crash Types at Non-Intersection Locations

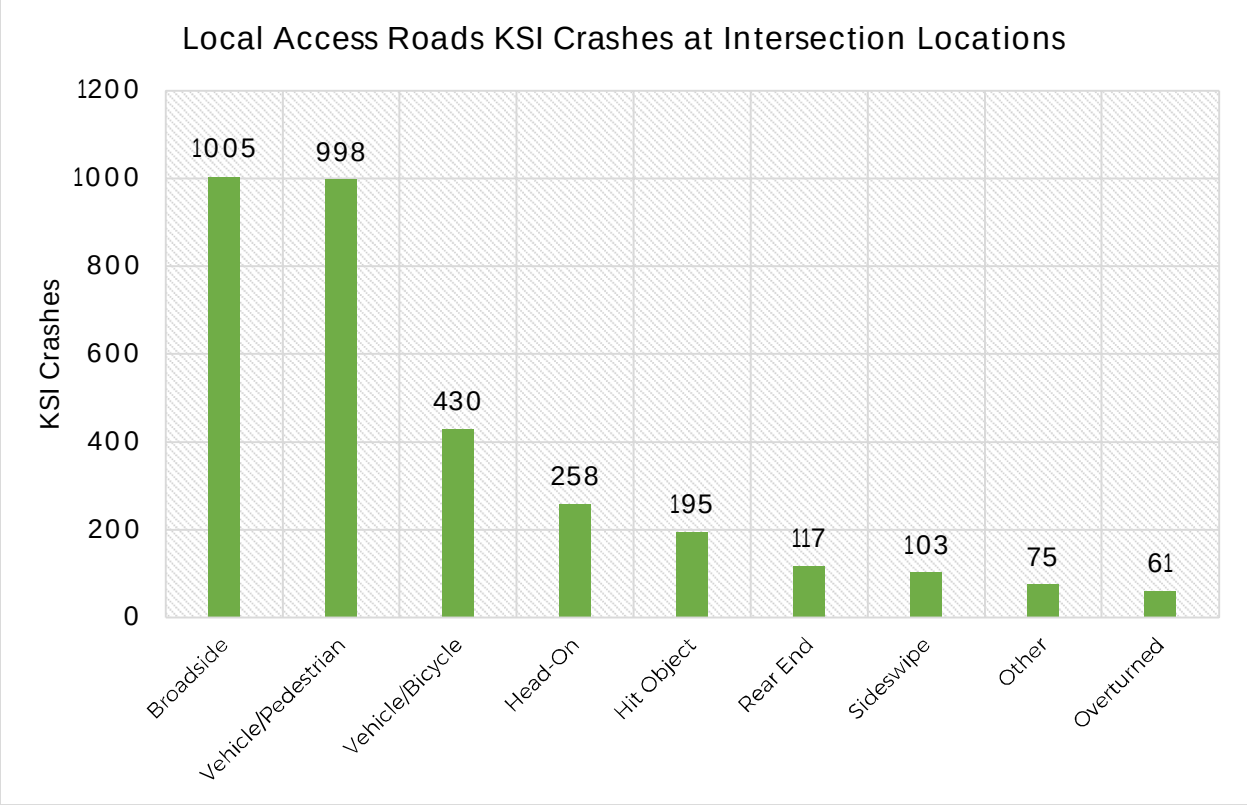


Figure 68: Local access roads KSI Crash Types at Intersection Locations

Pedestrian and Bicycle Crash Locations and Types

Data for bicycle crash locations were not available, but data for pedestrian locations were. This data shows that KSI crashes happened either at intersections (54%) or at non-intersection locations outside of marked crosswalks (42%). For pedestrian crashes that do not involve a pedestrian crossing the street, but rather walking along the street, 78% of them occurred when a pedestrian was walking in the street or shoulder. This would likely indicate that a sidewalk did not exist at these locations.

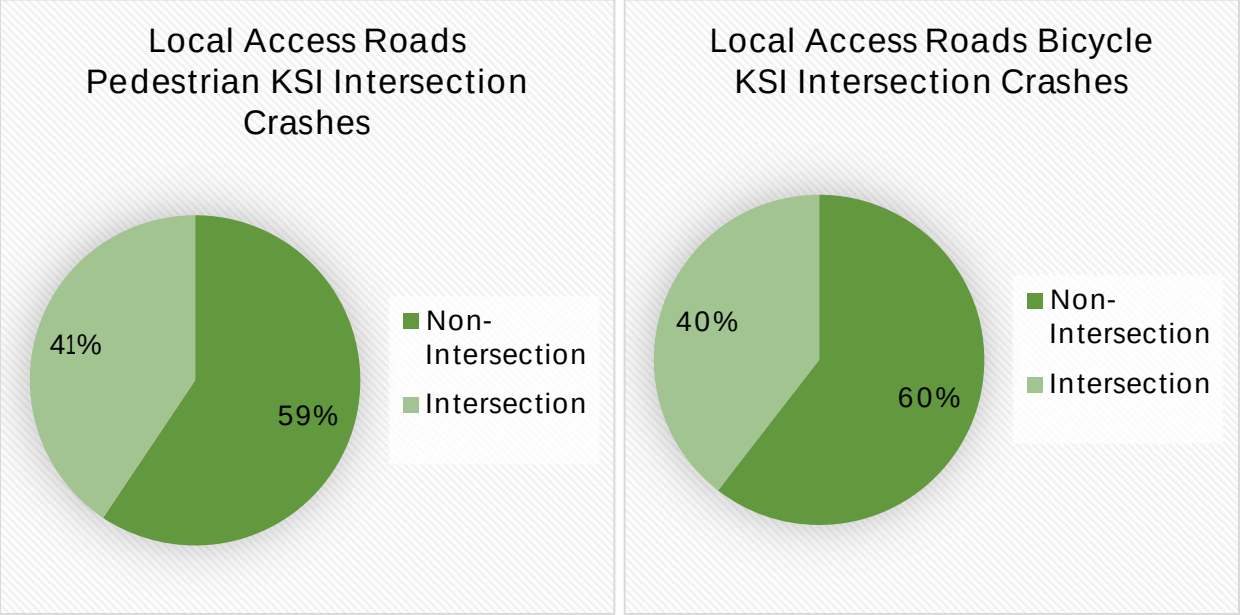


Figure 69: Local Access Roads Pedestrian and Bicycle KSI Intersection Crashes

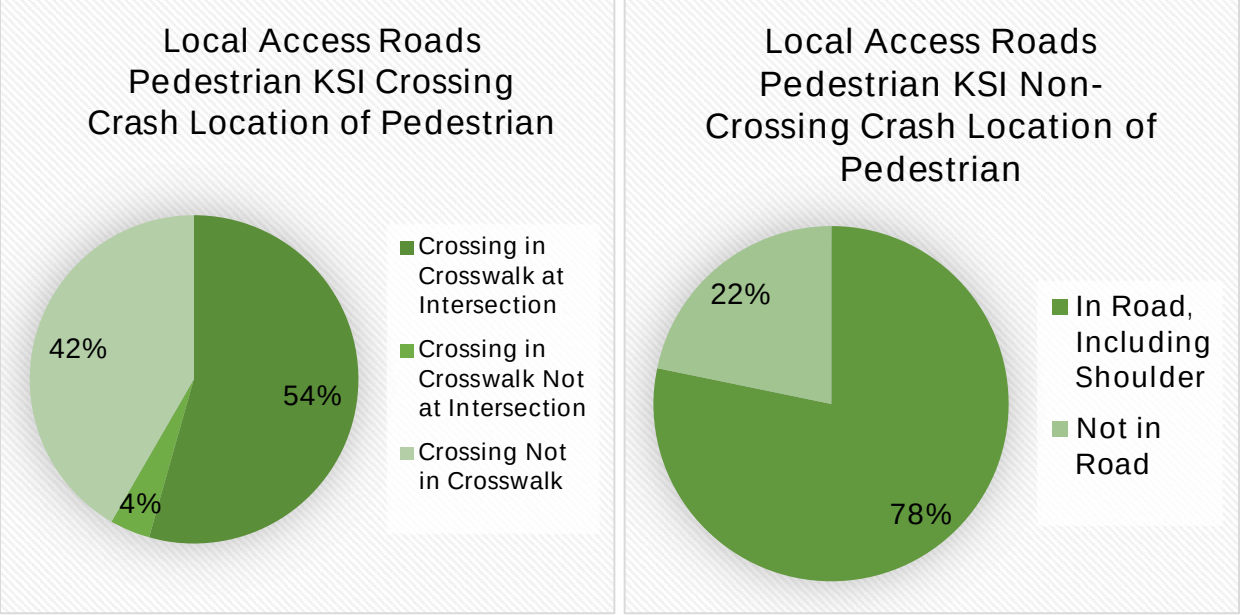


Figure 70: Local Access Roads Pedestrian KSI Crash Location of Pedestrian for Crossing Crashes and Non-Crossing Crashes

Contributing Circumstances

Contributing circumstances are the immediate identifiable cause of a crash as noted by the reporting law enforcement officer. These contributing circumstances can include things like driver behavior, weather, and pavement conditions. The contributing circumstances also note the party at fault in a crash as determined by the reporting law enforcement officer. The data in this section shows that while many contributing circumstances exist, many crashes have no reported contributing circumstances. The majority of KSI crashes do not involve adverse weather, dark lighting conditions, lack of seat belt usage, or negligent user behavior. Alcohol intoxication contributes to a substantial number of KSI crashes.

Driver Actions and Designation of Fault

The most cited driver violations include unsafe speed, improper turning, and driving under the influence. Unsafe speed is often used as a "catch all" by law enforcement officers if no other obvious violation exists, and this accounts for 19% of all crashes. Four of the five most common violations; unsafe speed, improper turning, and right of way violations all stem from underlying engineering design issues which is a focus of the vision zero philosophy of crash reduction. The most common party noted as at-fault by reporting law enforcement officers is "passenger car/station wagon" (56%) followed by "motorcycle/scooter" and "pedestrian." These three categories account for 80% of the at-fault users.

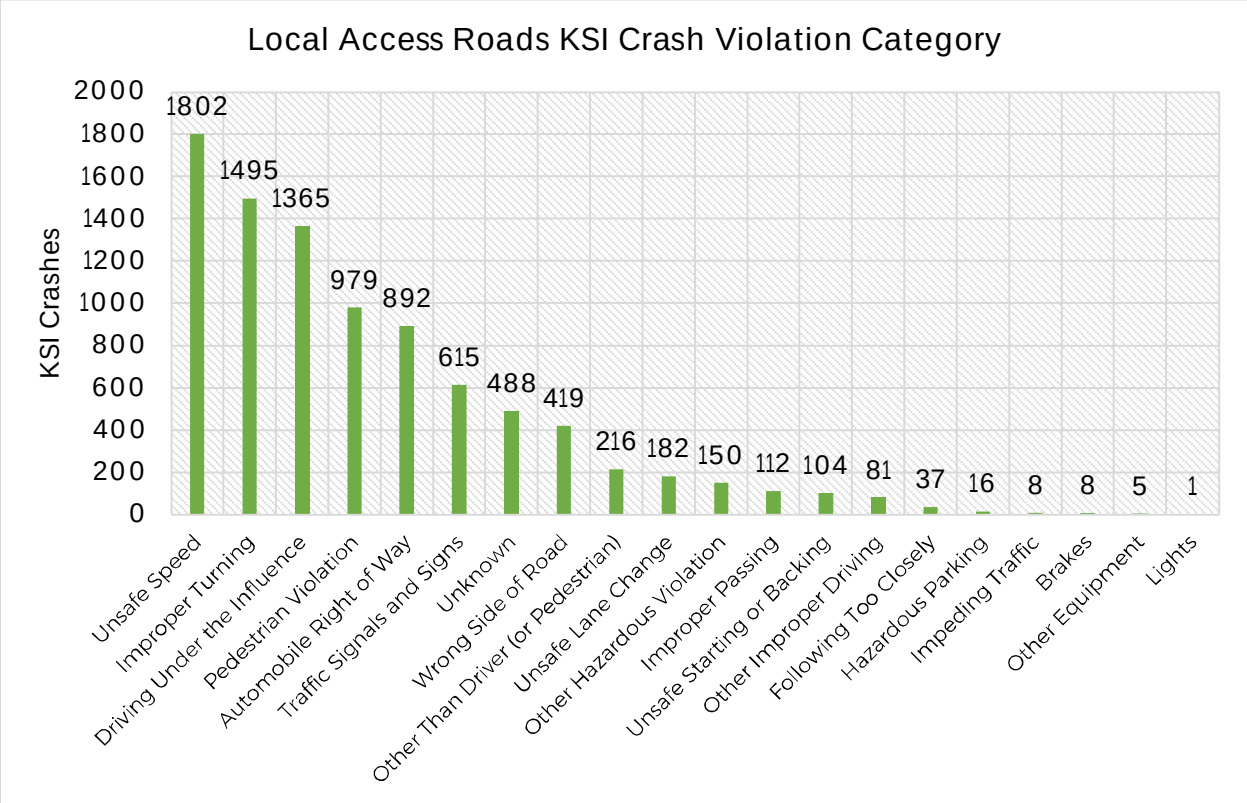


Figure 71: Local Access Roads KSI Crash Violation Category

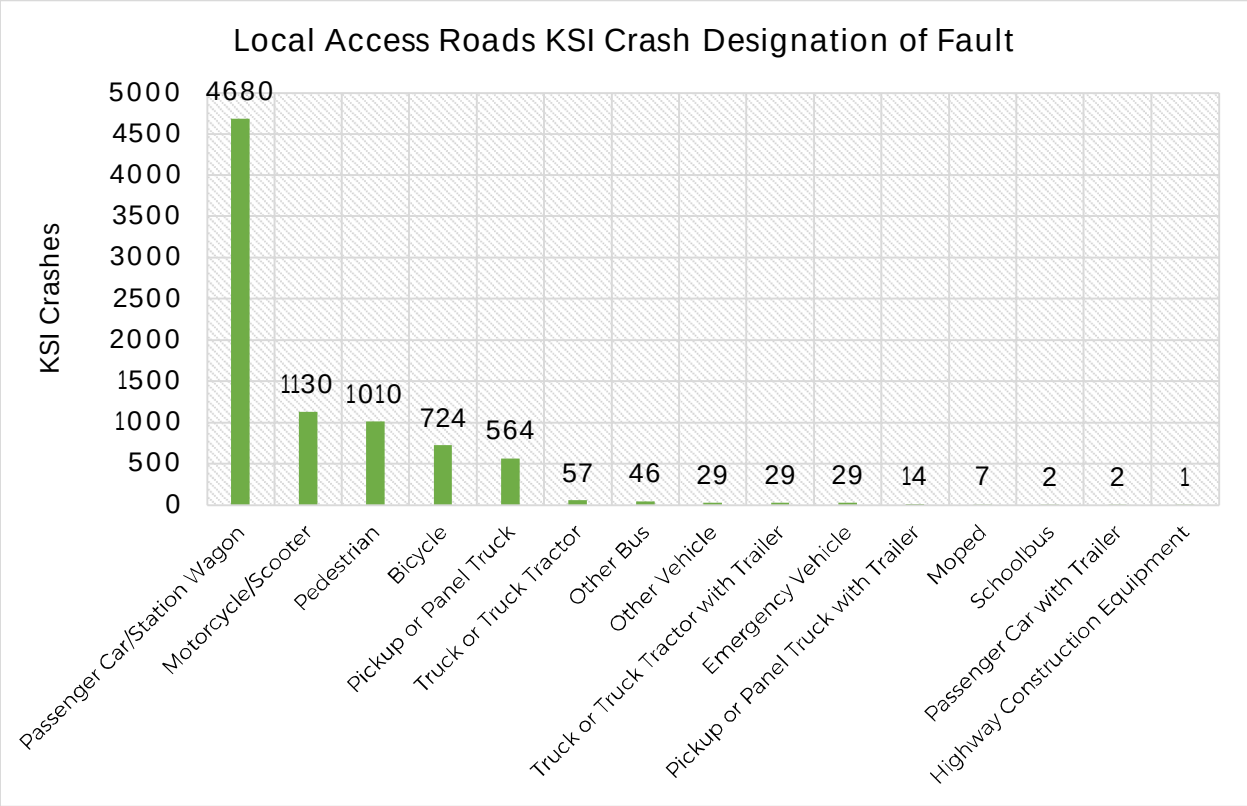


Figure 72: Local Access Roads KSI Crash Designation of Fault

Occupant Protection

89% of KSI crashes were found to have been wearing seatbelts and in 71% percent of KSI the airbags deployed. Motorcyclist behavior was also examined and found that 91% of all motorcycle KSI crashes were wearing their helmets. This data clearly shows that utilizing all proper occupant protection equipment in a vehicle will not stop fatal and serious injury crashes from occurring.

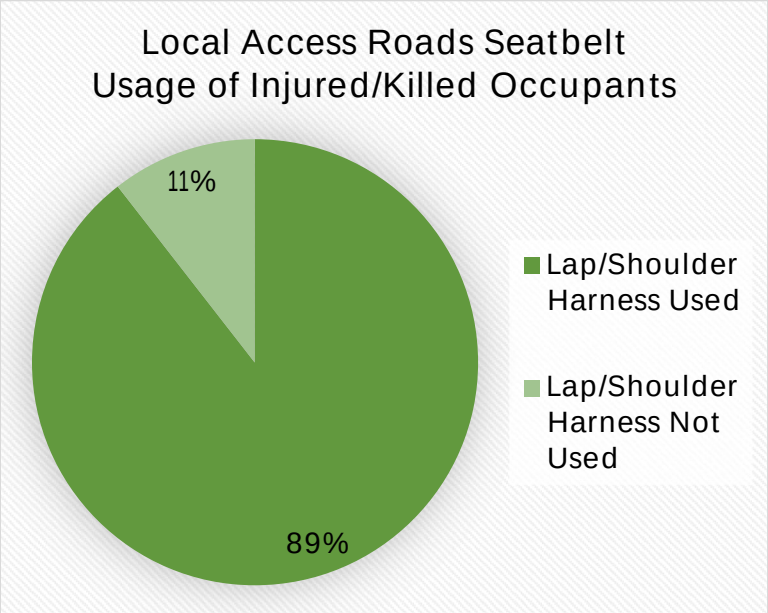


Figure 73: Local Access Roads KSI Crash Seatbelt Usage

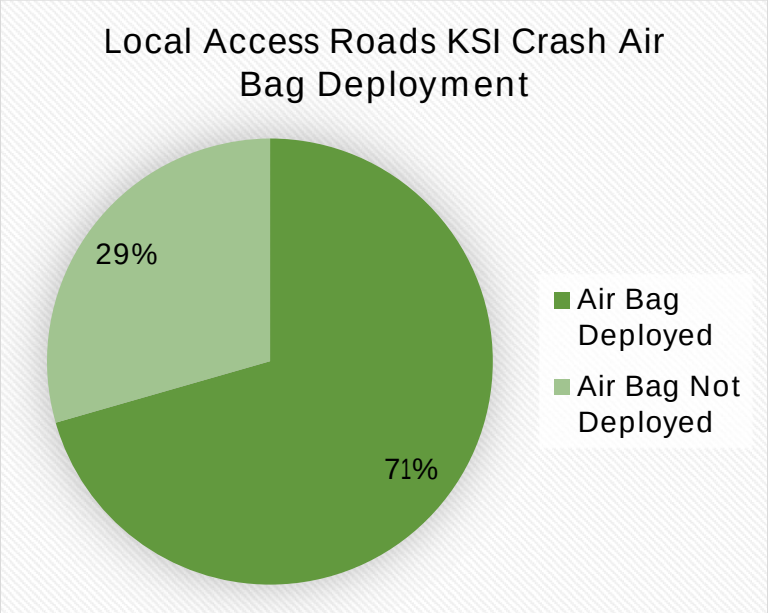


Figure 74: Local Access Roads KSI Crash Air Bag Deployment

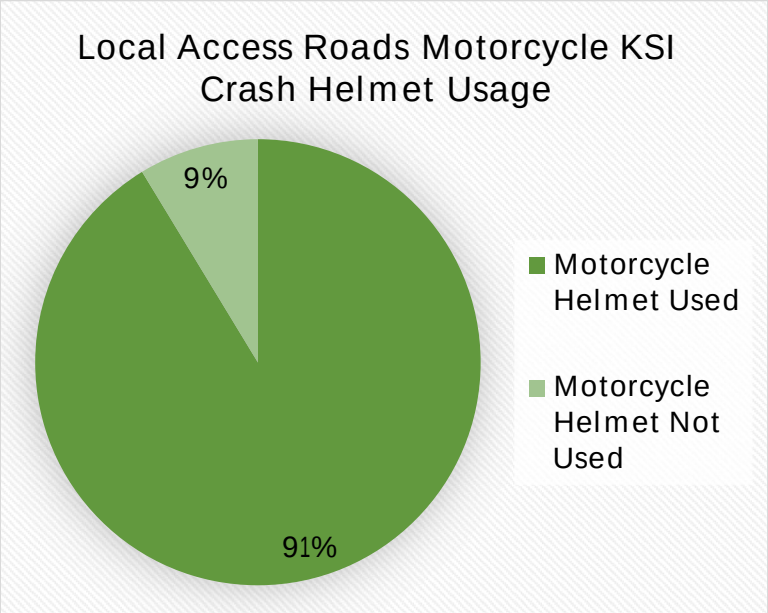


Figure 75: Local Access Roads KSI Motorcycle Crash Helmet Usage

Time and Day

Crash trends throughout the week tend to correspond to traffic pattern trends with higher numbers of crashes happening in the morning and afternoon peak periods of traffic. This trend holds true for both all users and for pedestrians and bicyclists. No major increase in crashes is seen in the weekend nights, suggesting impairment is not a major factor on weekend nights for any users. There is a small increase in bicycle KSI crashes on Saturday and Sunday mornings, which is likely a result of recreational cyclists riding at these times.

Local Access Roads KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.93%	0.36%	0.30%	0.32%	0.36%	0.39%	0.69%
1:00 AM	0.93%	0.32%	0.24%	0.24%	0.35%	0.34%	0.81%
2:00 AM	0.95%	0.29%	0.23%	0.27%	0.12%	0.42%	0.73%
3:00 AM	0.69%	0.27%	0.12%	0.19%	0.27%	0.27%	0.60%
4:00 AM	0.46%	0.20%	0.20%	0.25%	0.23%	0.20%	0.36%
5:00 AM	0.26%	0.31%	0.43%	0.44%	0.37%	0.31%	0.36%
6:00 AM	0.24%	0.41%	0.51%	0.46%	0.53%	0.43%	0.31%
7:00 AM	0.19%	0.51%	0.61%	0.60%	0.55%	0.52%	0.37%
8:00 AM	0.32%	0.61%	0.64%	0.65%	0.55%	0.59%	0.34%
9:00 AM	0.44%	0.42%	0.47%	0.49%	0.35%	0.44%	0.48%
10:00 AM	0.47%	0.52%	0.43%	0.41%	0.48%	0.39%	0.59%
11:00 AM	0.66%	0.60%	0.46%	0.38%	0.45%	0.55%	0.84%
Noon	0.73%	0.49%	0.56%	0.57%	0.55%	0.55%	0.85%
1:00 PM	0.79%	0.62%	0.52%	0.62%	0.59%	0.56%	0.73%
2:00 PM	0.65%	0.60%	0.59%	0.67%	0.69%	0.69%	0.82%
3:00 PM	0.57%	0.76%	0.68%	0.80%	0.72%	1.10%	0.76%
4:00 PM	0.66%	0.85%	0.84%	0.75%	0.87%	0.98%	0.83%
5:00 PM	0.87%	0.86%	1.07%	0.94%	1.01%	1.18%	0.99%
6:00 PM	0.83%	0.79%	1.01%	0.93%	1.30%	1.05%	0.89%
7:00 PM	0.78%	0.71%	0.87%	0.72%	0.85%	0.91%	0.76%
8:00 PM	0.74%	0.55%	0.62%	0.75%	0.73%	0.96%	0.80%
9:00 PM	0.70%	0.55%	0.73%	0.71%	0.74%	1.03%	0.77%
10:00 PM	0.70%	0.50%	0.53%	0.50%	0.57%	0.67%	0.96%
11:00 PM	0.52%	0.46%	0.32%	0.58%	0.53%	0.78%	1.00%

Figure 76: Local Access Roads KSI Crashes per Hour

Local Access Roads Pedestrian KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.83%	0.22%	0.22%	0.40%	0.36%	0.43%	0.50%
1:00 AM	0.72%	0.43%	0.11%	0.22%	0.32%	0.22%	0.68%
2:00 AM	1.01%	0.18%	0.22%	0.14%	0.00%	0.36%	0.50%
3:00 AM	0.29%	0.22%	0.18%	0.00%	0.18%	0.32%	0.36%
4:00 AM	0.25%	0.22%	0.18%	0.36%	0.22%	0.29%	0.25%
5:00 AM	0.40%	0.47%	0.47%	0.36%	0.54%	0.25%	0.40%
6:00 AM	0.14%	0.54%	0.86%	0.65%	0.43%	0.50%	0.36%
7:00 AM	0.14%	0.61%	0.79%	0.54%	0.54%	0.65%	0.25%
8:00 AM	0.25%	0.61%	0.86%	0.54%	0.76%	0.94%	0.36%
9:00 AM	0.32%	0.40%	0.47%	0.43%	0.22%	0.54%	0.29%
10:00 AM	0.07%	0.54%	0.29%	0.25%	0.50%	0.47%	0.32%
11:00 AM	0.36%	0.50%	0.36%	0.29%	0.40%	0.47%	0.29%
Noon	0.40%	0.36%	0.76%	0.47%	0.47%	0.22%	0.22%
1:00 PM	0.43%	0.61%	0.36%	0.50%	0.29%	0.58%	0.40%
2:00 PM	0.36%	0.29%	0.47%	0.61%	0.65%	0.25%	0.22%
3:00 PM	0.25%	0.72%	0.68%	0.61%	0.54%	0.90%	0.43%
4:00 PM	0.40%	0.65%	0.61%	0.61%	0.79%	0.65%	0.43%
5:00 PM	0.94%	1.08%	1.48%	0.76%	1.08%	1.01%	0.97%
6:00 PM	0.94%	1.12%	1.59%	1.26%	1.69%	1.48%	0.97%
7:00 PM	0.72%	1.08%	1.01%	1.01%	1.15%	1.30%	1.15%
8:00 PM	1.05%	0.72%	0.94%	0.97%	0.97%	1.80%	1.62%
9:00 PM	0.83%	0.72%	1.12%	1.12%	1.08%	1.30%	1.01%
10:00 PM	0.72%	0.61%	0.72%	0.72%	0.79%	0.90%	1.33%
11:00 PM	0.47%	0.32%	0.40%	0.65%	0.72%	0.79%	1.01%

Figure 77: Local Access Roads Pedestrian KSI Crashes per Hour

Local Access Roads Bicycle KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.29%	0.07%	0.22%	0.22%	0.00%	0.15%	0.07%
1:00 AM	0.36%	0.00%	0.15%	0.15%	0.07%	0.00%	0.29%
2:00 AM	0.29%	0.07%	0.00%	0.00%	0.07%	0.00%	0.07%
3:00 AM	0.00%	0.07%	0.00%	0.07%	0.07%	0.07%	0.07%
4:00 AM	0.00%	0.00%	0.07%	0.15%	0.07%	0.15%	0.07%
5:00 AM	0.07%	0.00%	0.51%	0.36%	0.29%	0.15%	0.00%
6:00 AM	0.07%	0.22%	0.29%	0.22%	0.73%	0.29%	0.15%
7:00 AM	0.00%	0.58%	0.73%	0.66%	0.88%	1.31%	0.44%
8:00 AM	0.66%	0.95%	1.09%	1.24%	0.44%	1.09%	0.73%
9:00 AM	0.73%	0.58%	0.22%	1.24%	0.44%	0.58%	1.46%
10:00 AM	1.31%	0.80%	0.44%	0.88%	0.51%	0.36%	1.53%
11:00 AM	1.09%	0.80%	0.51%	0.80%	0.44%	0.58%	2.41%
Noon	1.17%	0.80%	0.80%	0.88%	0.95%	1.02%	2.04%
1:00 PM	1.31%	0.80%	0.66%	0.73%	1.02%	0.66%	1.31%
2:00 PM	0.95%	0.51%	0.58%	0.58%	0.58%	0.29%	0.66%
3:00 PM	0.51%	0.36%	0.66%	1.02%	0.80%	1.24%	0.44%
4:00 PM	0.95%	1.39%	1.68%	1.09%	1.31%	0.80%	1.39%
5:00 PM	0.58%	1.24%	1.68%	1.60%	1.24%	1.24%	0.73%
6:00 PM	0.58%	1.09%	1.31%	1.31%	1.31%	1.09%	0.58%
7:00 PM	0.73%	0.73%	1.39%	0.51%	0.80%	1.09%	0.51%
8:00 PM	0.29%	0.58%	0.29%	0.73%	0.95%	0.58%	0.44%
9:00 PM	0.29%	0.22%	0.22%	0.66%	0.22%	0.66%	0.29%
10:00 PM	0.15%	0.51%	0.51%	0.22%	0.29%	0.44%	0.44%
11:00 PM	0.51%	0.07%	0.15%	0.29%	0.22%	0.36%	0.44%

Figure 78: Local Access Roads Bicycle KSI Crashes per Hour

Weather, Road, and Lighting Conditions

95% of KSI crashes occurred with clear or cloudy weather and only 5% with rain or some other adverse weather condition active. Similarly, 90% of KSI crashes occurred on dry pavement and 97% of KSI crashes occurred on well-maintained pavement. Lighting factors are also shown. The majority of KSI crashes happened in daylight hours, or at night with streetlights on. Only 10% of crashes occurred at night without streetlights. Adverse weather, wet pavement, poor pavement quality, and dark/unlit roadways contribute very little to KSI crash risk.

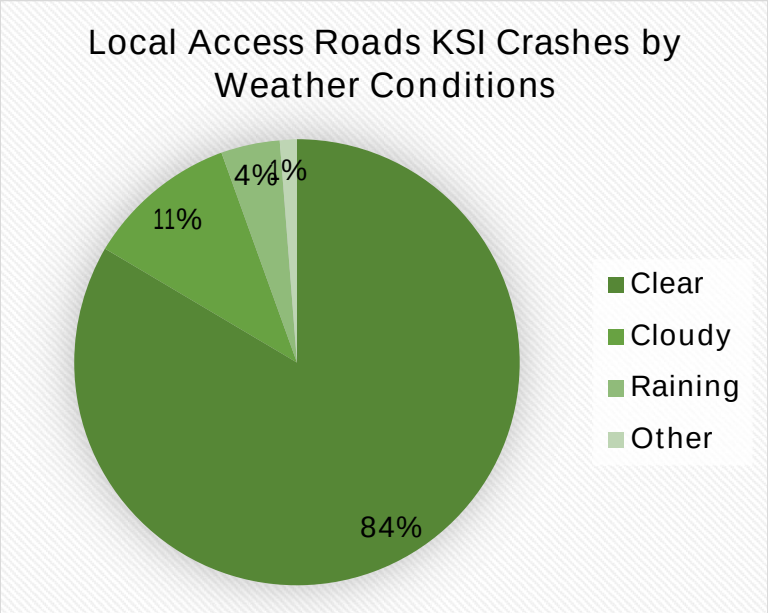


Figure 79: Local Access Roads KSI Crashes by Weather Conditions

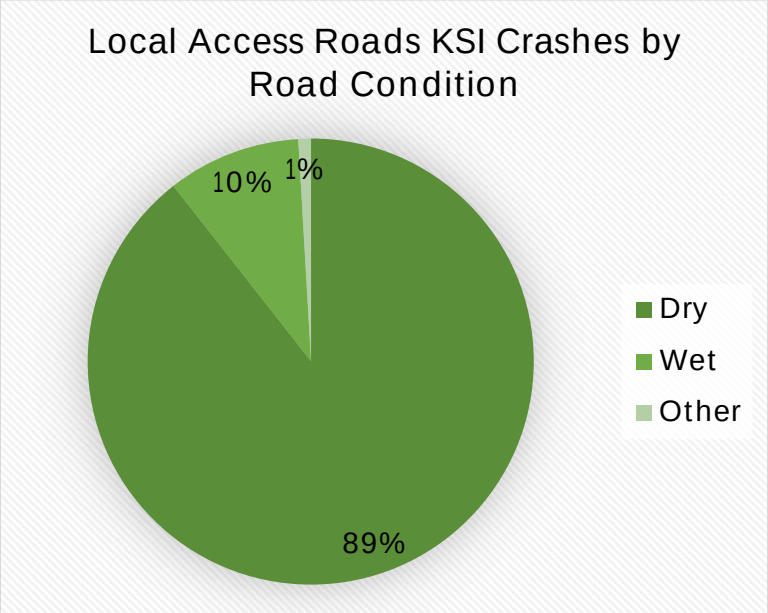


Figure 80: Local Access Roads KSI Crashes by Road Condition

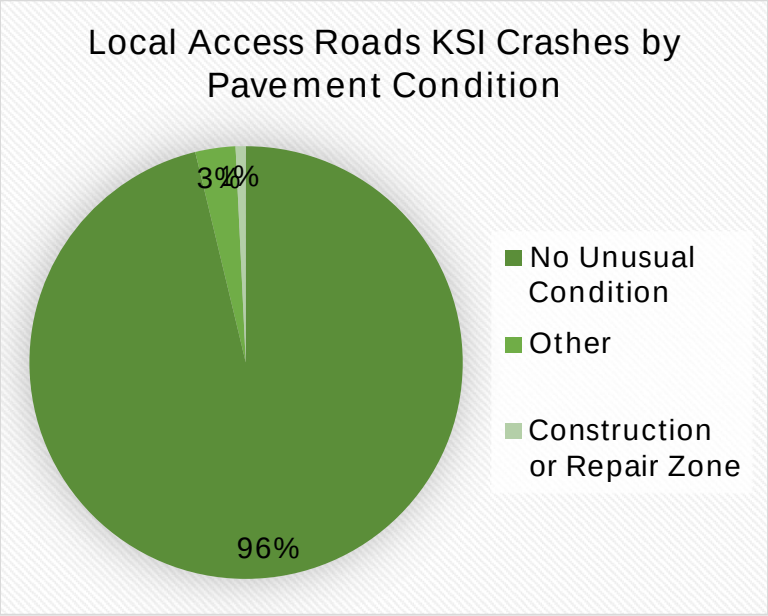


Figure 81: Local Access Roads KSI Crashes by Pavement Condition

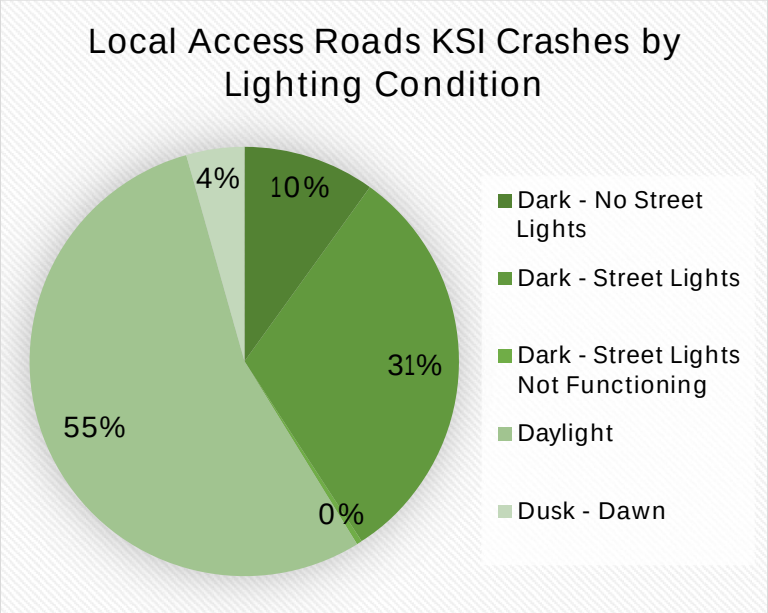


Figure 82: Local Access Roads KSI Crashes by Lighting Condition

Inattention and Impairment

Inattentive or "distracted" driving is often cited as an important contributing circumstance for crashes in common literature. However, the data shows that only 1% of drivers and 1% of bicyclists and pedestrians involved in KSI crashes in the Bay Area on local access roads were inattentive. More users are impaired, but even still only 17% of drivers and 7% of cyclists and pedestrians were impaired with either alcohol or drugs. Campaigns to curb driving under the influence have been successes to the point that expansion of a focus results in diminishing returns. This does not mean there

should not be any attempt to educate or enforcement but that focus on discrete action should be seen as ancillary to a more systemic vision zero approach. The majority of KSI crashes in the bay area involve non-impaired and attentive drivers. In both cases of inattention and intoxication, drivers are more likely to be inattentive or intoxicated than pedestrians or cyclists.

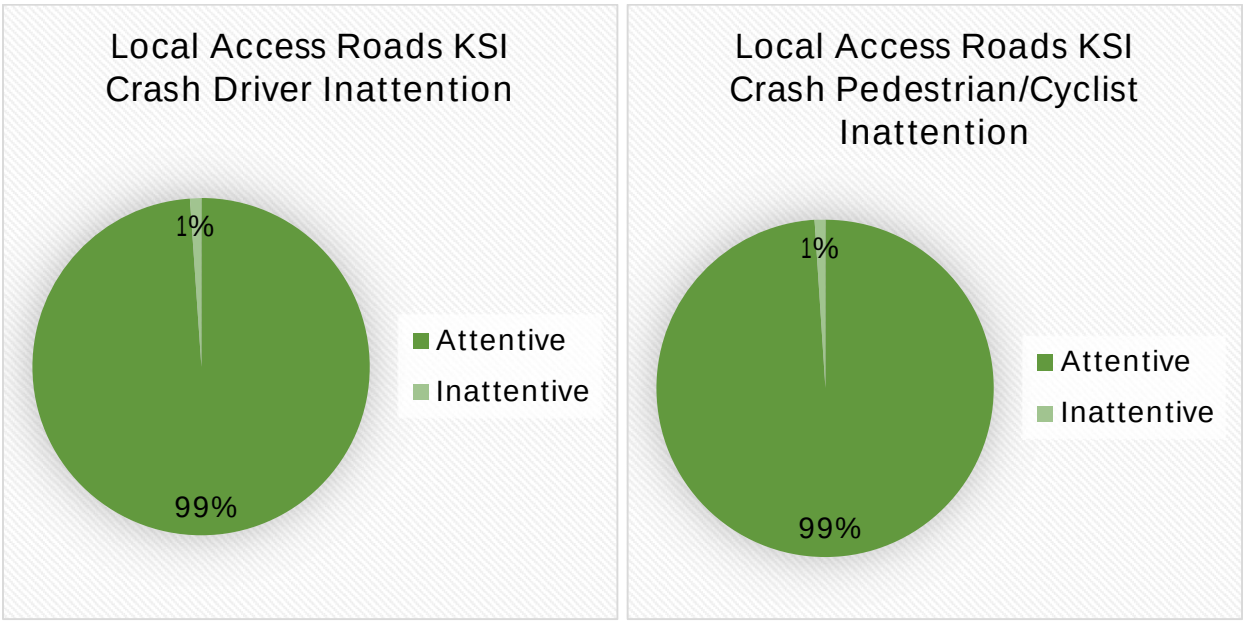


Figure 83: Local Access Roads KSI Crash Inattention Involvement

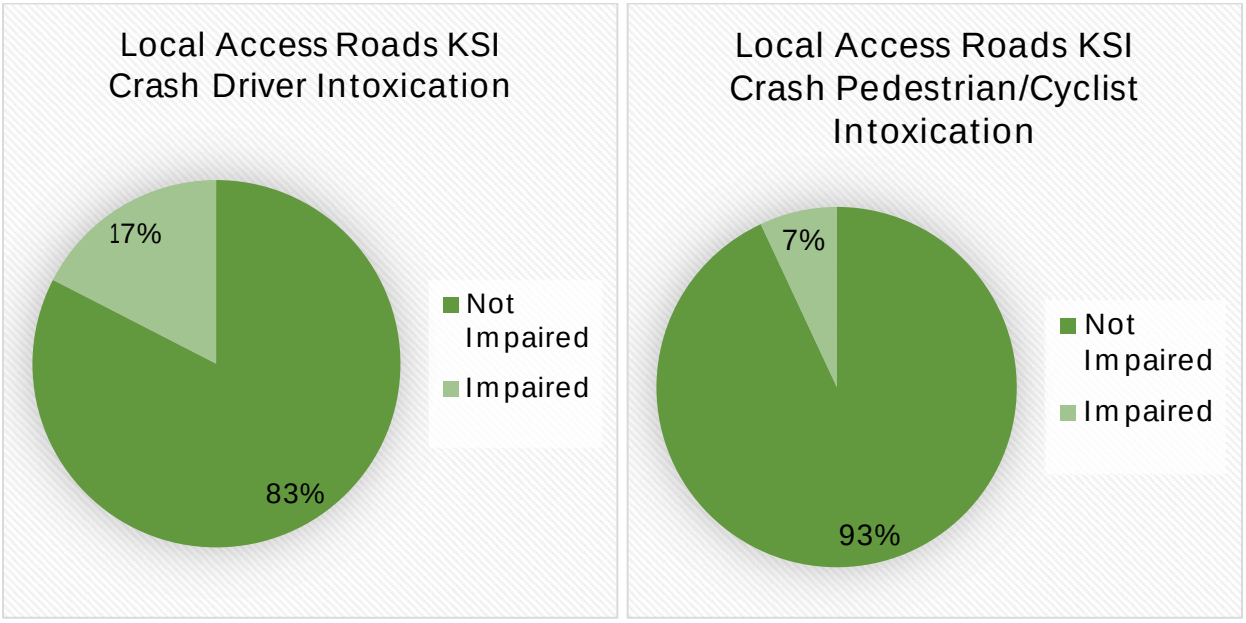


Figure 84: Local Access Roads KSI Crash Alcohol Intoxication Involvement

Sub-Area Local Access Roads KSI Crash Summary

Traffic crashes in different types of areas have different causes and require different countermeasures to address the safety issues. For example, rural Sonoma County will require different countermeasures than downtown Oakland. To account for these different crash characteristics and different needs, a sub-area analysis was conducted based on different place and equity typologies. The place typologies consist of four typology levels which were based on population and job density and include:

- Rural
- Suburban
- Urban
- Dense Urban

The equity typologies were determined based on locations designated as Equity Priority Areas and locations not designated as Equity Priority Areas. The following sections provide the same information as the regional analysis but provide it for each specific sub-area individually.

Land Use Area Type and Equity Priority Community Definitions

As previously discussed, the study area was divided into different sub-areas based on determined topology levels. The levels and results of the analysis are shown in Figure 85. The heart of San Francisco largely consists of “Central Business District” and “Urban Business.” Berkeley and Oakland mainly consist of “Urban,” “Suburban,” and “Urban Business” areas. The map below shows these areas. The areas are also shown online and can be viewed using this link: https://reports.mysidewalk.com/ca56316847

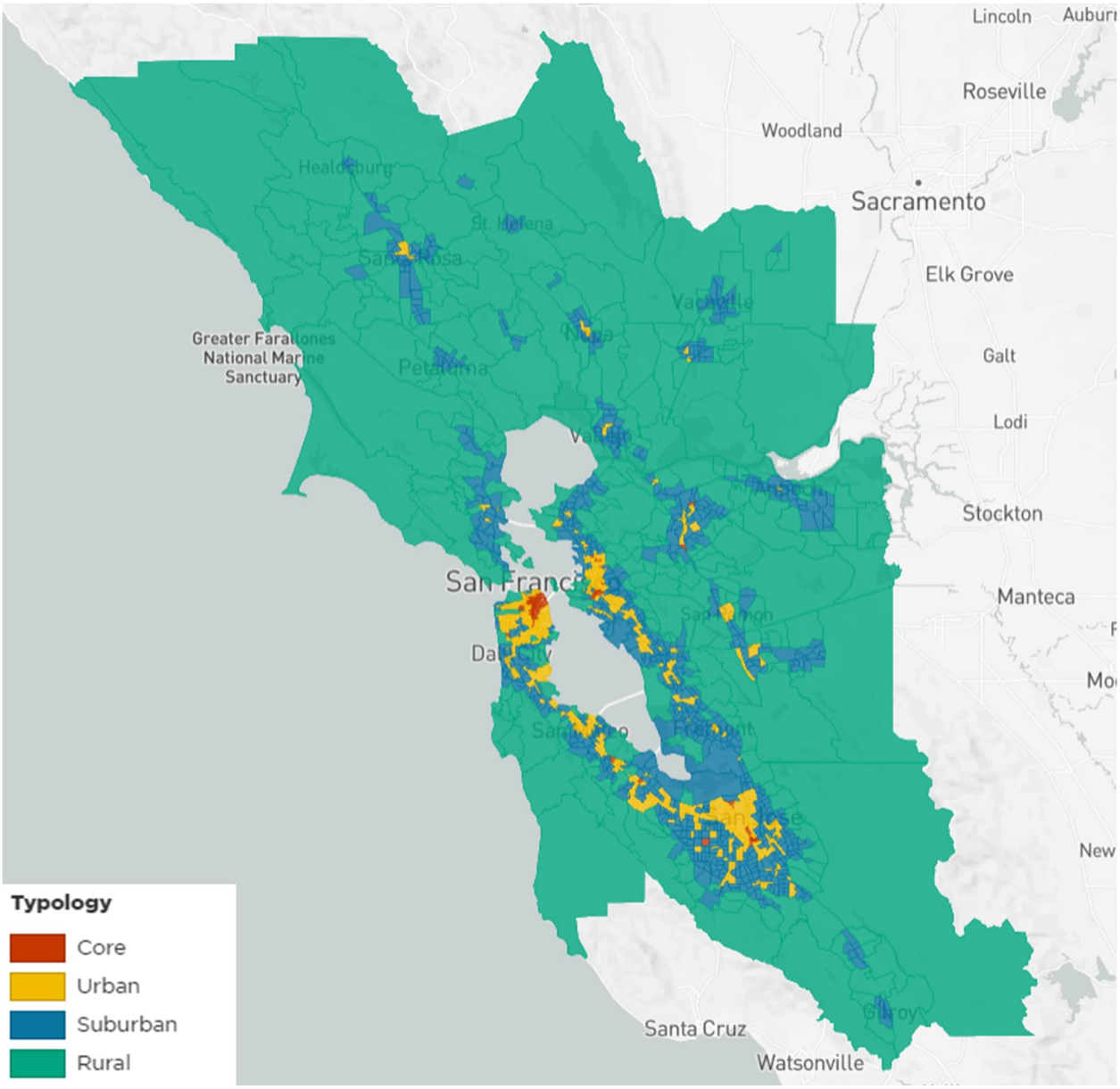


Figure 85: MTC TravelModel2 Area Types (https://reports.mysidewalk.com/ca56316847)

Across rural, suburban, and urban sub-areas have increased. Only in the dense urban core areas has there not been a rise from 2010 to 2019 in fatal crashes However, injury crashes across the surface streets of every sub-area have increased dramatically over the 10-year period 2010 – 2019. Fatal and serious injury crash trends from 2010 to 2019 are shown in Figure 86 and Figure 87. The following sections highlight the summary of KSI crashes in each of the four sub-areas.

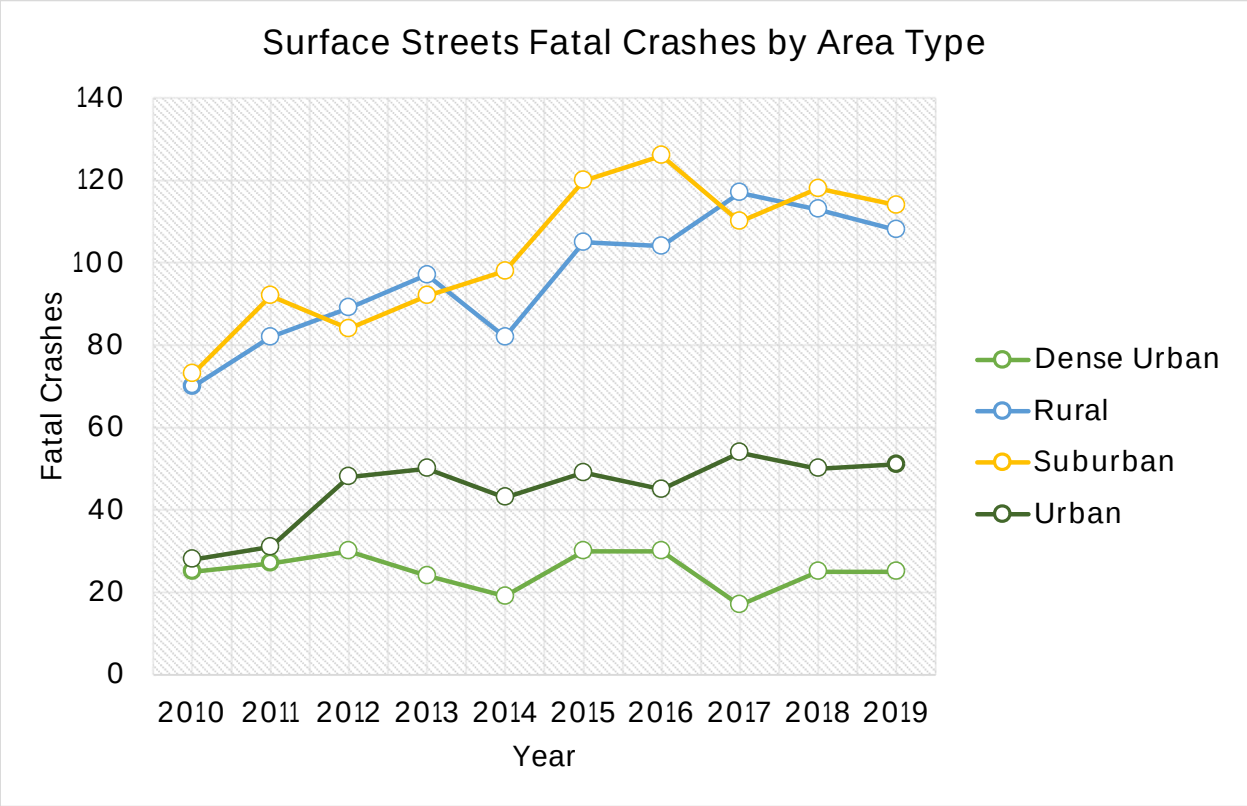


Figure 86: Local Access Roads Fatal Crash Trend 2010 – 2019 by Area Type

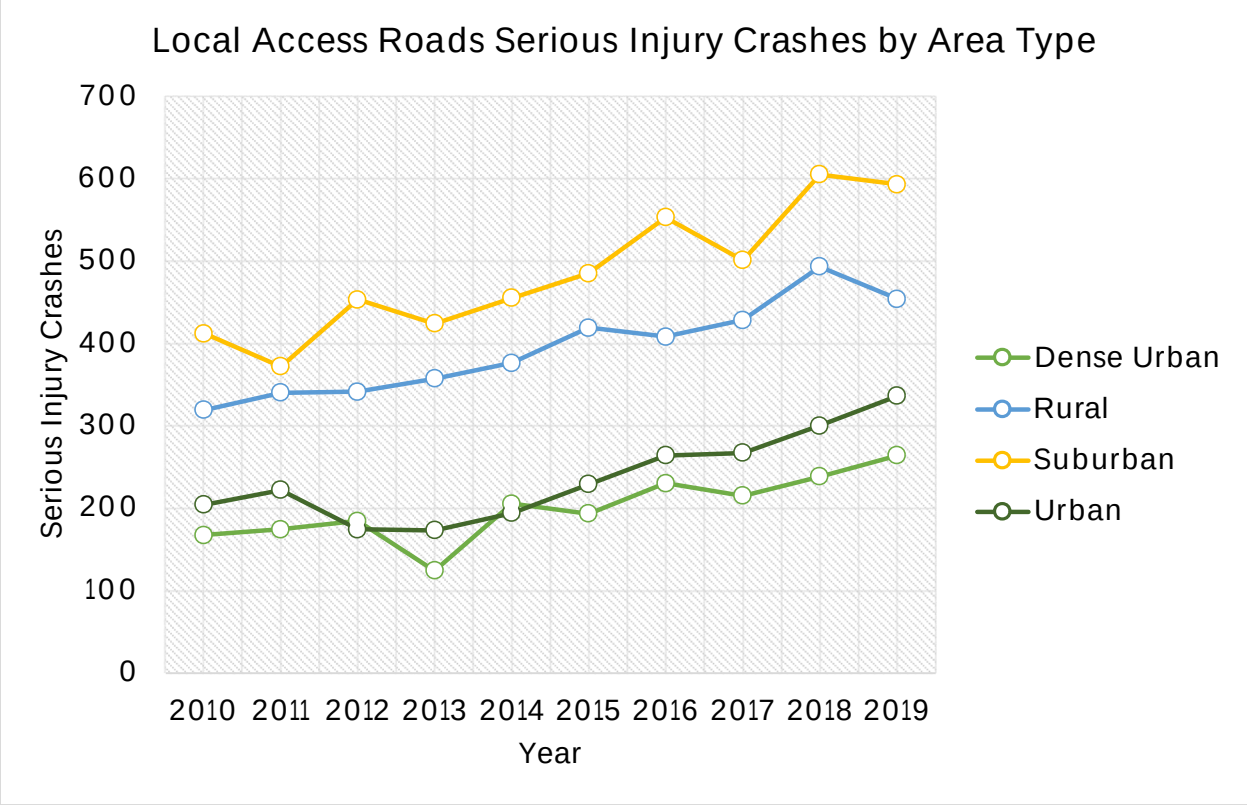


Figure 87: Local Access Roads Serious Injury Crash Trend 2010 – 2019 by Area Type

Rural Areas KSI Crash Summary

Trends

KSI crashes on rural roads in the Bay Area have increased dramatically over the 10-year period 2010 – 2019. Fatal crashes on all rural roads have increased 48% and serious injury crashes have increased 42%. While it must be noted that definition from "severe injury" to "suspected serious injury" in 2017 which may account for part of the rise, the continued rise in injuries from 2010 to 2016 and from 2017 to 2018 show that the problem lies in the roads themselves not definitions. Fatal and serious injury crash trends from 2010 to 2019 are shown in Figure 88 and Figure 89.

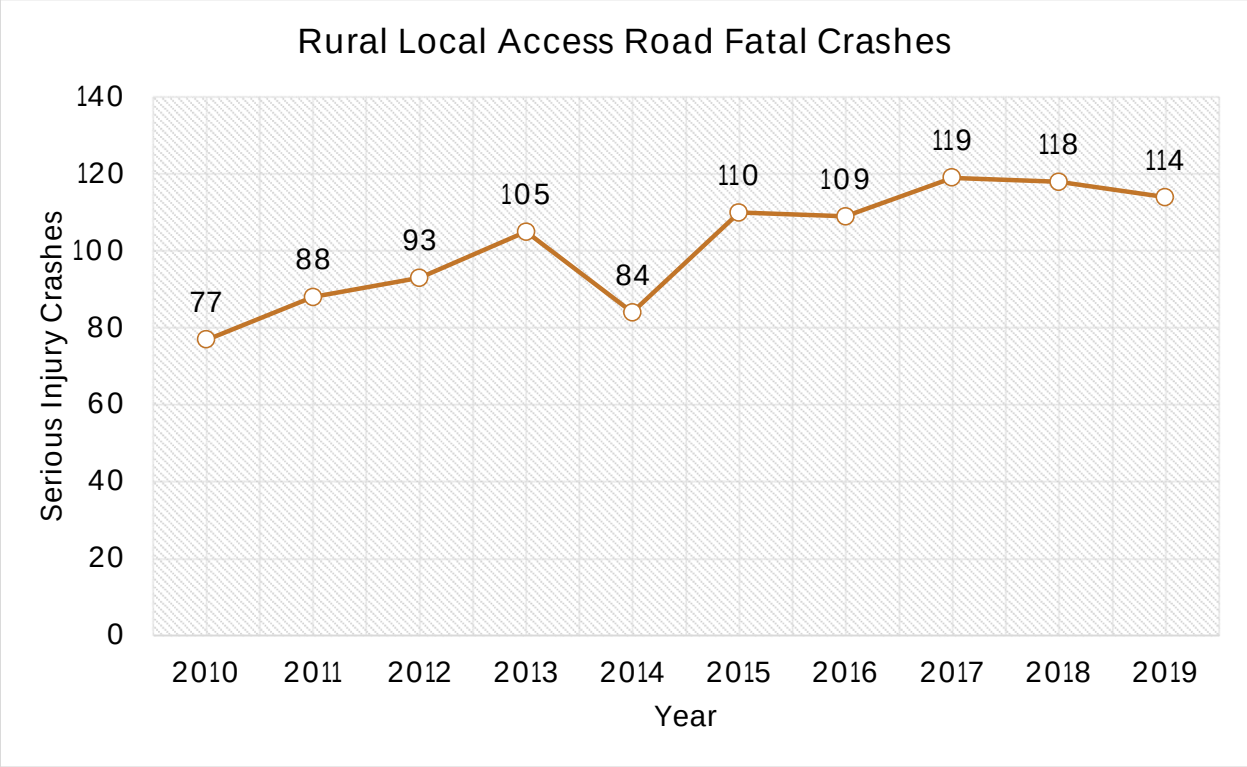


Figure 88: Rural Local Access Roads Fatal Crash Trend 2010 - 2019

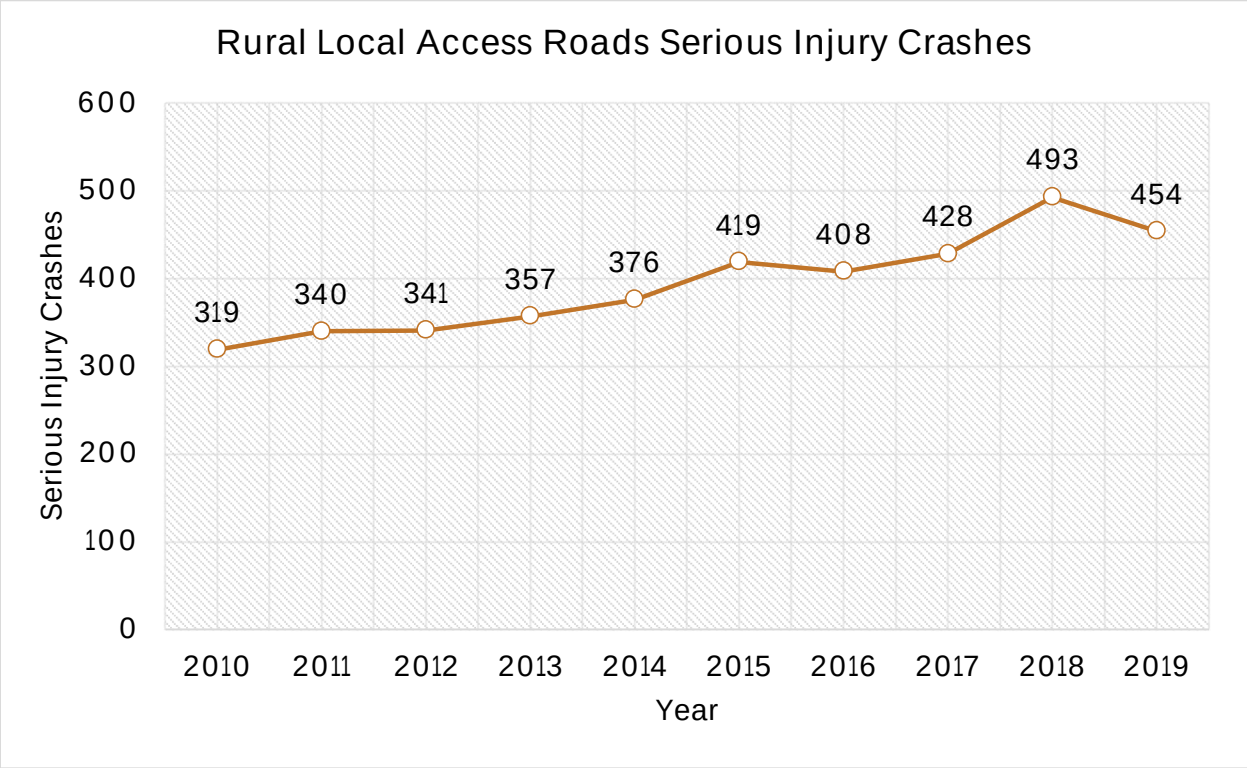


Figure 89: Rural Local Access Roads Crash Trend 2010-2019

Transportation Modes

Rural areas often do not provide mobility for all modes of transportation. This is reflected in crash data which shows that the majority of KSI crashes on rural roads are vehicle crashes that do not involve a pedestrian or cyclists. However, a large enough share involves pedestrians (8%) and cyclists (14%) that would almost certainly be mitigated with better facilities. While the Bay Area is often seen as a totally urbanized with many walkable and bikeable neighborhoods; there are still vast swathes of rural areas with poor bike/ped facilities which must be considered, the Bay Area is not a monolith. Although biking and walking KSI crashes represent a smaller share of overall KSI crashes on rural roads, the relative risk is much higher than for driving. This signifies that to achieve Vision Zero, all areas and modes must be considered.

KSI crashes on rural roads in the Bay Area have been increasing dramatically. Since 2010, vehicle KSI crashes have increased 53% between 2010 and 2019. Pedestrian KSI crashes have increased 29% and bicycle crashes have increased 9% over the years between 2010 and 2019. These trends can be seen in Figure 90 and Figure 91.

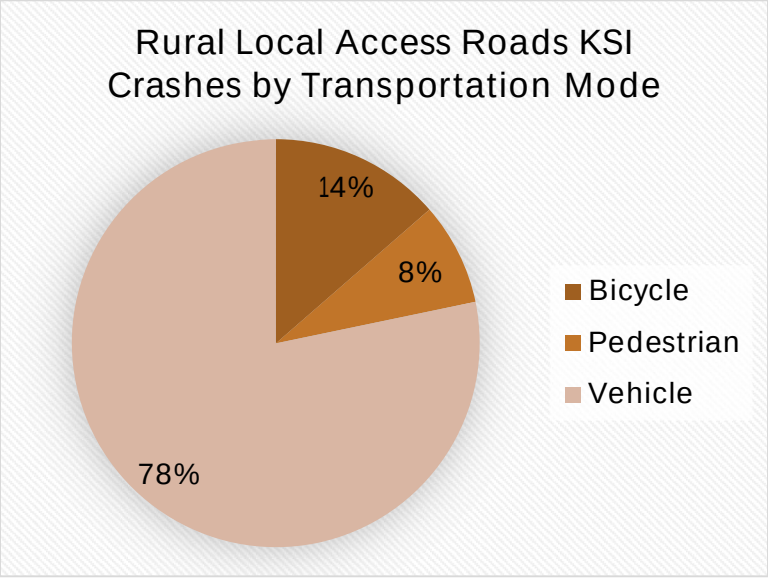


Figure 90: Rural Local Access Roads KSI Crashes by Transportation Mode

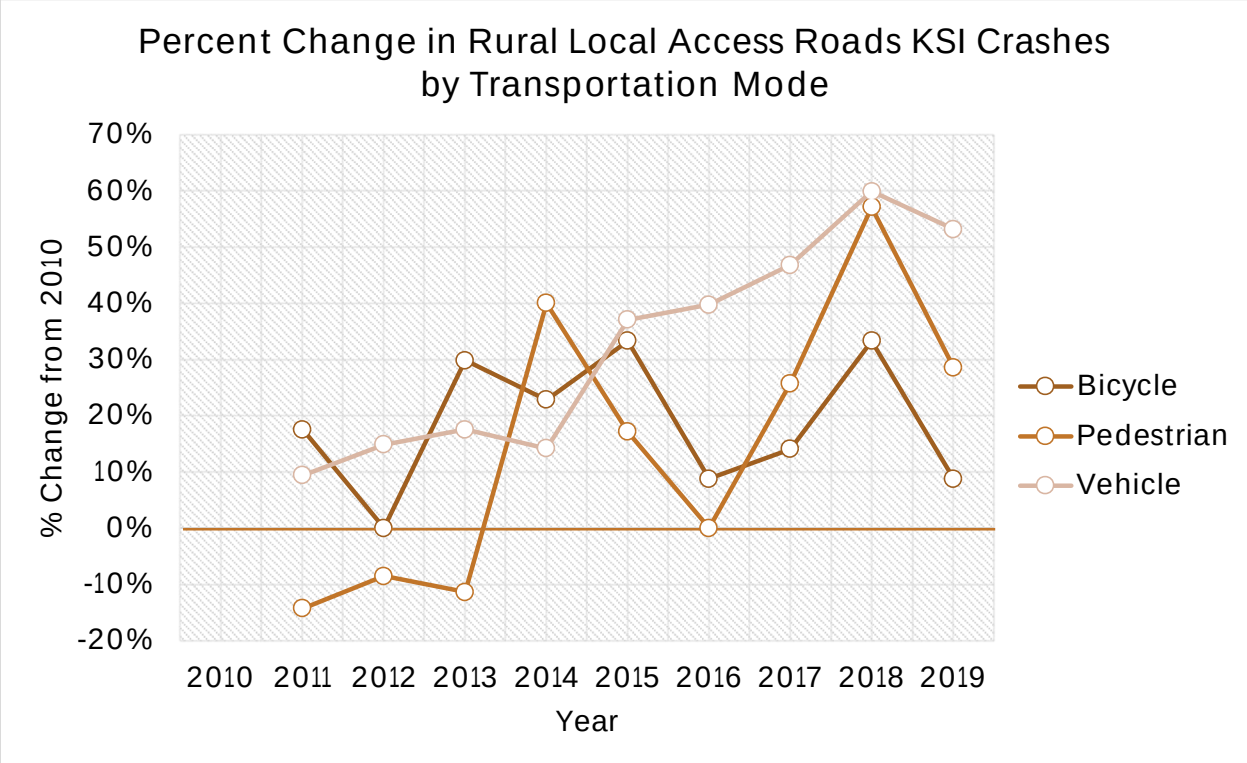


Figure 91: Percent Change in Local Access Roads KSI Crashes by Transportation Mode

Users and Equity

Rural areas in the 9 county Bay Area are whiter than adjacent urbanized areas which can be seen in KSI crash a data by race which show that the vast majority of KSI crashes involve White People. Black and Other users (which primarily consist of indigenous peoples) still account for a disproportionally large proportion of crashes, but unlike other locations in this case White people are 2nd in crash proportionality,

followed by Black People. Hispanic and Asian Peoples where the only group to be under-represented relative to their population. These trends can be seen below in Figure 92 and Figure 93.

Equity priority areas as defined by MTC were also examined for KSI crashes. These areas are of special focus as they are areas in which are affected disproportionally by safety issues affecting roadways and include the most vulnerable users. However, due to the relatively small amount of EPCs in rural areas trends here must be seen as outliers. Still, when looking at crashes in equity priority communities vs crashes not in equity priority communities, only 7% of all crashes occur in equity priority communities; however, when adjusted for population proportion, there is a 4.4 times higher chance of a KSI crash happening in an equity priority community than outside an equity priority community. As such, it is important that any steps taken towards safety improvements keep equity as a key consideration even in rural areas.

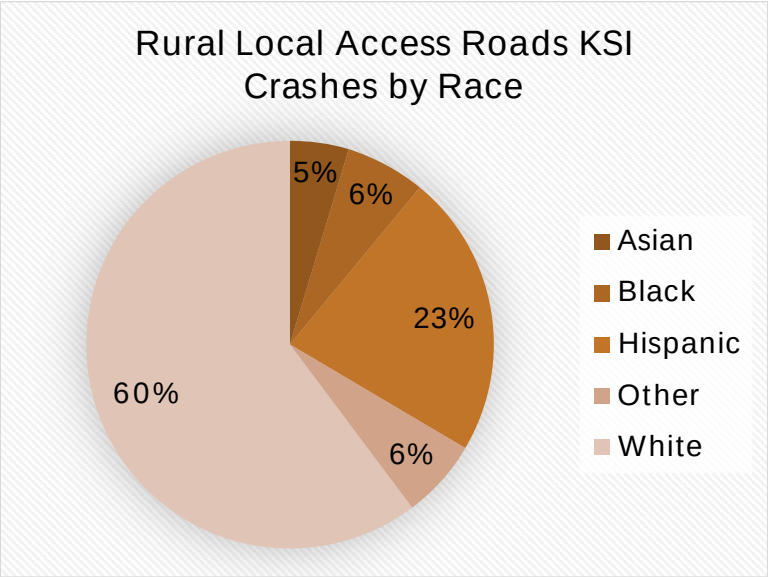


Figure 92: Rural Local Access Roads KSI by Race

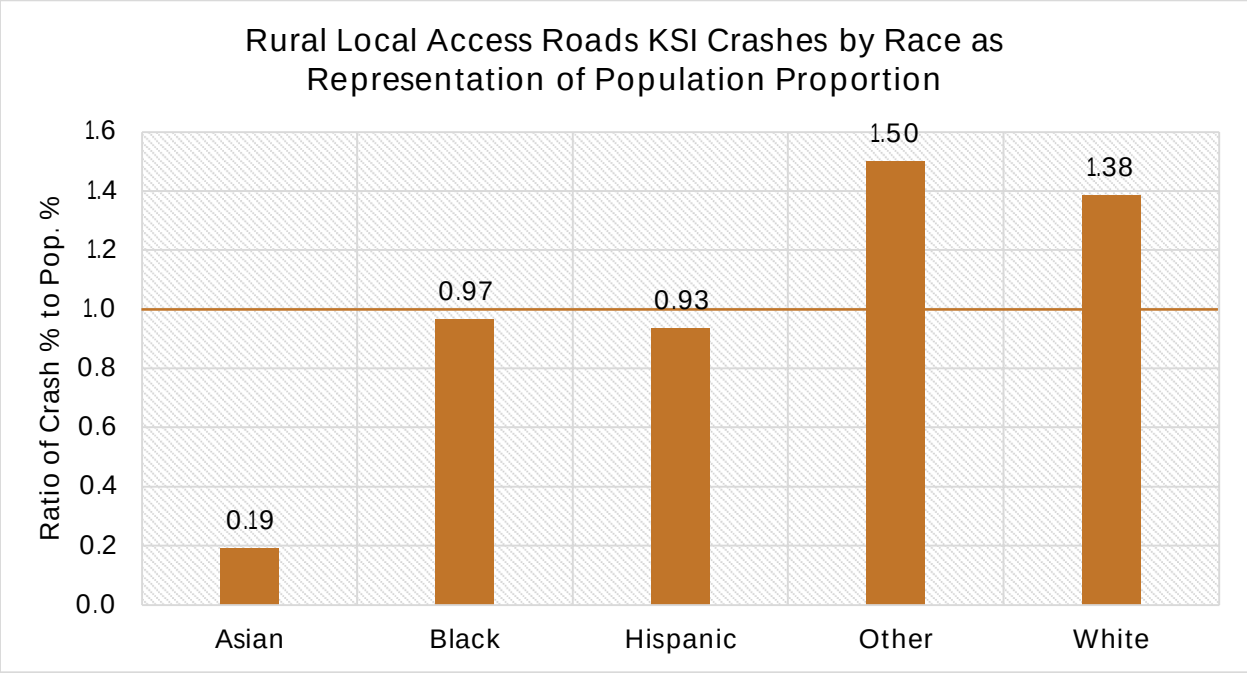


Figure 93: Rural Local Access Roads KSI by Race as a Proportion of Population

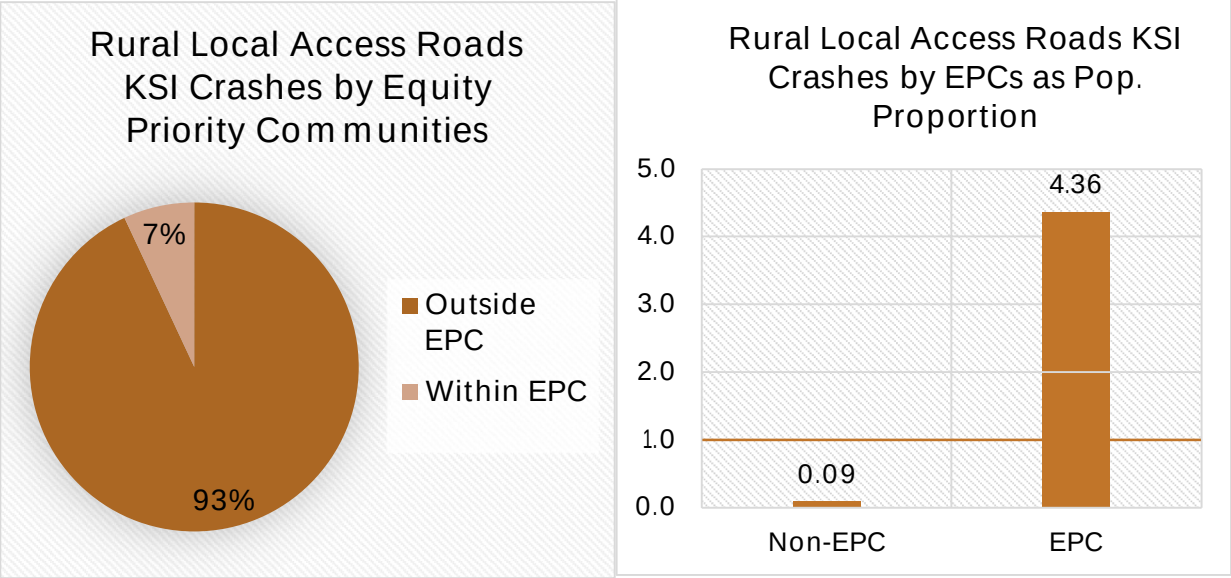


Figure 94: Rural Local Access Roads KSI Crashes by Equity Priority Communities and Crashes by Equity Priority Communities as a Representation of Population (>1.0 = Over-Representation)

Age

Crashes in rural areas do not occur evenly across age groups, as young people move away from these areas, this is reflected by having a relatively older group for KSI crash data. Figure 95. The groups that account for the largest number of crashes is still those in their 20s, with 20-24 accounting for 412 KSI crashes and 25-29 for 353. Normalizing for population, users in their 20s not only are involved in a high frequency of KSI crashes, but that these users are also highly over-represented. Users in the age group of

20-24 are 2.3 times more likely to be involved in a KSI crash than average. However, users 50-54 are not far behind as the 4th most over-represented group and the highest of any group over 30 as seen in Figure 96.

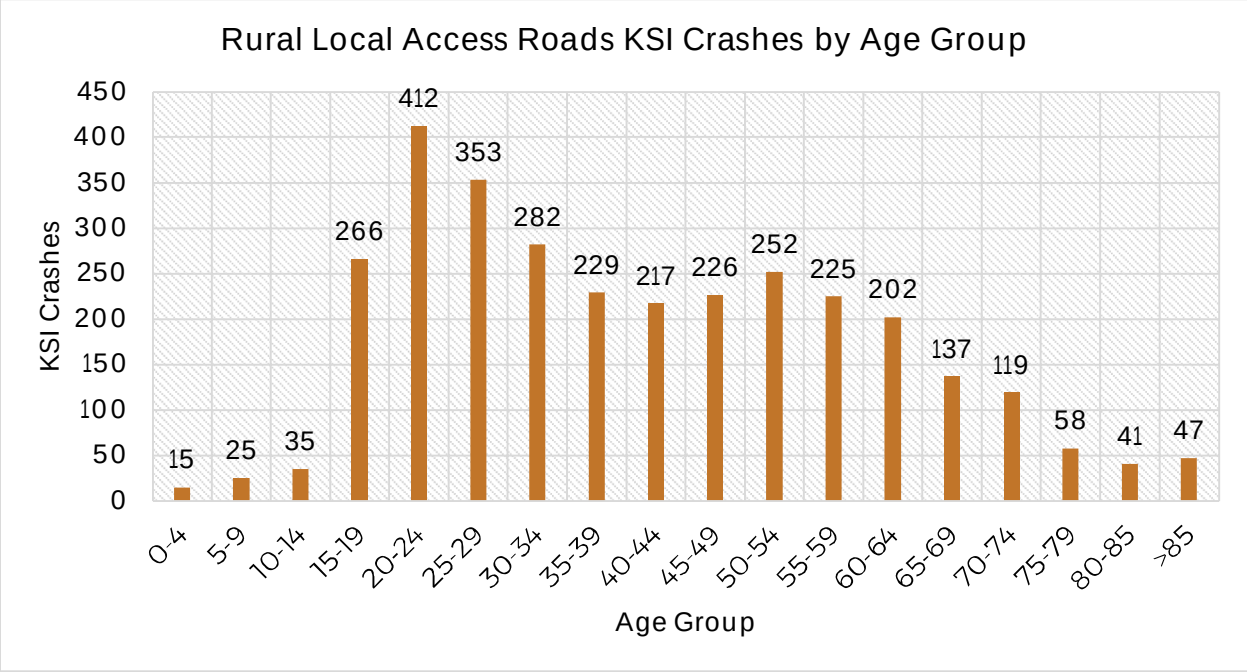


Figure 95: KSI Crashes by Age Group

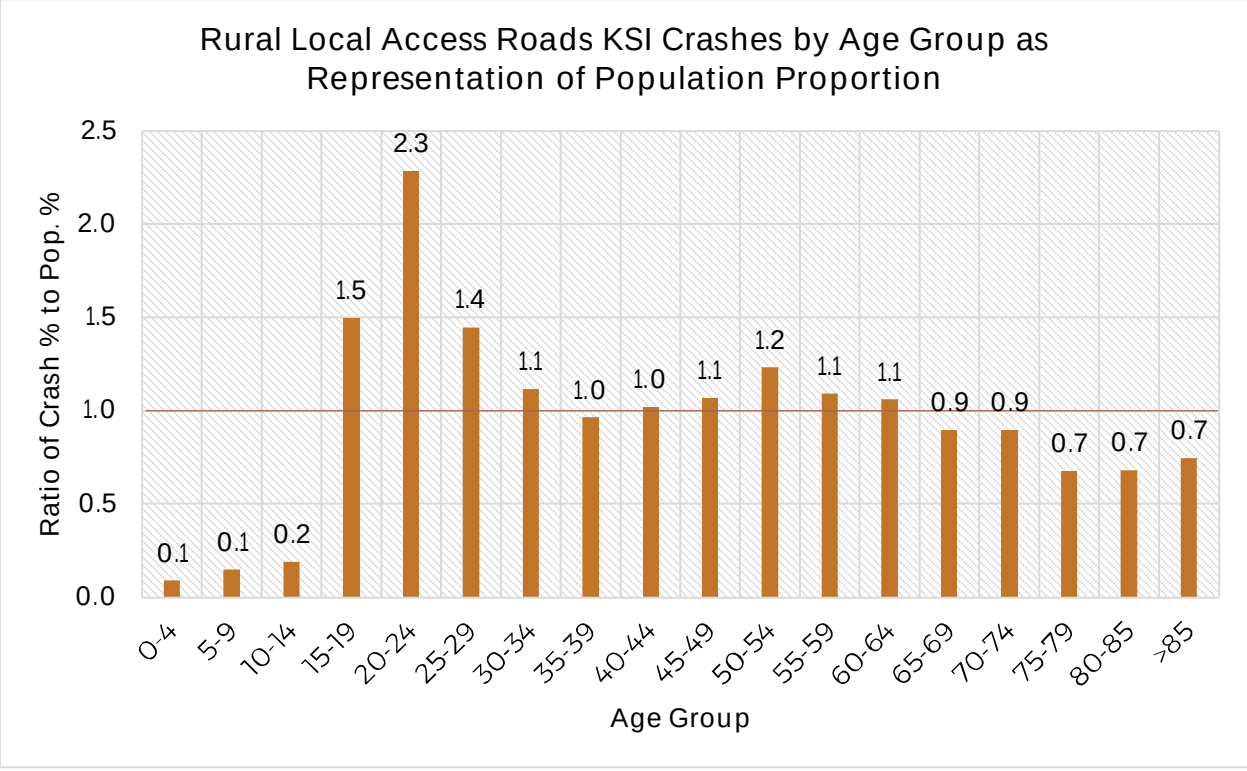


Figure 96 Rural Local Access Roads KSI Crashes by Age Group as a Proportion of Population

Sex

Males currently account for 71% of crashes and are nearly 1.36 times as likely to be involved in a KSI crash compared to females on local access roads in rural areas. This data can be seen in Figure 97.

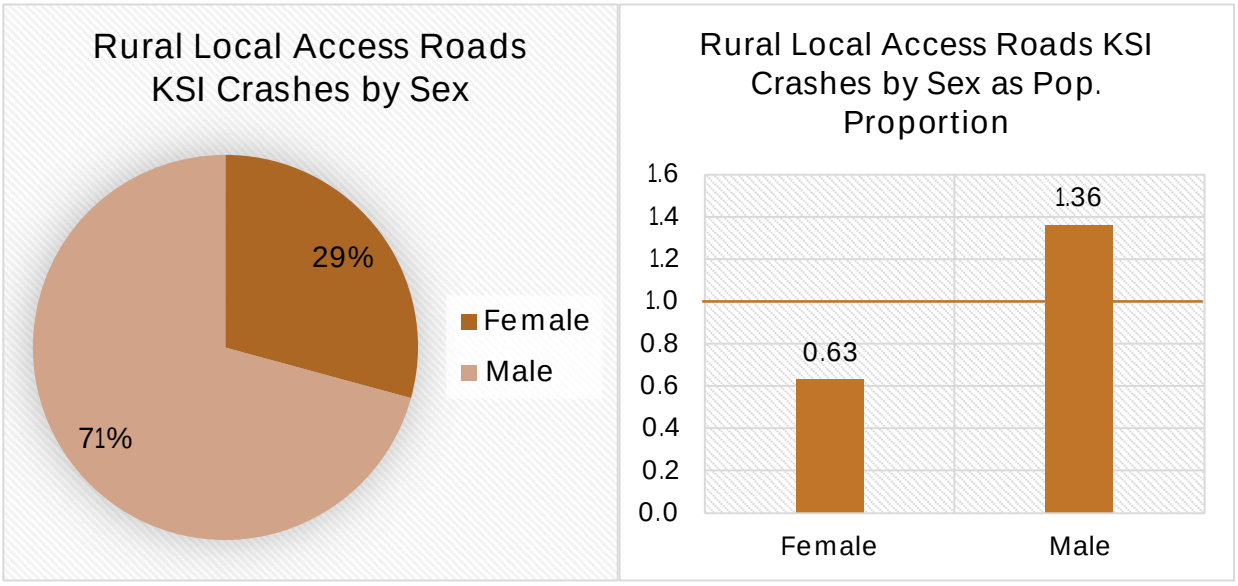


Figure 97: Rural Local Access Roads KSI Crashes by Sex and Crashes by Sex as a Representation of Population (>1.0 = Over-Representation)

Crash Locations and Types

The majority of Local Access Road KSI crashes in rural areas occur at non-intersection locations as seen in Figure 98. Most of the non-intersection crashes involve crashes with fixed objects (809) and overturned (380) as seen in Figure 99. Figure 100 shows that most of the crashes at intersections involve broadsides (200), cyclists (59) and hit object (54). The high number of hit object crashes is to be expected for rural roads which often have more natural objects such as trees to hit. The high number of cyclists hit also likely results due to rural areas having a lack of facilities for bicyclists. There needs to be a focus on creating separated and safe facilities for cyclists and pedestrians via protected lanes. Additionally, fixed object and broadside crashes should be a focus of vehicle crashes.

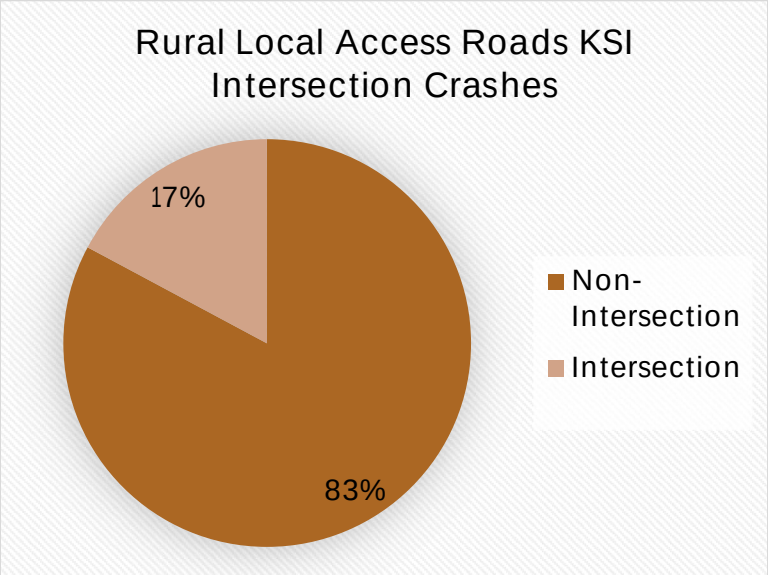


Figure 98: Rural Local Access Roads KSI Intersection vs Non-Intersection Crashes

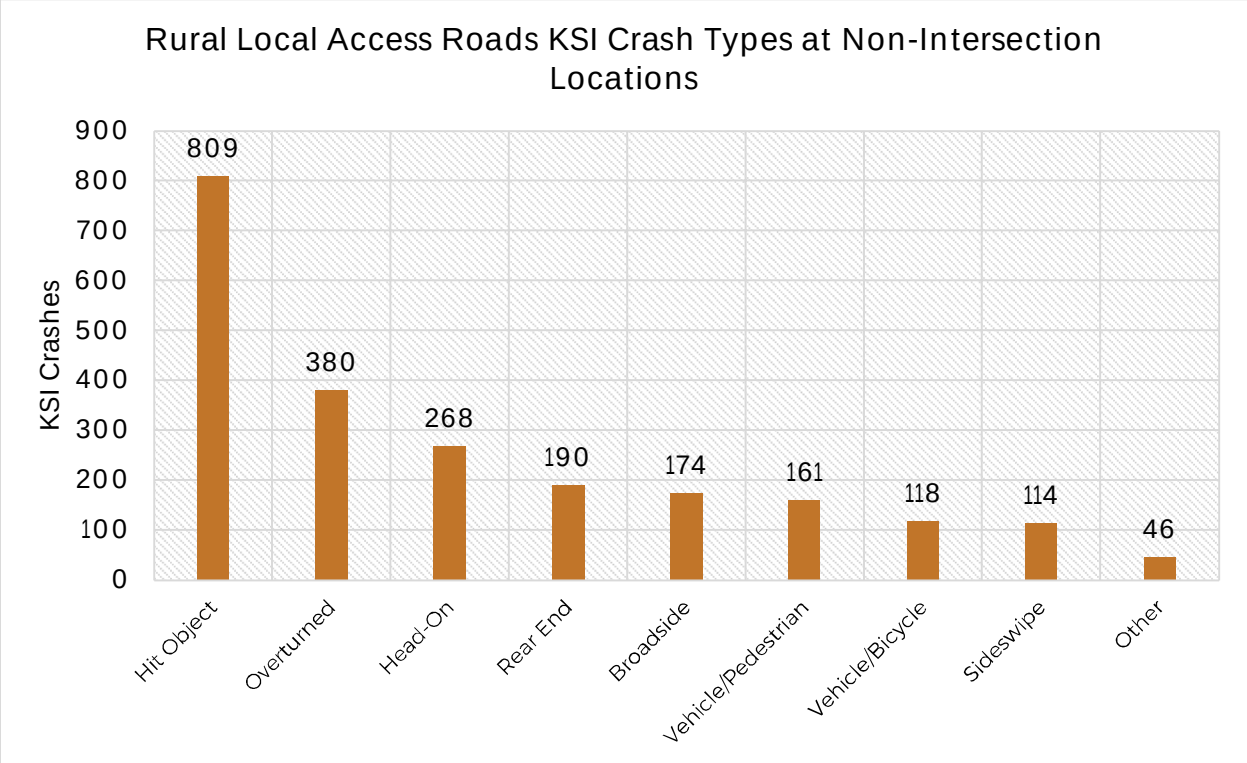


Figure 99: Rural Local Access Roads KSI Crash Types at Non-Intersection Locations

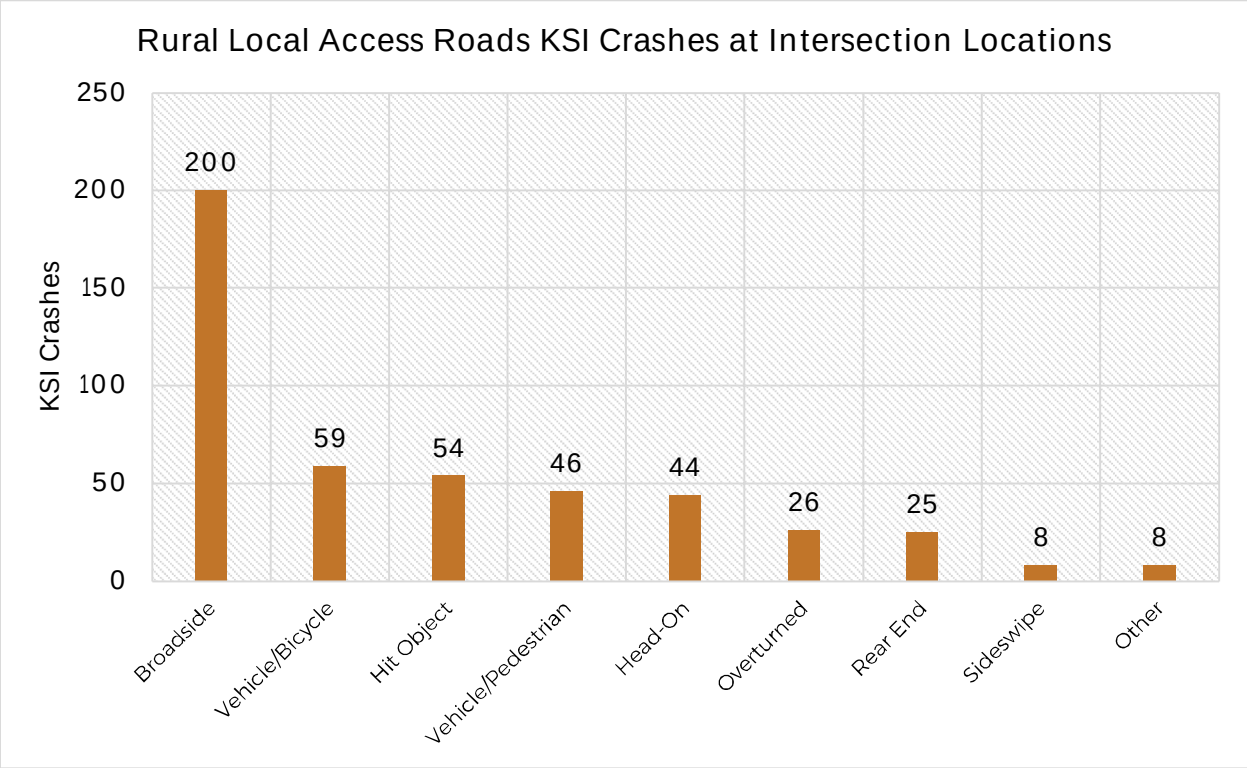


Figure 100: Rural Local Access Roads KSI Crash Types at Intersection Locations

Pedestrian and Bicycle Crash Locations and Types

According to Figure 101 the majority of bicycle and pedestrian crashes happen at non-intersection locations (77%), compared to the number that occur at intersections (23%). This data shows that in rural areas there is a lack of adequate facilities to for bicyclists and pedestrians. Many are either forced to cross at non-intersection locations which increases the likelihood of a KSI crash or walk alongside traffic rather than be protected by other means such as a multi-use trail. This pattern holds true as well for cyclists where an overwhelming majority (77%) occur at non-Intersection locations. Rural KSI crashes for pedestrians occur due to crossing at areas which are not crosswalks (56%), while crossing at a crosswalk at an intersection accounted for (37%), with non-intersection crosswalks rounding out the remainder (7%). For pedestrian crashes that do not involve a pedestrian crossing the street, but rather walking along the street, Figure 102 shows that 85% of them occurred when a pedestrian was walking in the street or shoulder. This would likely indicate that a sidewalk did not exist at these locations.

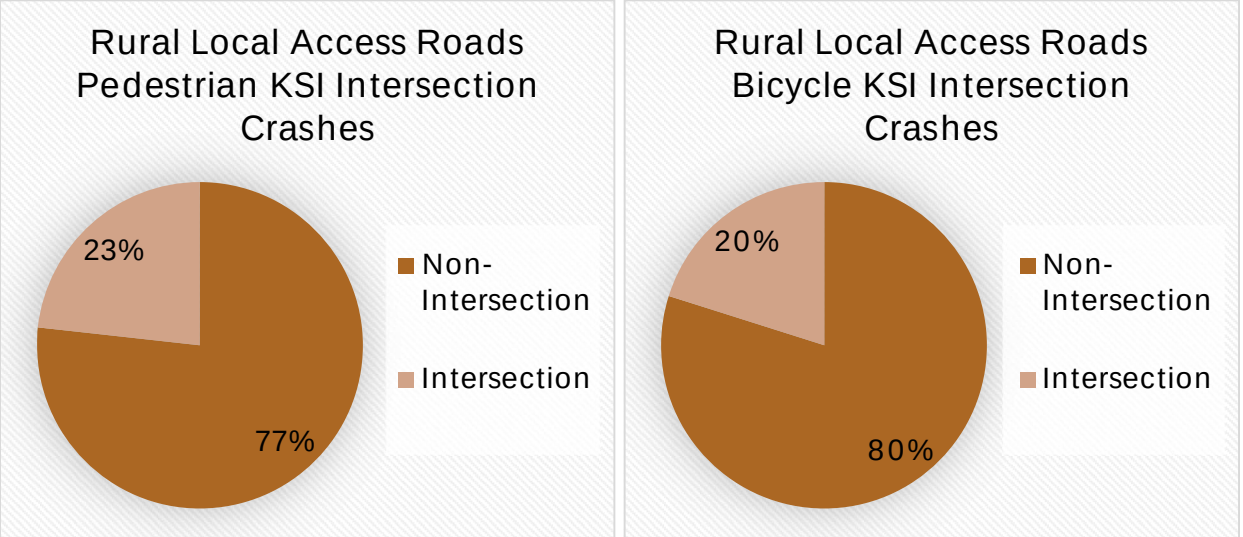


Figure 101: Rural Local Access Roads Pedestrian and Bicycle KSI Intersection Crashes

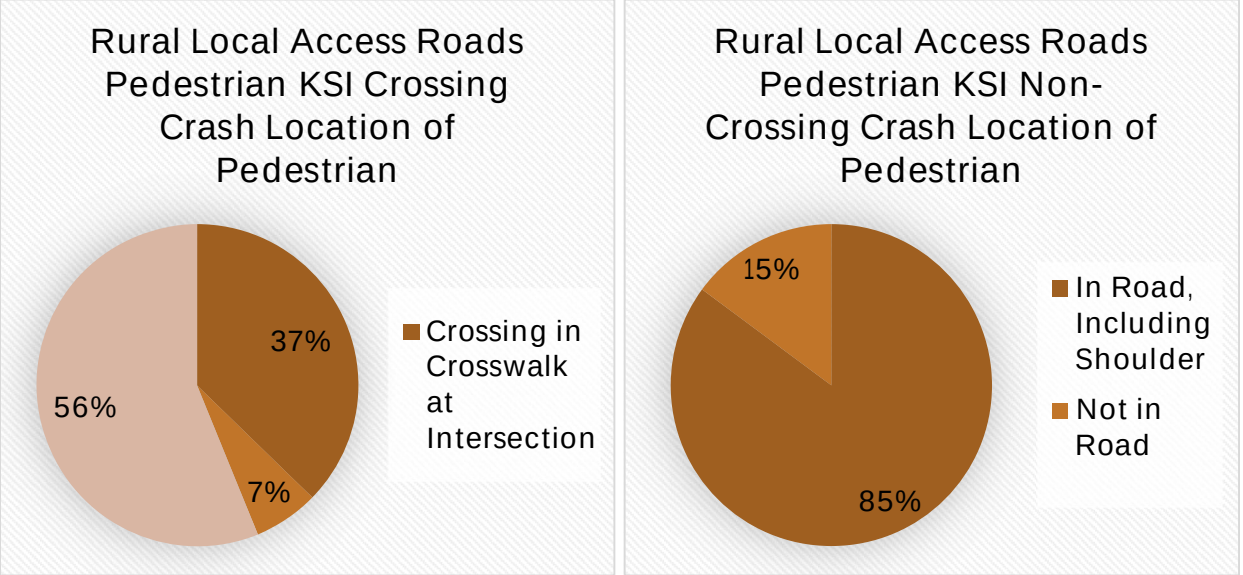


Figure 102: Rural Local Access Roads Pedestrian KSI Crash Location

Contributing Circumstances

Contributing circumstances are the immediate identifiable cause of a crash as noted by the reporting law enforcement officer. These contributing circumstances can include things like driver behavior, weather, and pavement conditions. The contributing circumstances also note the part at fault in a crash as determined by the reporting law enforcement officer. The data in this section show that while many contributing circumstances exist, many crashes have no reported contributing circumstances. The majority of KSI crashes do not involve adverse weather, dark lighting conditions, lack of seat belt usage, or negligent user behavior. Alcohol intoxication is one of the few behaviors that contributes to a substantial number of KSI crashes.

Occupant Protection

Occupant protection is something that is often cited as an area of improvement and is usually a focus of many educational campaigns. 89% of KSI crashes were found to have been wearing seatbelts and in 72% percent of KSI the airbags deployed, both of which can be seen in Figure 103 and Figure 104. Figure 105 motorcyclist behavior was also examined and found that 94% of all motorcycle KSI crashes were wearing their helmets. This data clearly shows that utilizing all proper occupant protection equipment in a vehicle will not stop fatal and serious injury crashes from occurring in rural areas. While there may be a reduction in KSI crashes overall by use of occupant protection but these ease symptoms rather than causes.

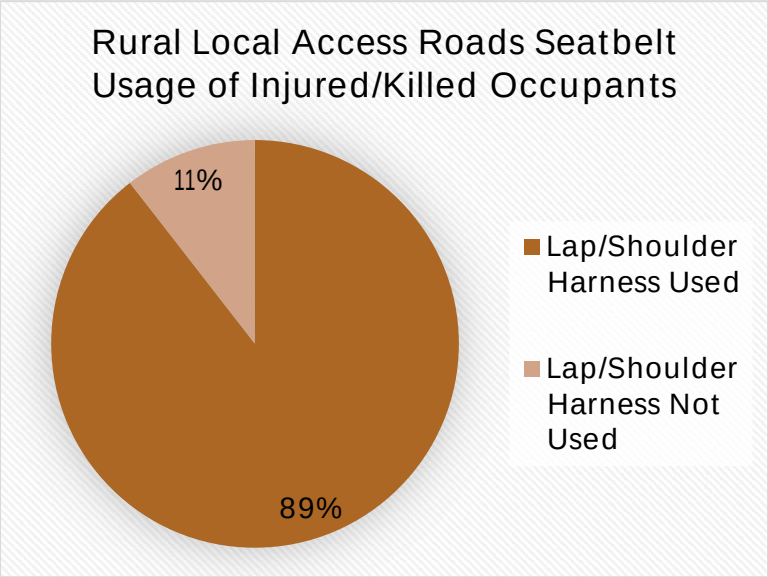


Figure 103: Rural Local Access Roads KSI Crash Seatbelt Usage

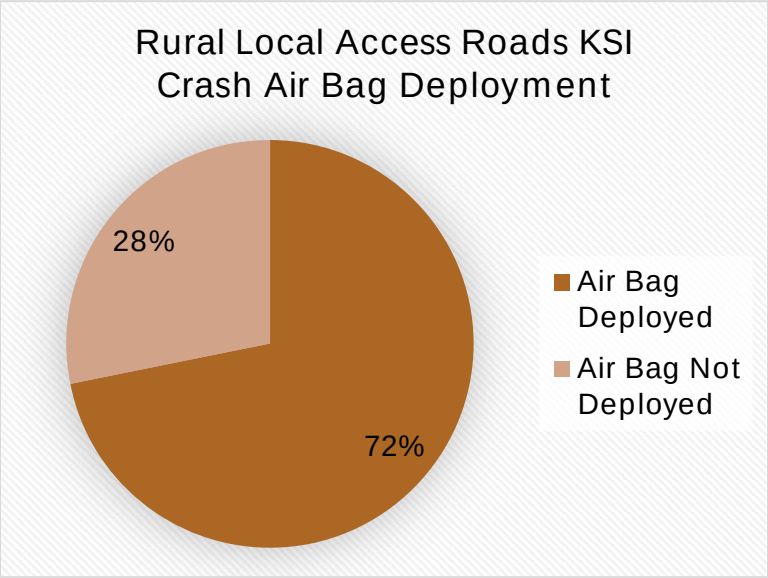


Figure 104: Rural Local Access Roads KSI Crash Air Bag Deployment

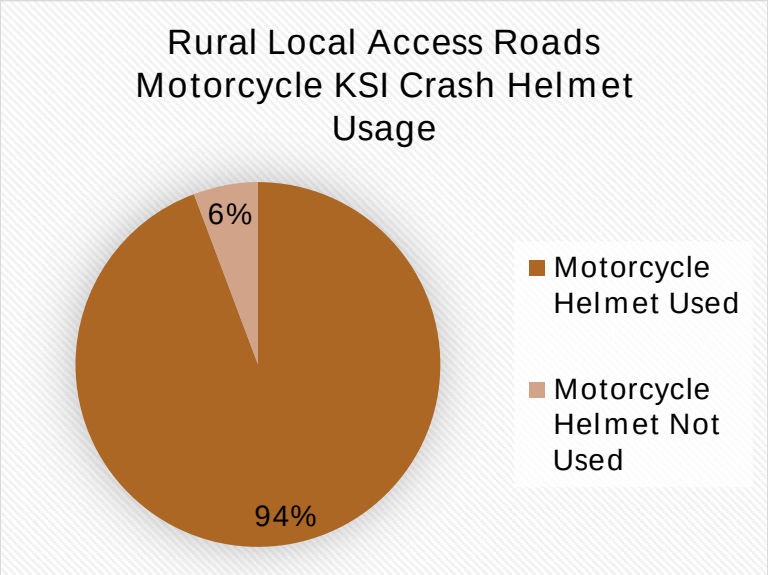


Figure 105: Rural Local Access Roads KSI Motorcycle Crash Helmet Usage

Time and Day

Crash trends throughout the week tend to correspond to traffic pattern trends with higher numbers of crashes happening in the morning and afternoon peak periods of traffic. This trend holds true for both all users and for pedestrians and bicyclists. No major increase in crashes is seen in the weekend nights, suggesting impairment is not a major factor on weekend nights for any users. There is an increase in bicycle KSI crashes on Saturday and Sunday mornings, which is likely a result of recreational cyclists riding at these times. This spike is also likely bolstered by the lack of bike lanes in rural areas. Figure 106, Figure 107, and Figure 108 below show this.

Rural Local Access Roads KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	1.14%	0.49%	0.38%	0.27%	0.27%	0.33%	0.74%
1:00 AM	0.82%	0.27%	0.16%	0.30%	0.30%	0.46%	0.52%
2:00 AM	0.93%	0.30%	0.16%	0.30%	0.14%	0.44%	0.68%
3:00 AM	0.95%	0.19%	0.22%	0.14%	0.22%	0.30%	0.71%
4:00 AM	0.49%	0.08%	0.25%	0.22%	0.30%	0.14%	0.44%
5:00 AM	0.30%	0.27%	0.41%	0.57%	0.46%	0.33%	0.30%
6:00 AM	0.19%	0.41%	0.52%	0.57%	0.49%	0.54%	0.25%
7:00 AM	0.22%	0.41%	0.60%	0.79%	0.49%	0.49%	0.49%
8:00 AM	0.38%	0.52%	0.60%	0.57%	0.27%	0.38%	0.41%
9:00 AM	0.54%	0.54%	0.44%	0.44%	0.38%	0.25%	0.60%
10:00 AM	0.82%	0.44%	0.33%	0.41%	0.38%	0.30%	0.95%
11:00 AM	1.01%	0.38%	0.49%	0.38%	0.60%	0.49%	1.33%
Noon	1.09%	0.49%	0.54%	0.57%	0.74%	0.57%	1.31%
1:00 PM	1.17%	0.79%	0.46%	0.76%	0.49%	0.60%	1.17%
2:00 PM	0.71%	0.76%	0.44%	0.65%	0.87%	0.87%	1.03%
3:00 PM	0.76%	0.71%	0.84%	0.68%	0.93%	1.03%	1.20%
4:00 PM	0.74%	0.74%	0.74%	0.63%	0.71%	1.14%	1.03%
5:00 PM	0.68%	0.63%	0.74%	0.84%	0.82%	1.28%	1.01%
6:00 PM	0.90%	0.63%	0.65%	0.82%	1.09%	1.23%	0.98%
7:00 PM	0.84%	0.60%	0.65%	0.68%	0.65%	0.74%	0.57%
8:00 PM	0.98%	0.49%	0.46%	0.57%	0.38%	0.71%	0.76%
9:00 PM	0.54%	0.57%	0.49%	0.49%	0.71%	0.68%	0.60%
10:00 PM	0.68%	0.30%	0.52%	0.33%	0.68%	0.54%	0.82%
11:00 PM	0.41%	0.52%	0.22%	0.46%	0.60%	0.79%	1.03%

Figure 106: Rural Local Access Roads KSI Crashes per Hour

Rural Local Access Roads Pedestrian KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	1.40%	0.70%	0.00%	0.35%	0.70%	1.40%	0.70%
1:00 AM	0.35%	0.70%	0.00%	0.35%	0.35%	0.35%	0.00%
2:00 AM	2.10%	0.00%	0.00%	0.70%	0.00%	1.40%	0.35%
3:00 AM	0.70%	0.35%	0.00%	0.00%	0.35%	0.70%	0.35%
4:00 AM	0.00%	0.00%	0.35%	0.00%	0.35%	0.35%	0.70%
5:00 AM	1.40%	1.05%	0.35%	0.70%	0.00%	0.35%	0.35%
6:00 AM	0.00%	0.70%	0.70%	1.75%	0.00%	1.05%	0.00%
7:00 AM	0.00%	0.70%	0.70%	0.70%	0.00%	0.35%	0.70%
8:00 AM	0.35%	0.35%	0.70%	0.00%	0.35%	0.70%	0.35%
9:00 AM	0.70%	0.00%	0.70%	0.70%	0.35%	0.35%	0.35%
10:00 AM	0.35%	0.00%	0.00%	0.00%	0.35%	0.70%	0.00%
11:00 AM	0.35%	0.35%	0.70%	0.35%	0.35%	0.00%	0.00%
Noon	0.35%	0.00%	0.00%	0.35%	0.35%	0.00%	0.70%
1:00 PM	0.35%	0.00%	0.00%	0.70%	0.00%	0.70%	1.05%
2:00 PM	0.00%	0.35%	0.35%	0.35%	1.75%	0.35%	0.00%
3:00 PM	0.00%	0.70%	1.05%	0.00%	0.35%	1.05%	1.05%
4:00 PM	0.00%	0.00%	0.35%	0.35%	0.70%	0.00%	0.35%
5:00 PM	0.00%	0.70%	1.75%	1.05%	1.40%	2.10%	1.75%
6:00 PM	1.05%	0.70%	0.00%	1.40%	1.75%	1.40%	1.05%
7:00 PM	0.00%	1.75%	0.35%	1.40%	0.70%	0.35%	1.05%
8:00 PM	1.05%	0.70%	0.70%	0.70%	0.70%	2.10%	2.45%
9:00 PM	0.35%	1.40%	1.75%	0.35%	1.05%	0.70%	1.40%
10:00 PM	1.75%	0.00%	1.75%	0.70%	0.70%	1.40%	1.05%
11:00 PM	0.70%	0.35%	0.00%	0.70%	0.35%	0.00%	2.10%

Figure 107: Rural Local Access Roads Pedestrian KSI Crashes per Hour

Rural Local Access Roads Bicycle KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.00%	0.00%	0.28%	0.28%	0.00%	0.00%	0.00%
1:00 AM	0.28%	0.00%	0.00%	0.28%	0.00%	0.00%	0.00%
2:00 AM	0.28%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3:00 AM	0.00%	0.00%	0.00%	0.28%	0.00%	0.00%	0.00%
4:00 AM	0.00%	0.00%	0.28%	0.00%	0.28%	0.00%	0.00%
5:00 AM	0.00%	0.00%	0.00%	0.28%	0.56%	0.00%	0.00%
6:00 AM	0.00%	0.00%	0.28%	0.56%	0.56%	0.00%	0.00%
7:00 AM	0.00%	0.00%	0.56%	0.56%	0.56%	1.13%	0.85%
8:00 AM	0.56%	1.13%	1.13%	0.85%	0.28%	0.85%	1.69%
9:00 AM	1.13%	0.85%	0.28%	0.56%	0.56%	0.56%	2.82%
10:00 AM	2.25%	1.13%	0.28%	1.13%	0.28%	0.85%	4.23%
11:00 AM	2.82%	0.85%	0.56%	1.13%	0.28%	0.85%	5.07%
Noon	1.69%	0.00%	1.41%	0.85%	1.69%	1.13%	3.66%
1:00 PM	1.69%	1.69%	0.56%	1.41%	1.13%	1.41%	2.82%
2:00 PM	0.85%	0.28%	0.00%	0.85%	0.56%	0.00%	0.28%
3:00 PM	0.85%	0.28%	1.13%	0.56%	1.13%	0.56%	0.28%
4:00 PM	0.28%	1.69%	0.85%	1.13%	1.69%	0.28%	1.69%
5:00 PM	0.28%	1.69%	0.56%	1.41%	1.13%	0.85%	0.85%
6:00 PM	0.28%	1.69%	0.85%	0.85%	0.56%	1.13%	0.56%
7:00 PM	0.56%	0.85%	1.13%	0.56%	0.56%	0.28%	0.00%
8:00 PM	0.28%	0.28%	0.00%	0.00%	0.28%	0.56%	0.00%
9:00 PM	0.00%	0.00%	0.00%	0.28%	0.00%	0.28%	0.00%
10:00 PM	0.00%	0.28%	0.56%	0.00%	0.28%	0.28%	0.00%
11:00 PM	0.28%	0.00%	0.00%	0.00%	0.00%	0.28%	0.00%

Figure 108: Rural Local Access Roads Bicycle KSI Crashes per Hour

Weather, Road, and Lighting Conditions

97% of rural local access roads KSI crashes occurred with clear or cloudy weather and only 3% with rain or some other adverse weather condition active. Similarly, 90% of KSI crashes occurred on dry pavement and 96% of KSI crashes occurred on well-maintained pavement. Lighting factors are also shown. The majority of KSI crashes happened in daylight hours, or at night with streetlights on. 21% of crashes occurred at night without streetlights which would seem clear area to address in rural areas. Adverse weather, wet pavement, poor pavement quality, and dark/unlit roadways contribute relatively little to overall KSI crash risk.

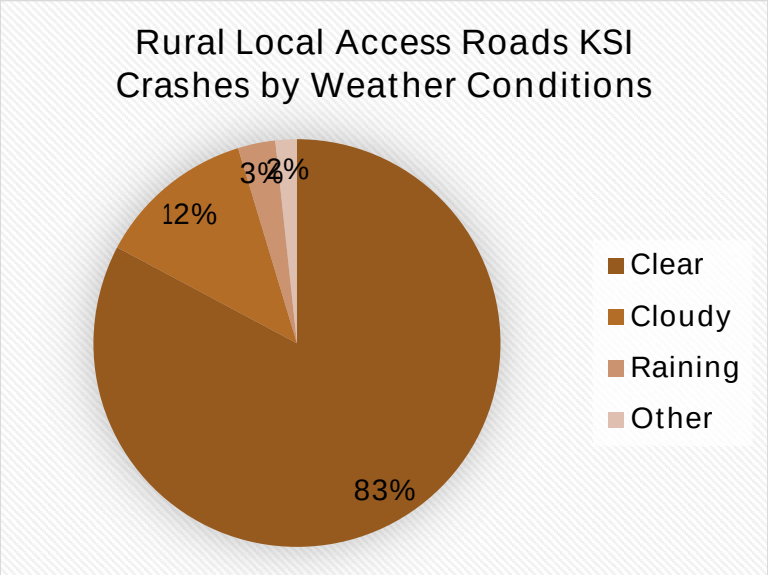


Figure 109: Rural Local Access Roads KSI Crashes by Weather Conditions

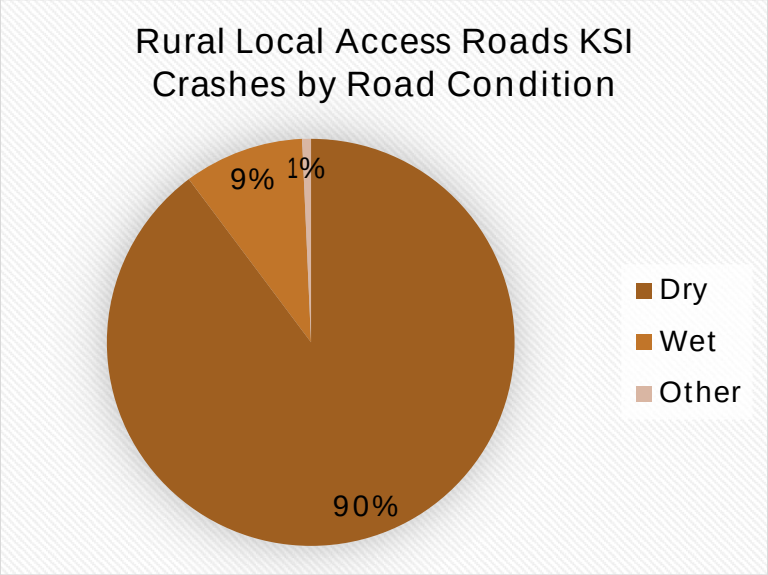


Figure 110: Rural Local Access Roads KSI Crashes by Road Condition

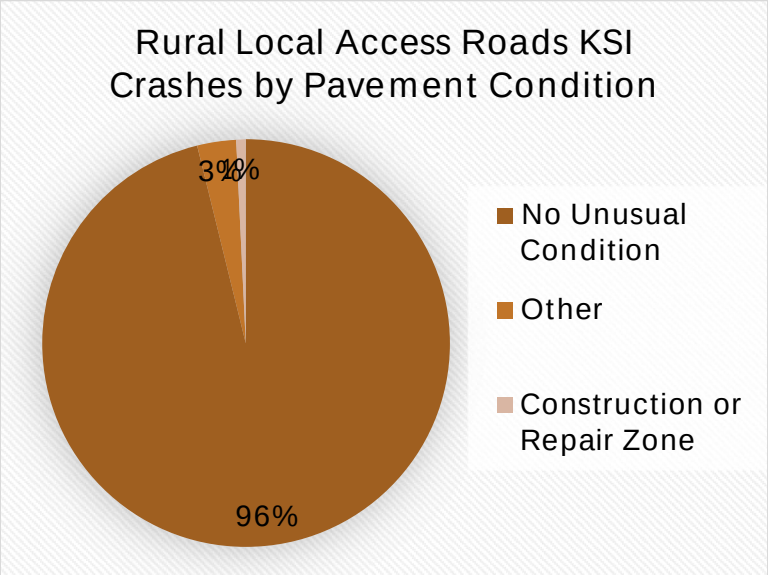


Figure 111: Rural Local Access Roads KSI Crashes by Pavement Condition

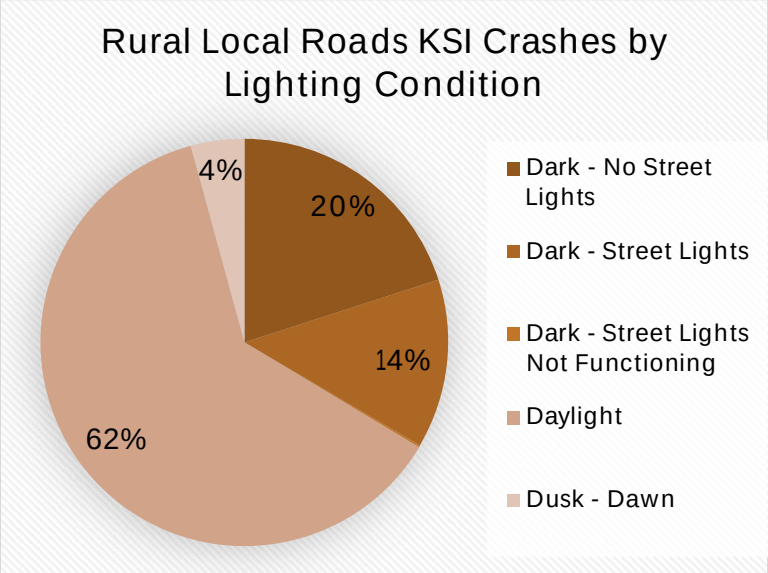


Figure 112: Rural Local Road KSI Crashes by Lighting Condition

Inattention and Impairment

Inattentive or "distracted" driving is often cited as an important contributing circumstance for crashes in common literature. However, the data shows that only 1% of drivers and 1% of bicyclists and pedestrians involved in KSI crashes in the Bay Area on rural roads were inattentive. More users are impaired, but even still only 20% of drivers and 6% of cyclists and pedestrians were impaired with either alcohol or drugs. Campaigns to curb driving under the influence have been successes to the point that expansion of a focus results in diminishing returns. This does not mean there should not be any attempt to educate or enforcement but that focus on discrete action

should be seen as ancillary to a more systemic vision zero approach. The majority of KSI crashes in the bay area involve non-impaired and attentive drivers. In both cases of inattention and intoxication, drivers are more likely to be inattentive or intoxicated than pedestrians or cyclists.

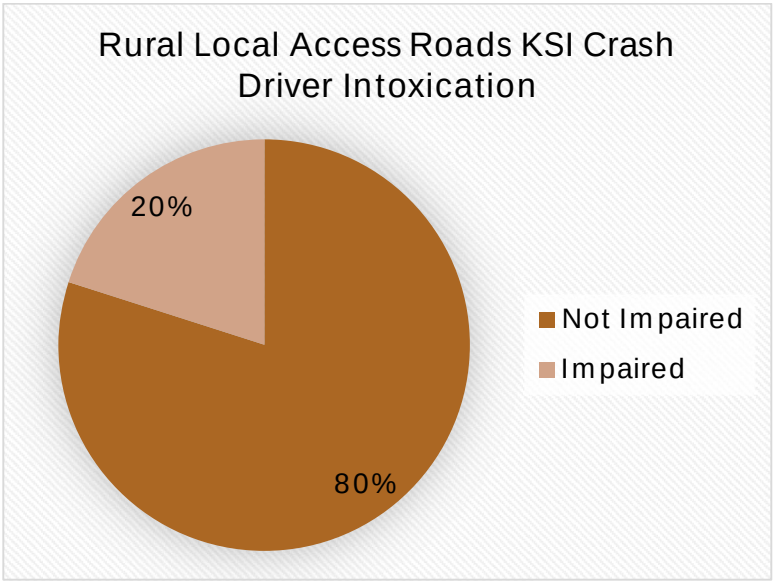


Figure 113: Rural Local Access Roads KSI Crashes by Impairment

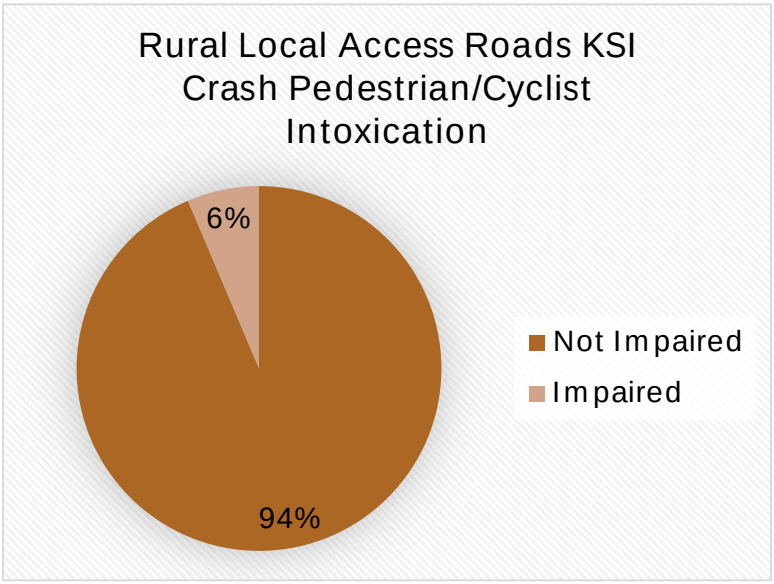


Figure 114: Rural Local Access Roads by Ped/Cyclists Intoxication

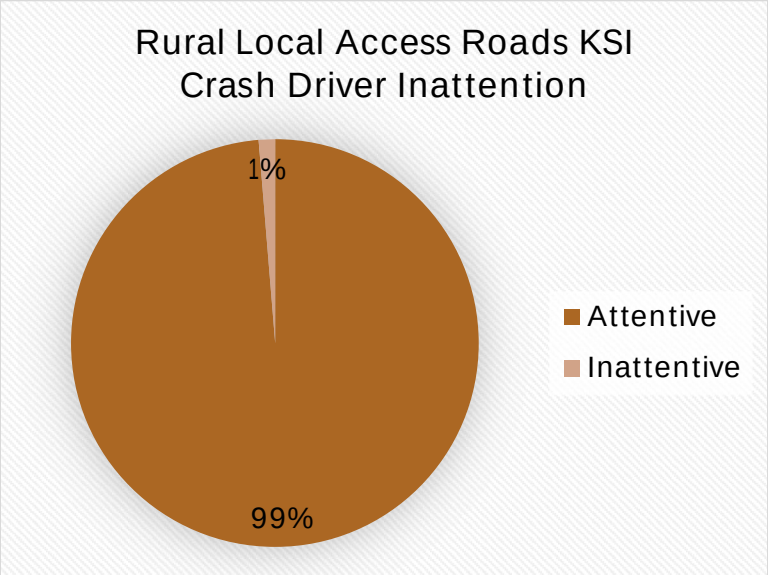


Figure 115: Rural Local Access Roads KSI Crashes by Driver Inattention

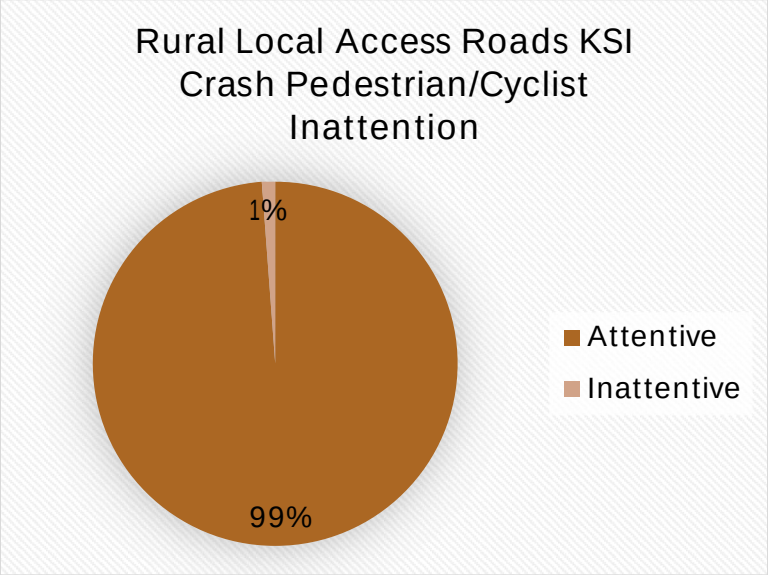


Figure 116: Rural Local Access Roads KSI Crashes by Driver Inattention

Suburban Areas KSI Crash Summary

Trends

Suburban KSI crashes (local access roads) in the Bay Area have also seen an increase over the decade period from 2010 – 2019. Fatal crashes in the suburbs have increased 56% and serious injury crashes have increased 44%. While again, must be noted that definition from "severe injury" to "suspected serious injury" in 2017 which may account for part of the rise, the continued rise in injuries from 2010 to 2016 and from 2017 to 2018 show that the problem lies in the roads themselves not definitions. These trends can be seen in Figure 117 and Figure 118.

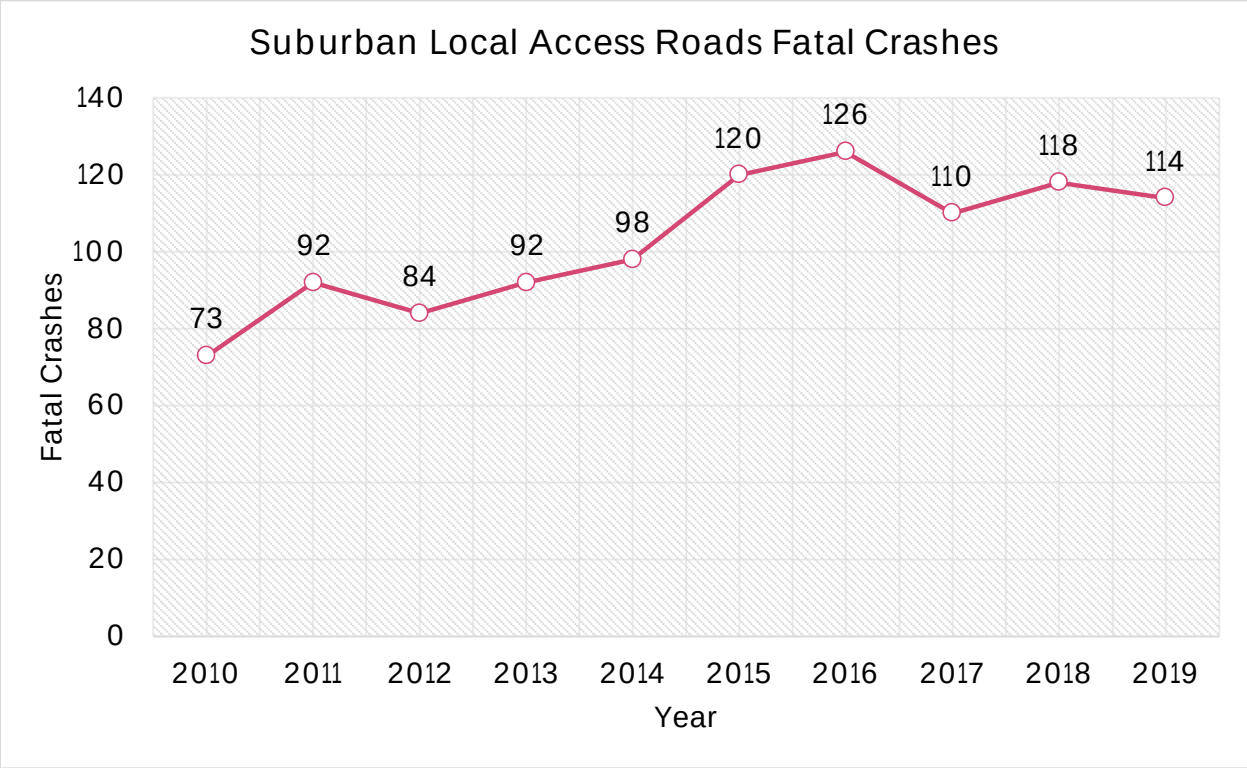


Figure 117: Suburban Local Access Road Fatal Crashes

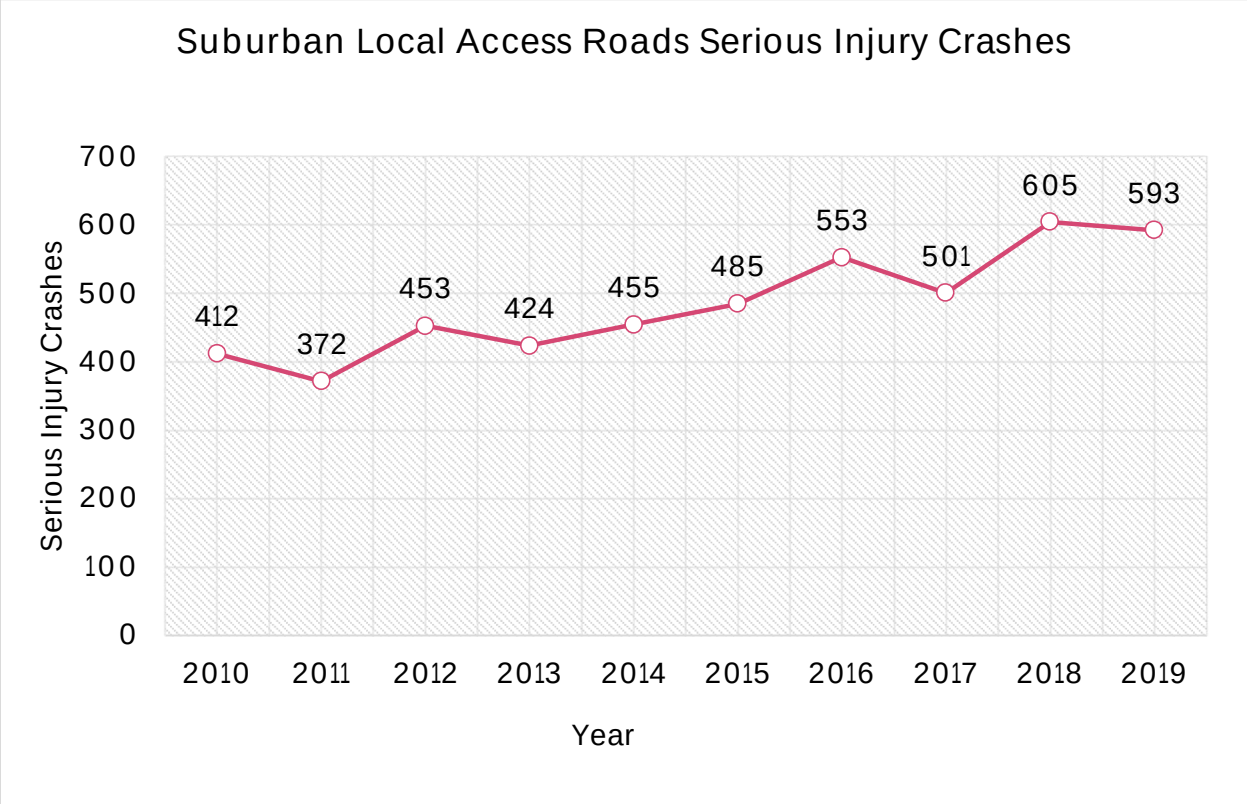


Figure 118: Suburban Local Access Road Serious Injury Crashes

Transportation Modes

Suburban areas often intentionally design car centered roadways to the exclusion of other users. This is reflected in crash data which shows that the majority of KSI crashes on rural roads are vehicle crashes that do not involve a pedestrian or cyclists as these methods are often not incentivized. However, this leads to poor facilities for other forms of transportation which helps account for the large share of pedestrians (29%) and cyclists (14%) KSI crashes which would almost certainly be mitigated with better facilities.

KSI crashes on suburban roads in the Bay Area have been increasing dramatically. Since 2010, vehicle KSI crashes have increased 51% between 2010 and 2019. Pedestrian KSI crashes have increased 51% and bicycle crashes have increased 21% over the years between 2010 and 2019. These trends can be seen in Figure 119 and Figure 120.

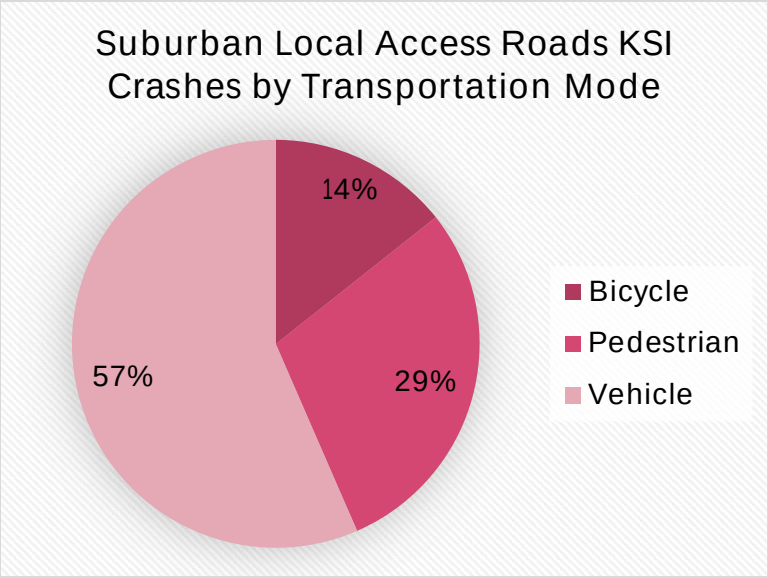


Figure 119: Suburban Local Access Road KSI Crashes by Transportation Mode

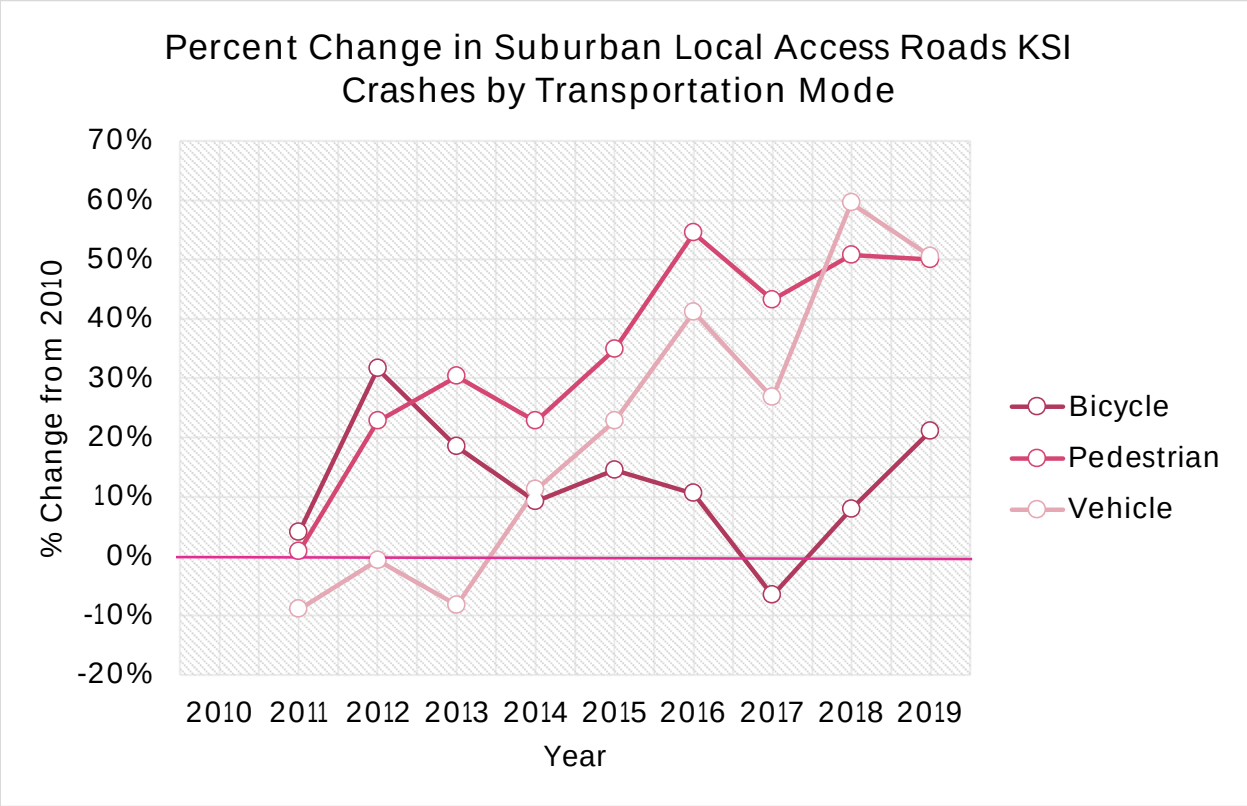


Figure 120: Percent Change in Suburban Local access roads KSI Crashes by Transportation Mode

Users and Equity

Suburban areas in the 9 county Bay Area as with many suburban areas elsewhere are generally whiter than surrounding communities more can be seen in KSI crash data by race which show that most of the KSI crashes involve White People. However, Black users and Other are the most disproportionally represented in the crash data. These trends can be seen below in Figure 121 and Figure 122.

Equity priority areas as defined by MTC were also examined for KSI crashes. These areas are of special focus as they are areas in which are affected disproportionally by safety issues affecting roadways and include the most vulnerable users. In suburban areas when looking at crashes in equity priority communities vs crashes not in equity priority communities, 31% of all crashes occur in equity priority communities; however, when adjusted for population proportion, there is a 1.47 times higher chance of a KSI crash happening in an equity priority community than outside an equity priority community. As such, it is important that any steps taken towards safety improvements keep equity as a key consideration even in rural areas. Suburban areas have long had a reputation

as areas structurally hostile to most POC communities, as the data as show here shows that there is truth to this, which must be addressed if vision zero is to be achieved.

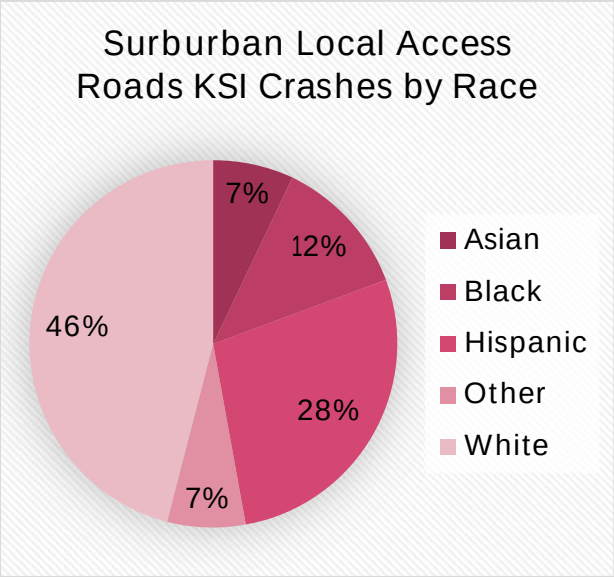


Figure 121: Suburban Local Access Roads KSI Crashes by Race

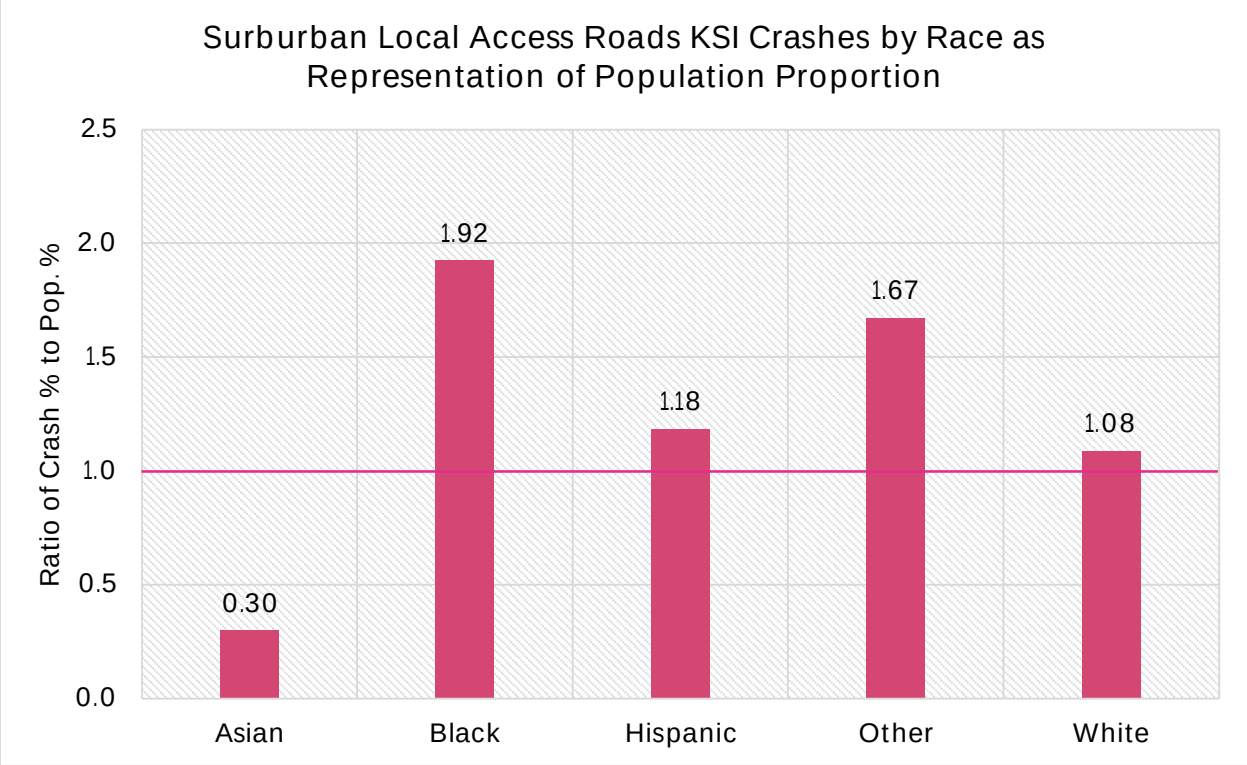


Figure 122: Suburban Local Access Roads KSI Crashes by Race as a Proportion of the Population

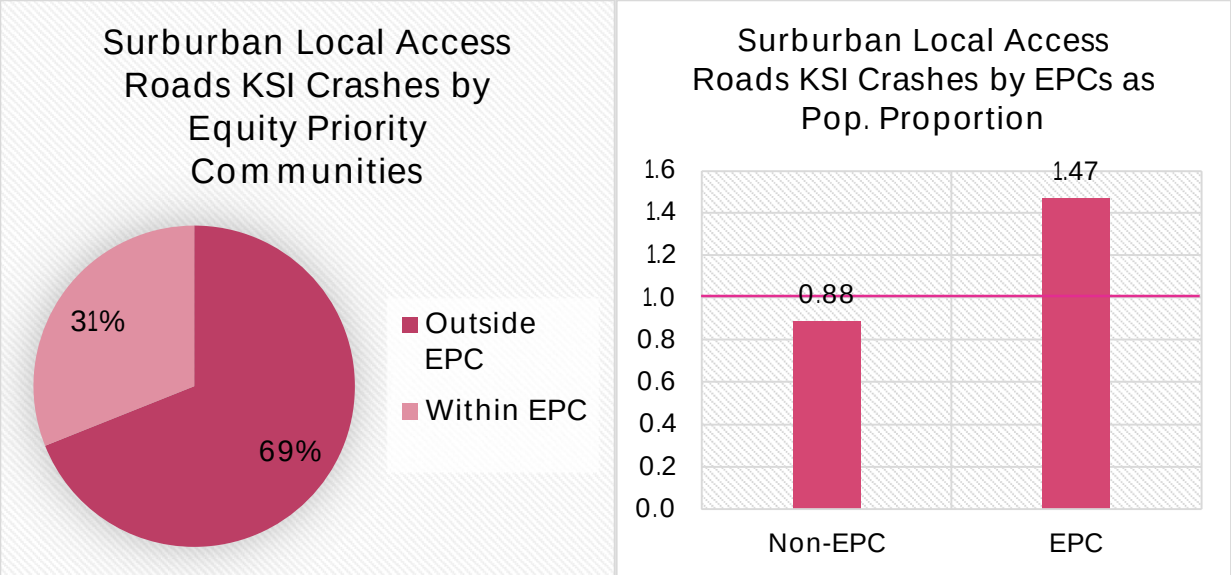


Figure 123: Suburban Local Access Roads KSI Crashes by Equity Priority Communities and Crashes by Equity Priority Communities as a Representation of Population (>1.0 = Over-Representation)

Age

Crashes in suburban areas do not occur evenly across age groups, as young people move away from these areas, this is reflected by having a relatively older group for KSI crash data in Figure 124. The groups that account for the largest number of crashes is still those in their 20s, with 20-24 accounting for 459 KSI crashes and 25-29 for 381. Normalizing for population, users in their 20s not only are involved in a high frequency of KSI crashes, but that these users are also highly over-represented. Users in the age group of 20-24 are 2.3 times more likely to be involved in a KSI crash than average. However, it is of interest to note that users 85+ are the 3rd most over-represented group being in crashes at 1.5 times the rate of representation seen in Figure 125.

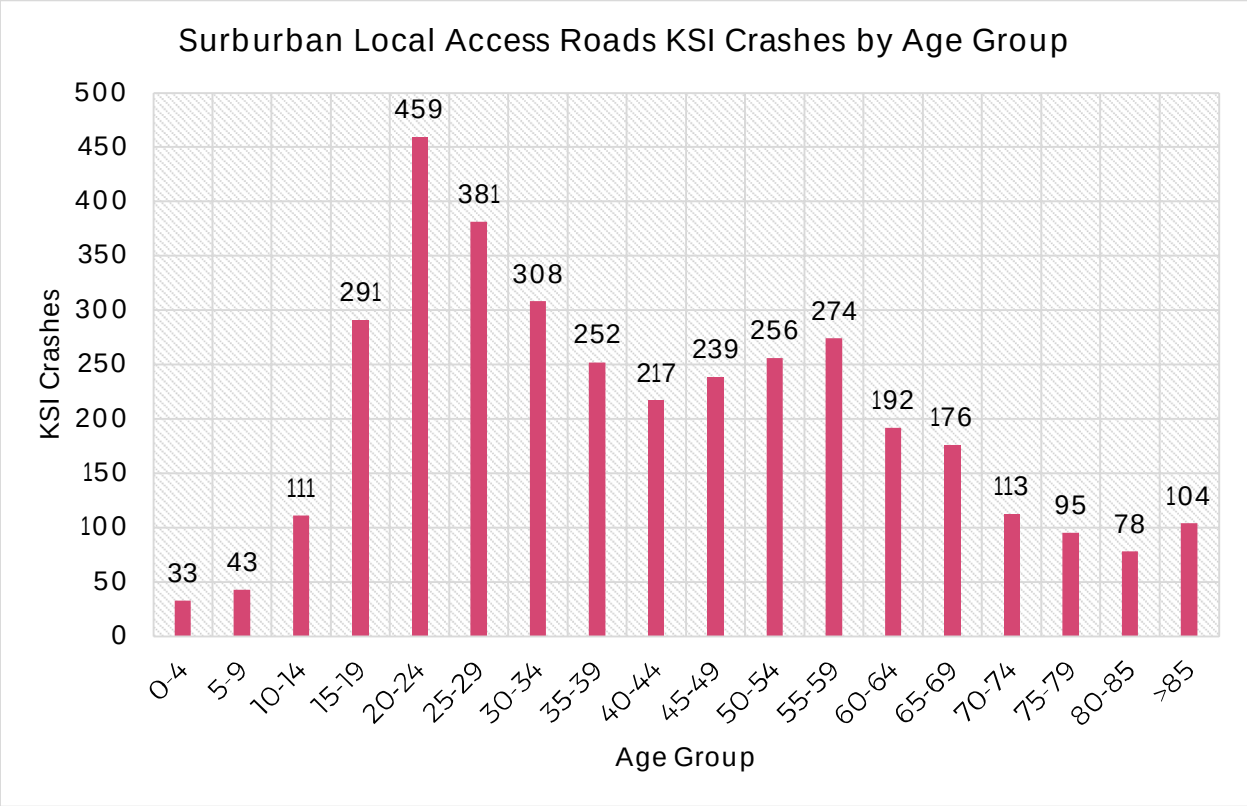


Figure 124: Suburban Local Access Roads KSI Crashes by Age Group

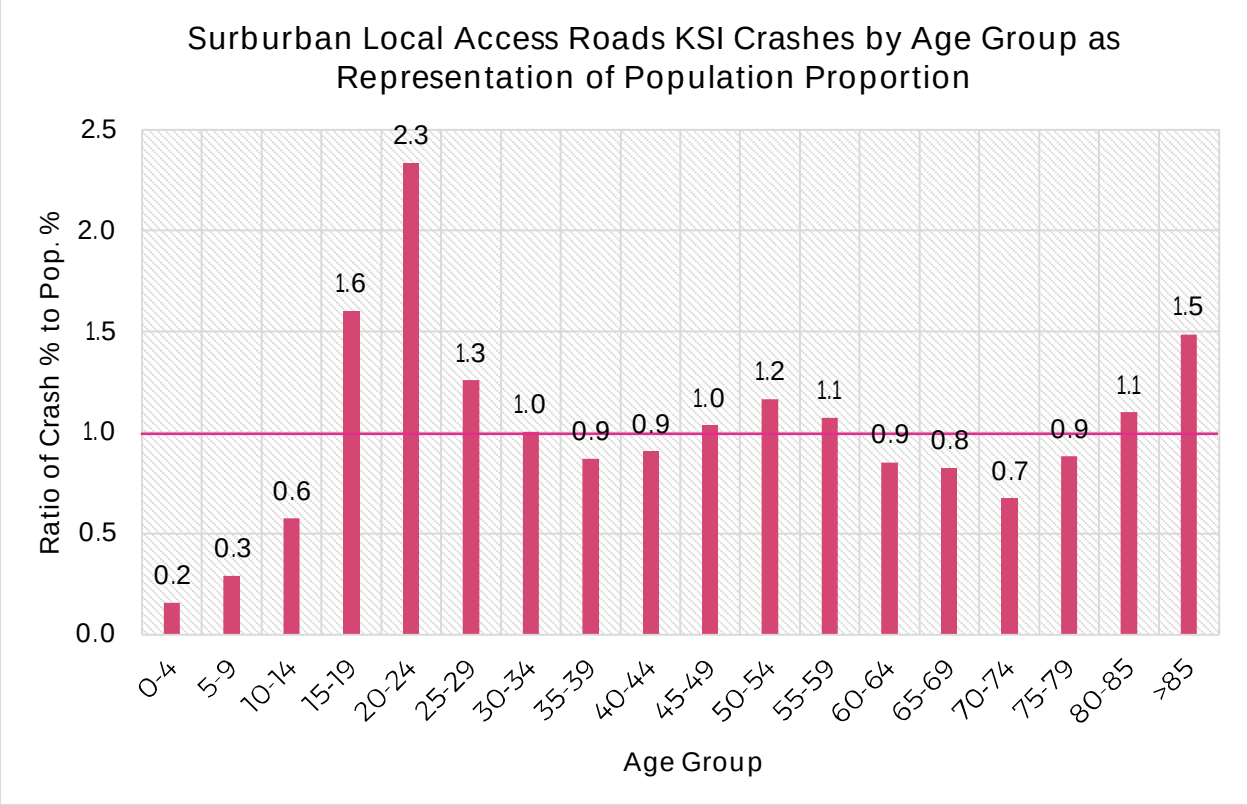


Figure 125 Suburban Local Access Roads KSI Crashes by Age Group as a Proportion of Population

Sex

Males currently account for 69% of crashes and are nearly 1.39 times as likely to be involved in a KSI crash compared to females on local suburban road. This data can be seen in Figure 126.

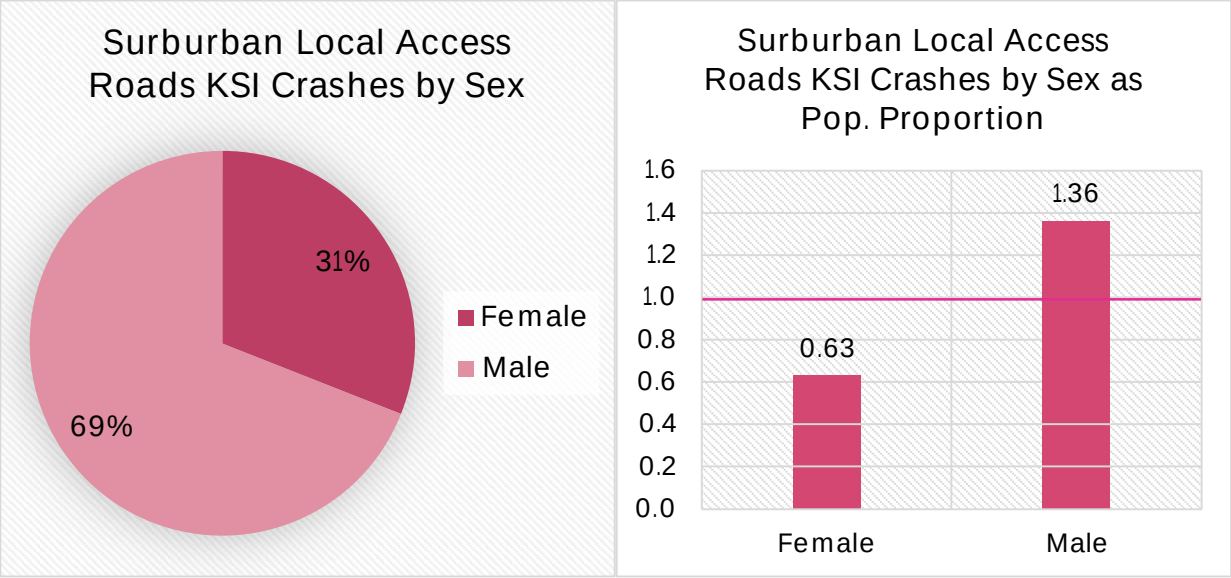


Figure 126: Suburban Local Access Roads KSI Crashes by Sex and Crashes by Sex as a Representation of Population (>1.0 = Over-Representation)

Crash Locations and Types

While the majority of KSI crashes in suburban areas occur at non-intersection locations, suburban areas have the 2nd highest proportion of intersection vs non-intersection crashes. Most of the non-intersection crashes involve crashes with collision with pedestrians (601) or a fixed object (418). Most of the crashes at intersections involve broadsides (399), pedestrians (353) and cyclists (153). The fact the 2 of the three most common interstation KSI crash types show that the current intersections are not safe enough for non-car users of the road.

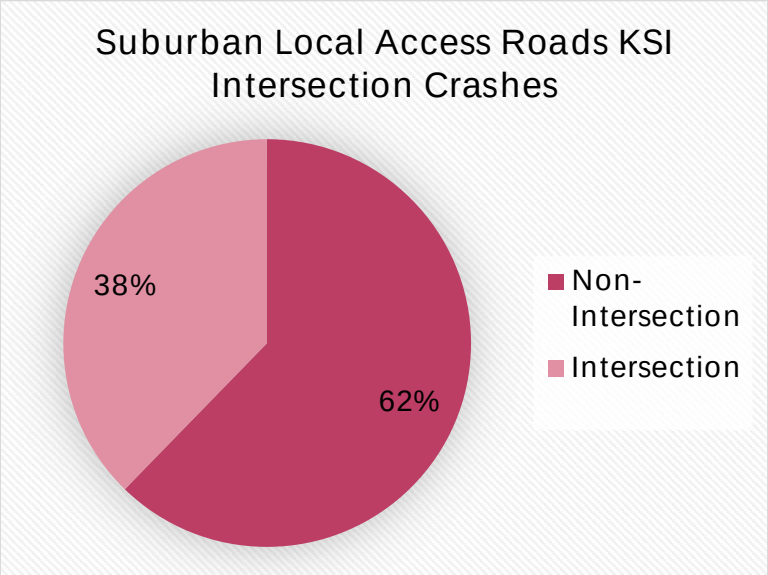


Figure 127: Suburban Local Access Roads KSI Intersection vs Non-Intersection Crashes

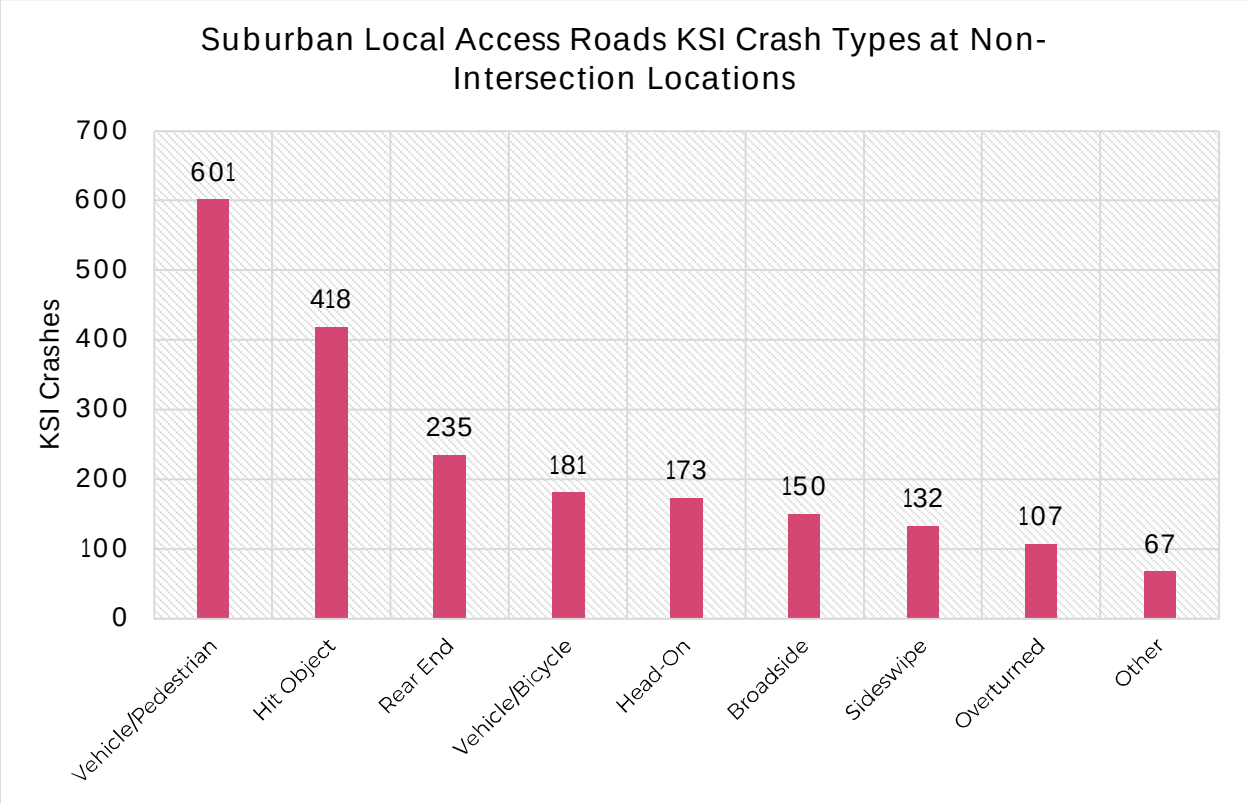


Figure 128: Suburban Local Access Roads KSI Crash Types at Non-Intersection Locations

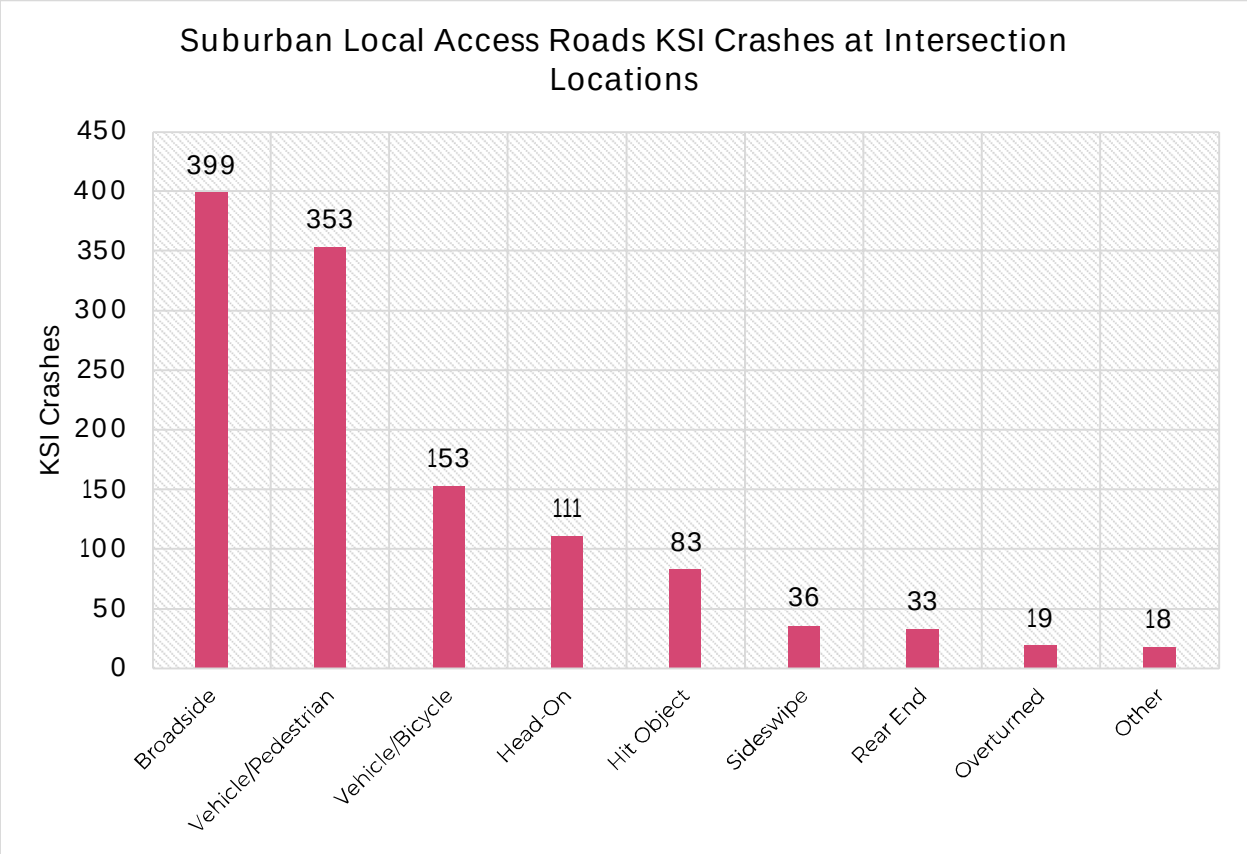
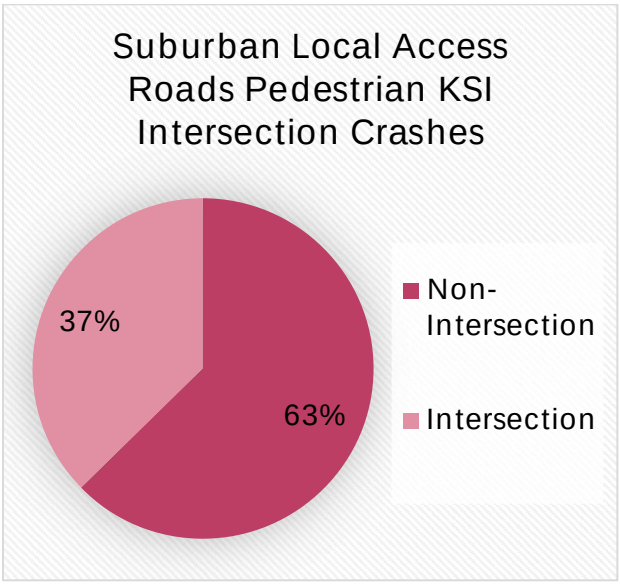


Figure 129: Suburban Local Access Roads KSI Crash Types at Intersection Locations

Pedestrian and Bicycle Crash Locations and Types

The majority of bicycle and pedestrian crashes happen at non-intersection locations (63%), though a substantial number also occur at intersections (37%). This data shows that in suburban areas a pedestrian KSI crash is more likely to occur when a pedestrian is crossing the street. This pattern holds true as well for cyclists where (58%) occur at non-Intersection locations. Suburban areas often have sparse bike/ped facilities so this may be a result. Most suburban KSI crashes for pedestrians occur due to crossing at crosswalks (58%), while crossing at non-crosswalks for (46%), with non-intersection crosswalks rounding out the remainder (4%). For pedestrian crashes that do not involve a pedestrian crossing the street, but rather walking along the street, 77% of them occurred when a pedestrian was walking in the street or shoulder.



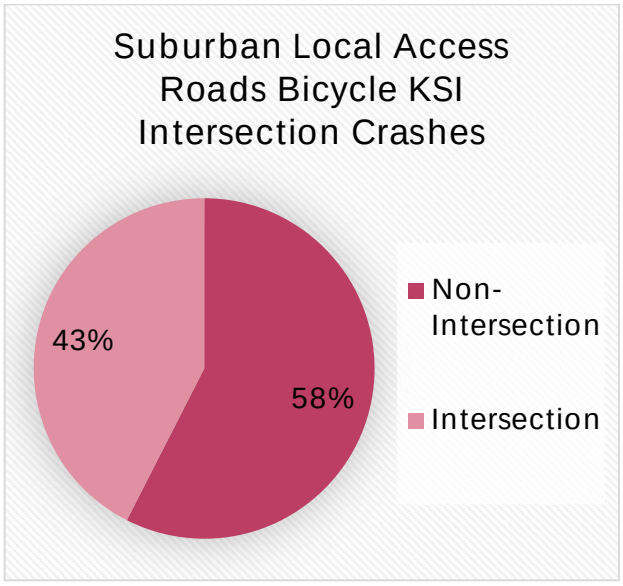


Figure 130: Suburban Local Access Roads Pedestrian and Bicycle KSI Intersection Crashes

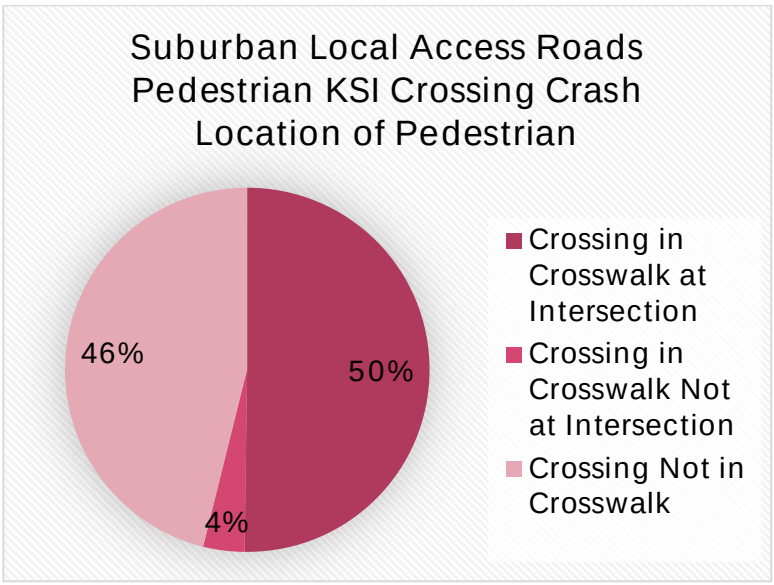


Figure 131 Suburban Local Access Roads Pedestrian KSI Crossing Crash Location of Pedestrian

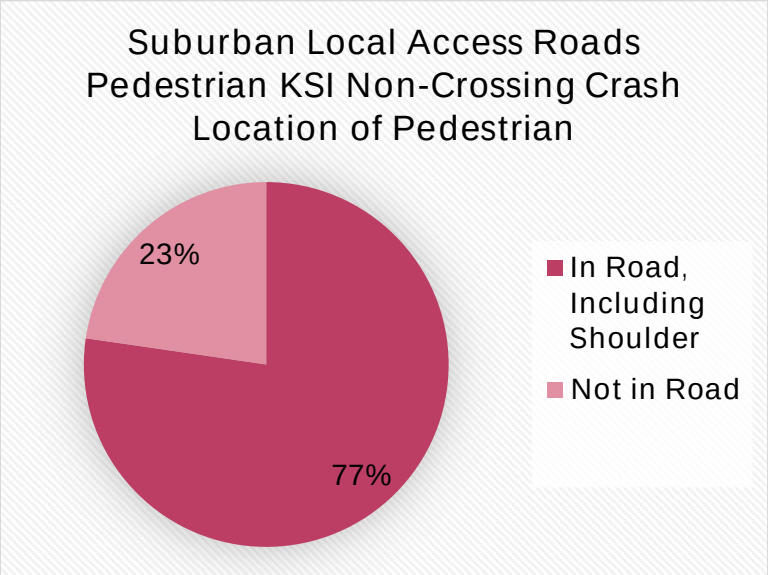


Figure 132: Suburban Local Access Roads Pedestrian KSI Non-Crossing Crash Location of Pedestrian

Contributing Circumstances

Contributing circumstances are the immediate identifiable cause of a crash as noted by the reporting law enforcement officer. These contributing circumstances can include things like driver behavior, weather, and pavement conditions. The contributing circumstances also note the part at fault in a crash as determined by the reporting law enforcement officer. The data in this section show that while many contributing circumstances exist, many crashes have no reported contributing circumstances. The majority of KSI crashes do not involve adverse weather, dark lighting conditions, lack of seat belt usage, or negligent user behavior.

Occupant Protection

89% of KSI crashes were found to have been wearing seatbelts and in 69% percent of KSI the airbags deployed. Motorcyclist behavior was also examined and found that 88% of all motorcycle KSI crashes were wearing their helmets. This data clearly shows that utilizing all proper occupant protection equipment in a vehicle will not stop fatal and serious injury crashes from occurring in suburban areas.

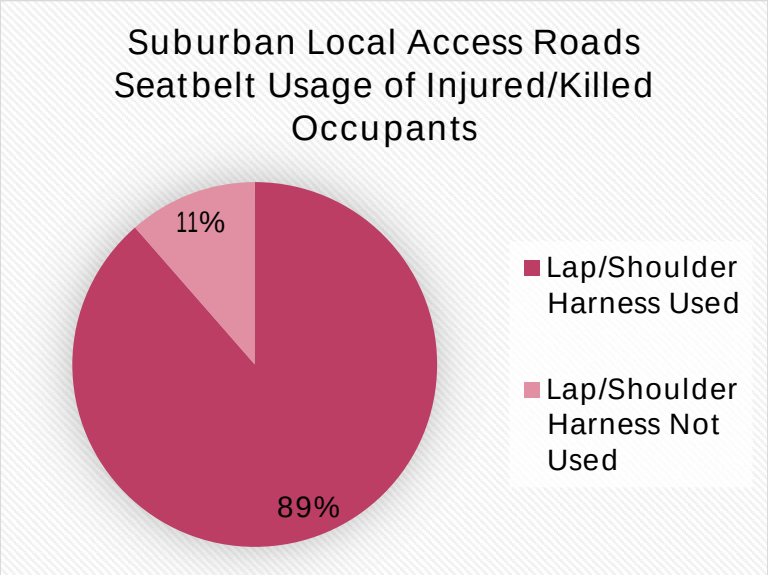


Figure 133: Suburban roads KSI Crash Seatbelt Usage

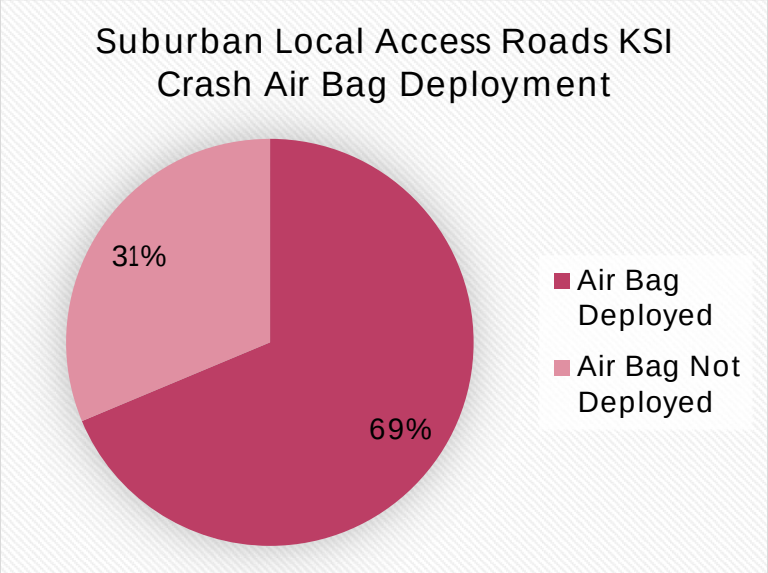


Figure 134: Suburban roads KSI Crash Air Bag Deployment

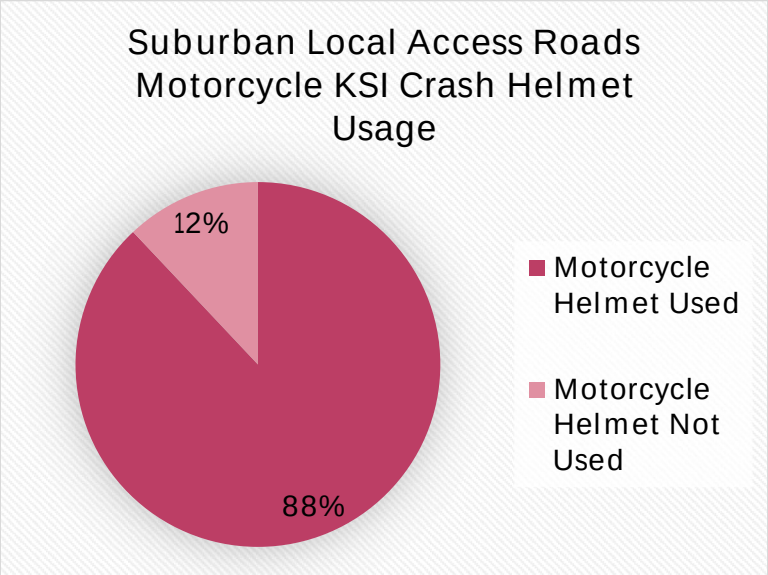


Figure 135: Suburban Local Access Roads KSI Motorcycle Crash Helmet Usage

Time and Day

Crash trends throughout the week tend to correspond to traffic pattern trends with higher numbers of crashes happening in the morning and afternoon peak periods of traffic. This trend holds true for both all users and for pedestrians and bicyclists. No major increase in crashes is seen in the weekend nights, suggesting impairment is not a major factor on weekend nights for any users. There is a small increase in bicycle KSI crashes on Saturday and Sunday mornings, which is likely a result of recreational cyclists riding at these times.

Suburban Local Access Roads KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.77%	0.35%	0.24%	0.31%	0.31%	0.48%	0.66%
1:00 AM	0.90%	0.37%	0.31%	0.09%	0.40%	0.33%	0.86%
2:00 AM	1.19%	0.35%	0.24%	0.26%	0.13%	0.31%	0.77%
3:00 AM	0.75%	0.37%	0.09%	0.18%	0.31%	0.24%	0.66%
4:00 AM	0.37%	0.29%	0.18%	0.11%	0.31%	0.13%	0.37%
5:00 AM	0.33%	0.40%	0.44%	0.53%	0.37%	0.44%	0.48%
6:00 AM	0.29%	0.37%	0.44%	0.51%	0.57%	0.40%	0.24%
7:00 AM	0.20%	0.53%	0.68%	0.59%	0.44%	0.48%	0.31%
8:00 AM	0.29%	0.51%	0.75%	0.64%	0.64%	0.51%	0.26%
9:00 AM	0.35%	0.37%	0.51%	0.57%	0.31%	0.46%	0.42%
10:00 AM	0.44%	0.57%	0.48%	0.26%	0.55%	0.55%	0.51%
11:00 AM	0.66%	0.62%	0.31%	0.46%	0.40%	0.53%	0.44%
Noon	0.62%	0.51%	0.55%	0.51%	0.48%	0.48%	0.70%
1:00 PM	0.51%	0.46%	0.48%	0.57%	0.70%	0.40%	0.59%
2:00 PM	0.48%	0.51%	0.62%	0.81%	0.68%	0.79%	0.79%
3:00 PM	0.37%	0.77%	0.64%	0.77%	0.79%	1.10%	0.70%
4:00 PM	0.64%	0.95%	0.77%	0.81%	1.08%	0.90%	0.64%
5:00 PM	0.70%	1.03%	1.14%	0.97%	1.06%	1.14%	0.97%
6:00 PM	0.81%	0.84%	0.95%	0.90%	1.39%	0.95%	0.81%
7:00 PM	0.99%	0.79%	0.95%	0.73%	0.88%	1.01%	0.86%
8:00 PM	0.59%	0.51%	0.66%	0.95%	0.88%	1.32%	0.88%
9:00 PM	0.73%	0.44%	0.86%	0.81%	0.59%	1.12%	0.95%
10:00 PM	0.81%	0.62%	0.40%	0.59%	0.59%	0.70%	1.19%
11:00 PM	0.55%	0.37%	0.42%	0.73%	0.35%	0.68%	1.06%

Figure 136: Suburban Local Access Roads KSI Crashes per Hour

Suburban Local Access Roads Pedestrian KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.85%	0.00%	0.19%	0.28%	0.38%	0.19%	0.66%
1:00 AM	0.85%	0.47%	0.09%	0.00%	0.09%	0.19%	0.28%
2:00 AM	0.85%	0.19%	0.19%	0.09%	0.00%	0.28%	0.09%
3:00 AM	0.19%	0.28%	0.28%	0.00%	0.28%	0.47%	0.28%
4:00 AM	0.09%	0.38%	0.00%	0.19%	0.28%	0.09%	0.47%
5:00 AM	0.47%	0.47%	0.75%	0.47%	0.94%	0.38%	0.56%
6:00 AM	0.19%	0.75%	0.66%	0.66%	0.75%	0.66%	0.28%
7:00 AM	0.09%	0.38%	0.75%	0.56%	0.09%	0.56%	0.09%
8:00 AM	0.09%	0.38%	1.13%	0.75%	1.13%	0.66%	0.28%
9:00 AM	0.09%	0.38%	0.28%	0.19%	0.09%	0.19%	0.19%
10:00 AM	0.09%	0.38%	0.47%	0.19%	0.38%	0.66%	0.47%
11:00 AM	0.47%	0.38%	0.09%	0.47%	0.47%	0.19%	0.09%
Noon	0.19%	0.19%	1.03%	0.56%	0.28%	0.28%	0.09%
1:00 PM	0.56%	0.85%	0.38%	0.28%	0.28%	0.00%	0.00%
2:00 PM	0.09%	0.19%	0.38%	0.75%	0.66%	0.28%	0.28%
3:00 PM	0.19%	0.56%	0.38%	0.85%	0.75%	1.03%	0.28%
4:00 PM	0.38%	0.75%	0.56%	0.75%	0.66%	0.75%	0.28%
5:00 PM	0.85%	1.22%	1.22%	0.75%	1.51%	1.03%	0.94%
6:00 PM	1.22%	1.32%	1.13%	1.32%	1.60%	1.88%	0.94%
7:00 PM	1.60%	1.13%	0.94%	1.32%	1.13%	1.22%	1.13%
8:00 PM	0.94%	0.85%	1.32%	1.22%	1.13%	2.82%	1.88%
9:00 PM	0.94%	0.38%	0.94%	1.41%	1.32%	1.41%	1.13%
10:00 PM	0.85%	0.85%	0.28%	0.94%	0.85%	0.66%	1.88%
11:00 PM	0.19%	0.28%	0.47%	0.85%	0.28%	1.03%	0.94%

Figure 137: Suburban Local Access Roads Pedestrian KSI Crashes per Hour

Suburban Local Access Roads Bicycle KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.45%	0.00%	0.23%	0.23%	0.00%	0.23%	0.00%
1:00 AM	0.23%	0.00%	0.45%	0.00%	0.23%	0.00%	0.68%
2:00 AM	0.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3:00 AM	0.00%	0.23%	0.00%	0.00%	0.00%	0.00%	0.23%
4:00 AM	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.23%
5:00 AM	0.00%	0.00%	0.91%	0.68%	0.23%	0.23%	0.00%
6:00 AM	0.00%	0.00%	0.45%	0.00%	0.45%	0.68%	0.23%
7:00 AM	0.00%	0.91%	1.13%	0.68%	0.68%	1.59%	0.45%
8:00 AM	0.68%	0.68%	0.68%	1.13%	0.45%	0.45%	0.45%
9:00 AM	0.68%	0.91%	0.23%	1.81%	0.45%	0.68%	1.13%
10:00 AM	0.68%	0.68%	0.00%	0.45%	0.91%	0.23%	0.68%
11:00 AM	0.68%	0.68%	0.23%	0.23%	0.45%	0.45%	0.68%
Noon	1.13%	1.13%	0.68%	0.68%	0.45%	1.36%	1.81%
1:00 PM	0.68%	0.23%	0.68%	0.91%	1.36%	0.45%	0.91%
2:00 PM	0.91%	0.68%	0.68%	0.68%	0.68%	0.45%	0.68%
3:00 PM	0.68%	0.91%	0.91%	0.91%	0.68%	1.81%	0.45%
4:00 PM	1.13%	1.81%	2.49%	1.36%	1.81%	0.68%	0.91%
5:00 PM	0.68%	0.91%	1.59%	1.13%	1.13%	0.91%	0.91%
6:00 PM	0.68%	0.91%	1.59%	1.59%	2.04%	0.91%	0.45%
7:00 PM	1.59%	0.91%	2.04%	0.00%	0.68%	1.36%	0.45%
8:00 PM	0.68%	0.45%	0.45%	1.13%	1.81%	0.68%	0.23%
9:00 PM	0.68%	0.45%	0.23%	0.68%	0.23%	0.45%	0.68%
10:00 PM	0.00%	0.68%	0.23%	0.00%	0.23%	0.23%	0.45%
11:00 PM	0.45%	0.00%	0.00%	0.45%	0.23%	0.00%	0.45%

Figure 138: Suburban Local Access Roads Bicycle KSI Crashes per Hour

Weather, Road, and Lighting Conditions

94% of suburban KSI crashes occurred with clear or cloudy weather and only 3% with rain or some other adverse weather condition active. Similarly, 90% of KSI crashes occurred on dry pavement and 97% of KSI crashes occurred on well-maintained pavement. Lighting factors are also shown. The majority of KSI crashes happened in daylight hours, or at night with streetlights on. 5% of crashes occurred at night without. Adverse weather, wet pavement, poor pavement quality, and dark/unlit roadways contribute relatively little to overall KSI crash risk.

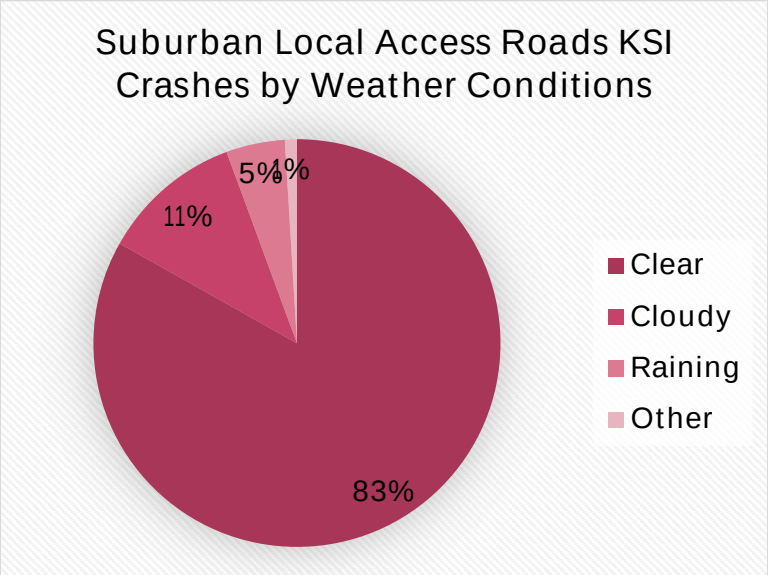


Figure 139: Suburban Local Access Roads KSI Crashes by Weather Conditions

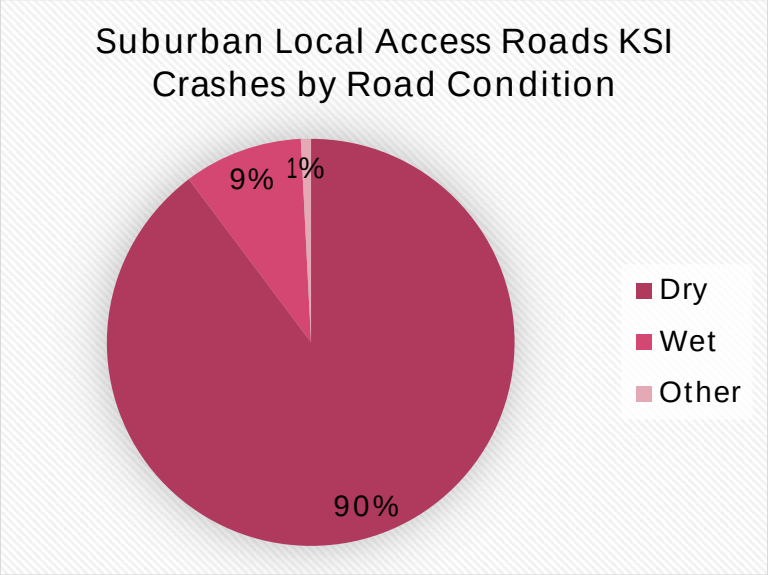


Figure 140: Suburban Local Access Roads KSI Crashes by Road Condition

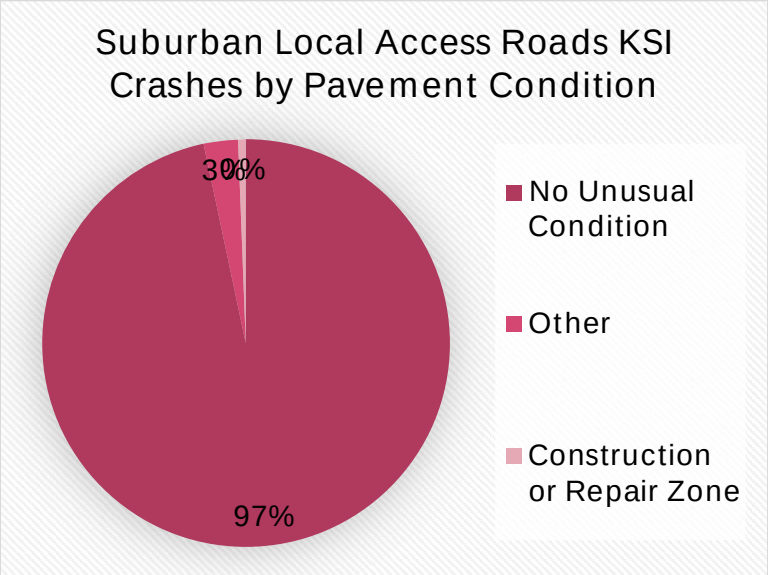


Figure 141: Suburban Local Access Roads KSI Crashes by Pavement Condition

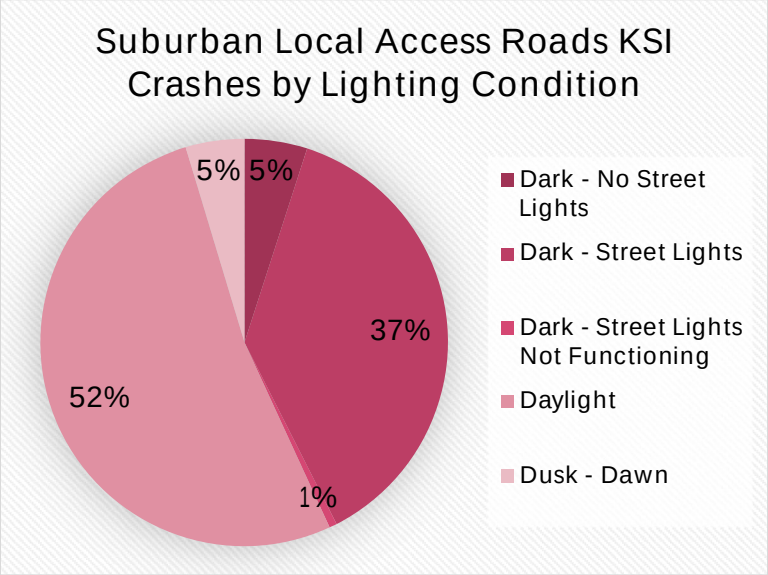


Figure 142: Suburban Local Access Roads KSI Crashes by Lighting Condition

Inattention and Impairment

Inattentive or "distracted" driving is often cited as an important contributing circumstance for crashes in common literature. However, the data shows that only 1% of drivers and 1% of bicyclists and pedestrians involved in KSI crashes in the Bay Area on suburban roads were inattentive. More users are impaired, but even still only 20% of drivers and 9% of cyclists and pedestrians were impaired with either alcohol or drugs. The majority of KSI crashes in the bay area involve non-impaired and attentive drivers. In both cases of inattention and intoxication, drivers are more likely to be inattentive or intoxicated than pedestrians or cyclists.

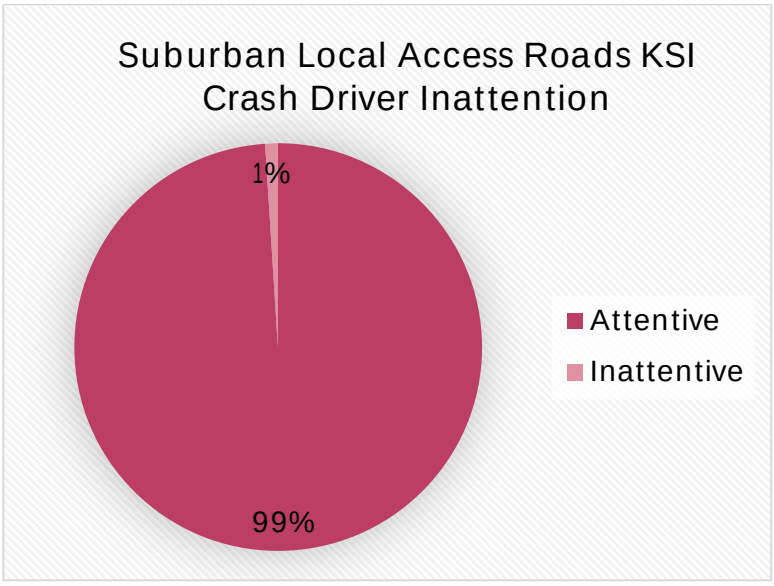


Figure 143: Suburban Local Access Roads KSI Crash Driver Inattention

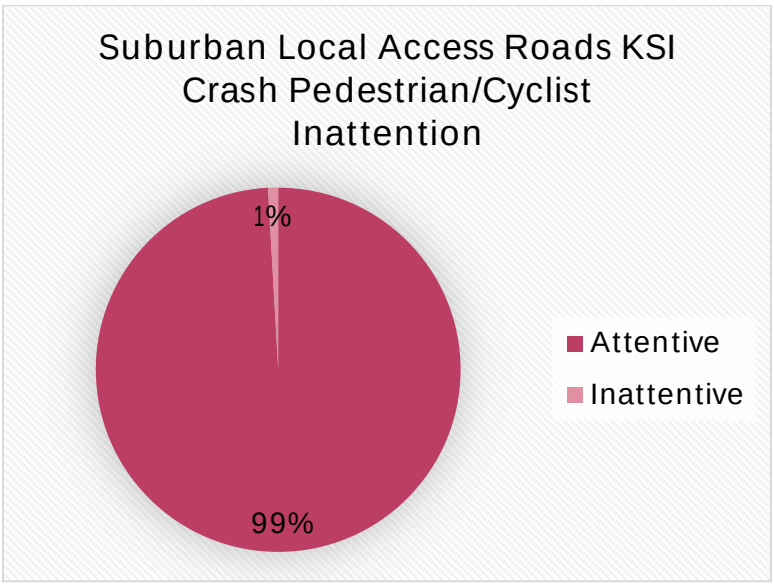


Figure 144: Suburban Local Access Roads KSI Crash Pedestrian/Cyclist Inattention

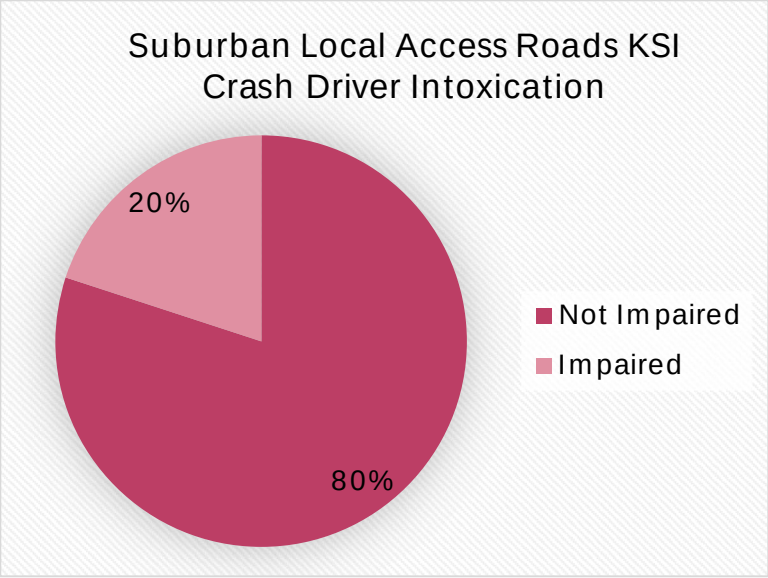


Figure 145: Suburban Local Access Roads KSI Crash Driver Intoxication

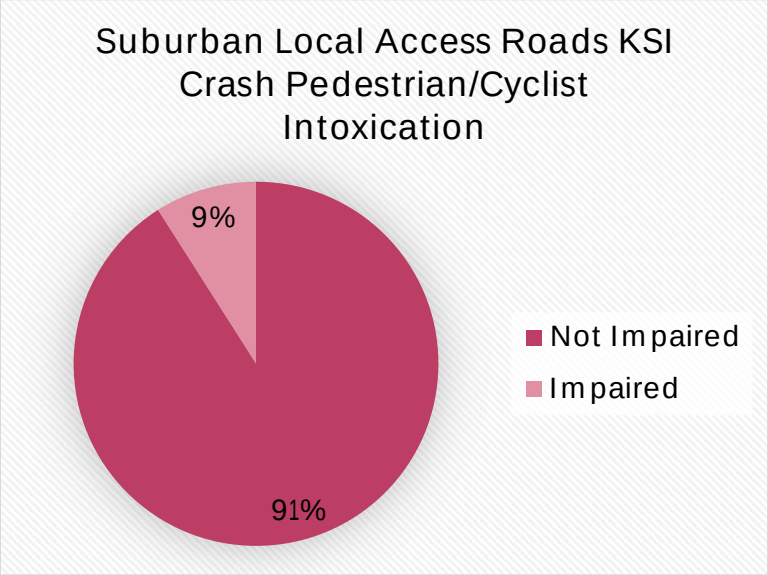


Figure 146: Suburban Local Access Roads

Urban Areas KSI Crash Summary

Trends

Urban KSI crashes in the Bay Area have also seen an increase over the decade period 2010 – 2019. Fatal crashes in these areas have increased by a staggering 82% and serious injury crashes have increased 65%. Fatal and serious injury crash trends from 2010 to 2019 are shown below. While overall numbers on urban local roads is lower overall compared to suburban roads, the large increase is concerning.

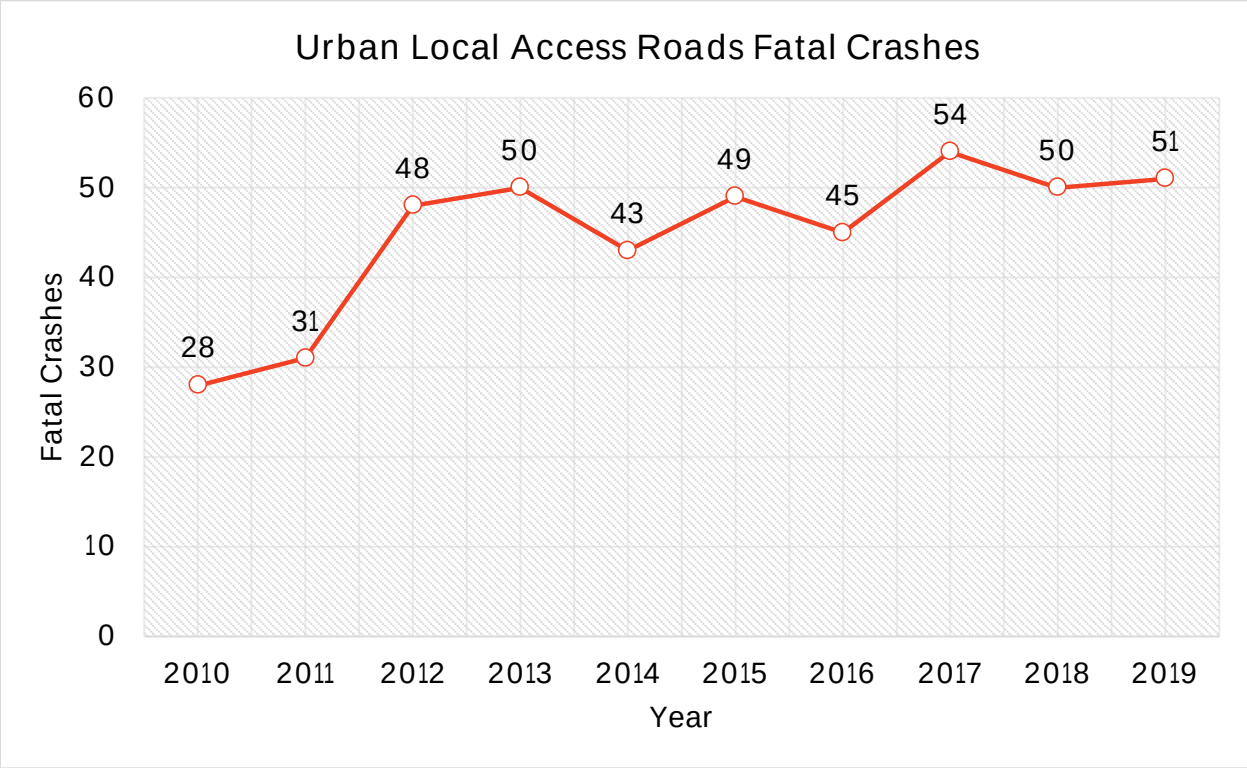


Figure 147: Urban Local Access Roads Fatal Crashes

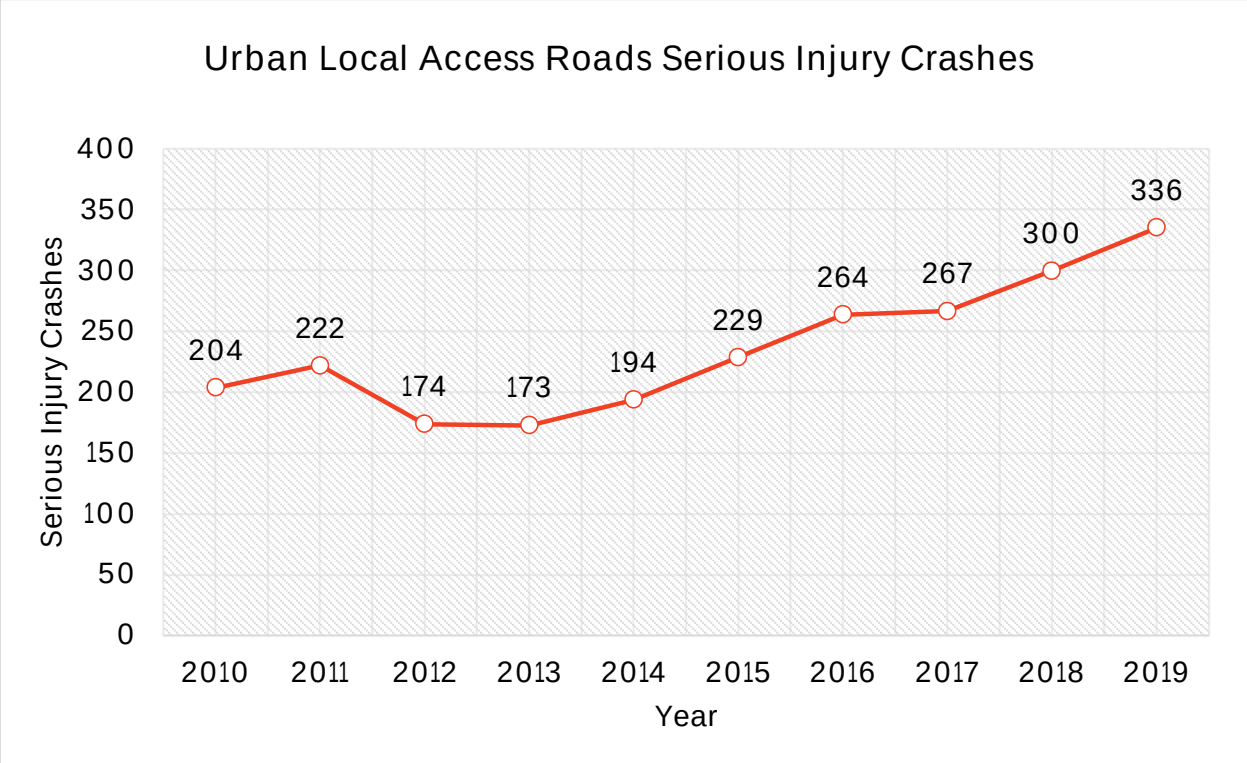


Figure 148: Urban Local Access Roads Serious Injury Crashes

Transportation Modes

Urban areas in the United States are often much more reliant on car-based infrastructure when compared to peer nations. Even still, Urban roadways still safer due to a more complete use of roads. This is reflected in crash data which shows that the almost half of KSI crashes on urban roads are vehicle crashes that involve a pedestrian or cyclists. Pedestrians (37%) and cyclists (15%) crashes overall are a much larger portion of the overall KSI crashes, in urban environments, likely due to increased density and presence.

KSI crashes on urban roads in the Bay Area have been increasing dramatically. Since 2010, vehicle KSI crashes have increased 54% between 2010 and 2019. Pedestrian KSI crashes have increased 101% and bicycle crashes have increased 39% over the years between 2010 and 2019.

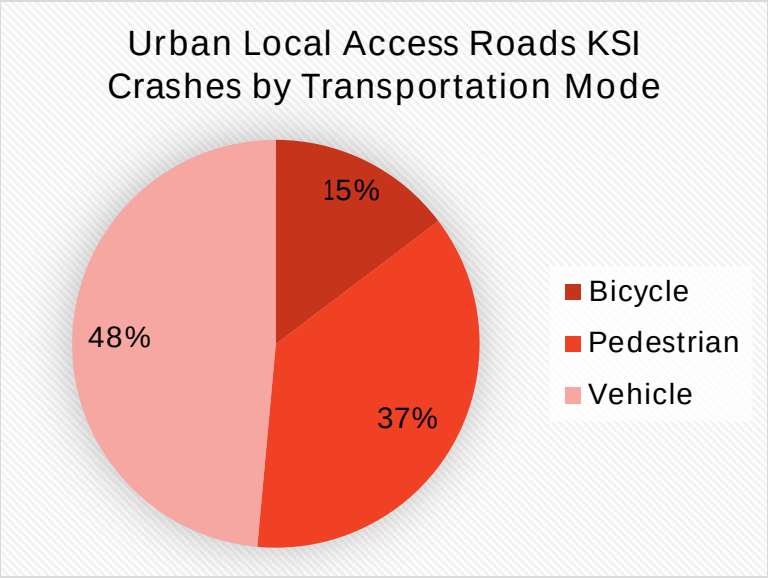


Figure 149: Urban Local Access Road KSI Crashes by Transportation Mode

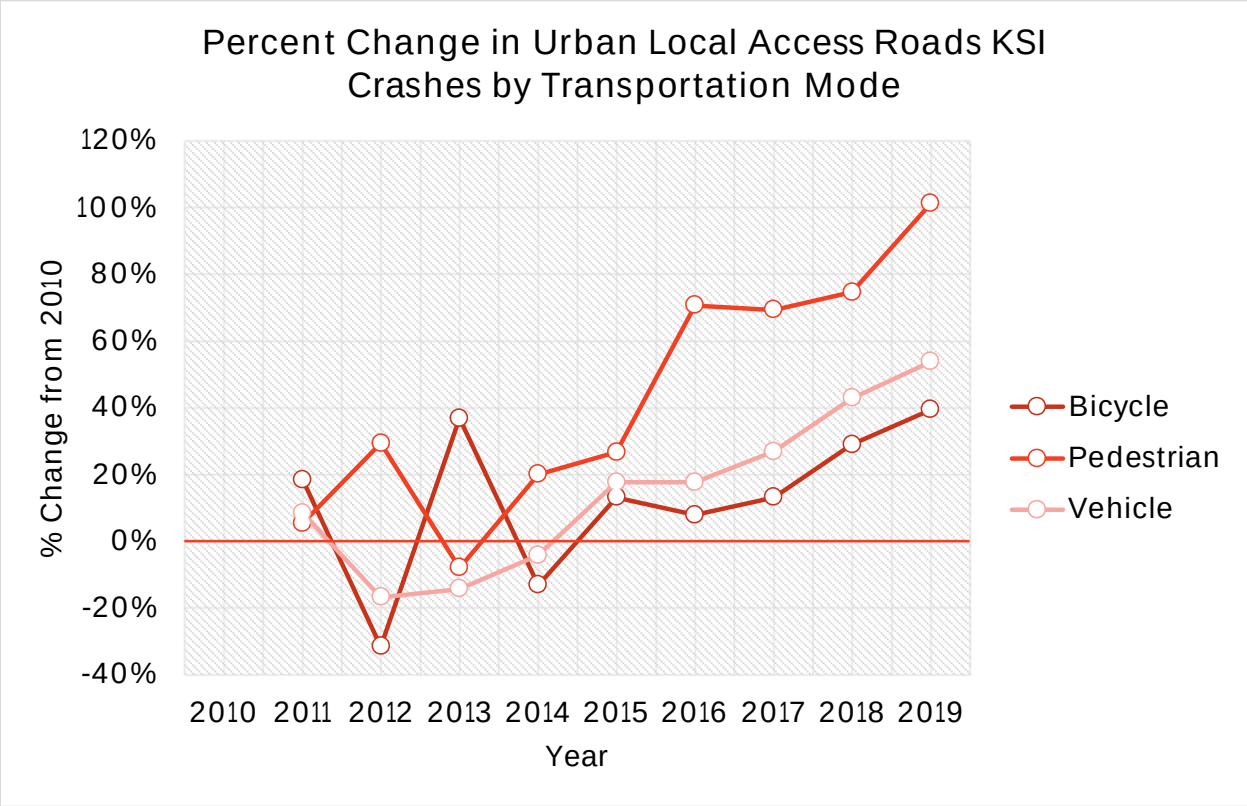


Figure 150: Percent Change in Local Access Roads KSI Crashes by Transportation Mode

Users and Equity

Urban areas in the Bay Area are more diverse which can be seen in KSI crash a data by race in which no group holds a majority. The group with the most crashes overall is White people with 35% of the total, with Hispanic being 2nd with 32%, Black people being 3rd with 16% followed by Asian with 10%, and Other (primarily Indigenous peoples) with 7%. However, by proportionality, Black and Other users of the road account for far higher shares of crashes. These disproportionally statistics point to systemic problems with the roadway network and the development pattern within neighborhoods with large amounts of POC.

Equity priority areas as defined by MTC were also examined for KSI crashes. These areas are of special focus as they are areas in which are affected disproportionally by safety issues affecting roadways and include the most vulnerable users. Urban areas exhibit slightly less discrepancy between EPC and Non-EPC crashes than other areas likely because Urban areas are safer in general. Still, when looking at crashes in equity priority communities vs crashes not in equity priority communities, 42% of all crashes occur in equity priority communities; however, when adjusted for population proportion, there

is a 1.21 times higher chance of a KSI crash happening in an equity priority community than outside an equity priority community.

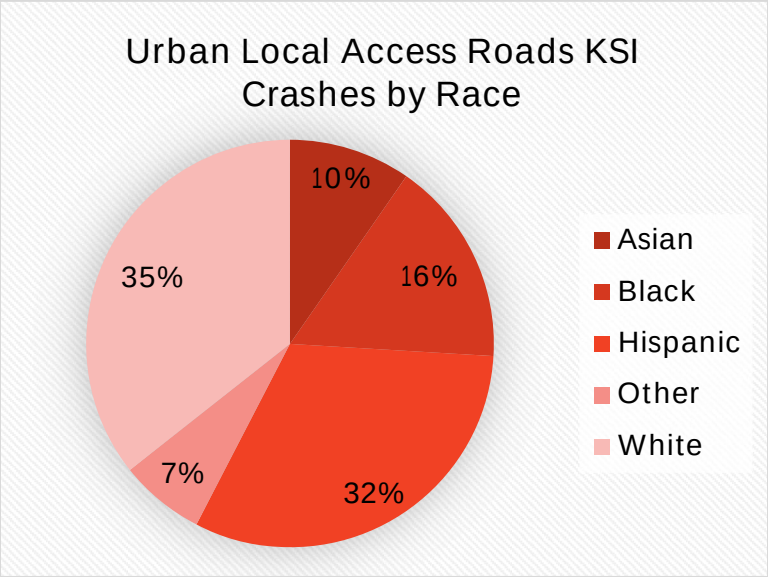


Figure 151 Urban Local Access Roads KSI Crashes by Race

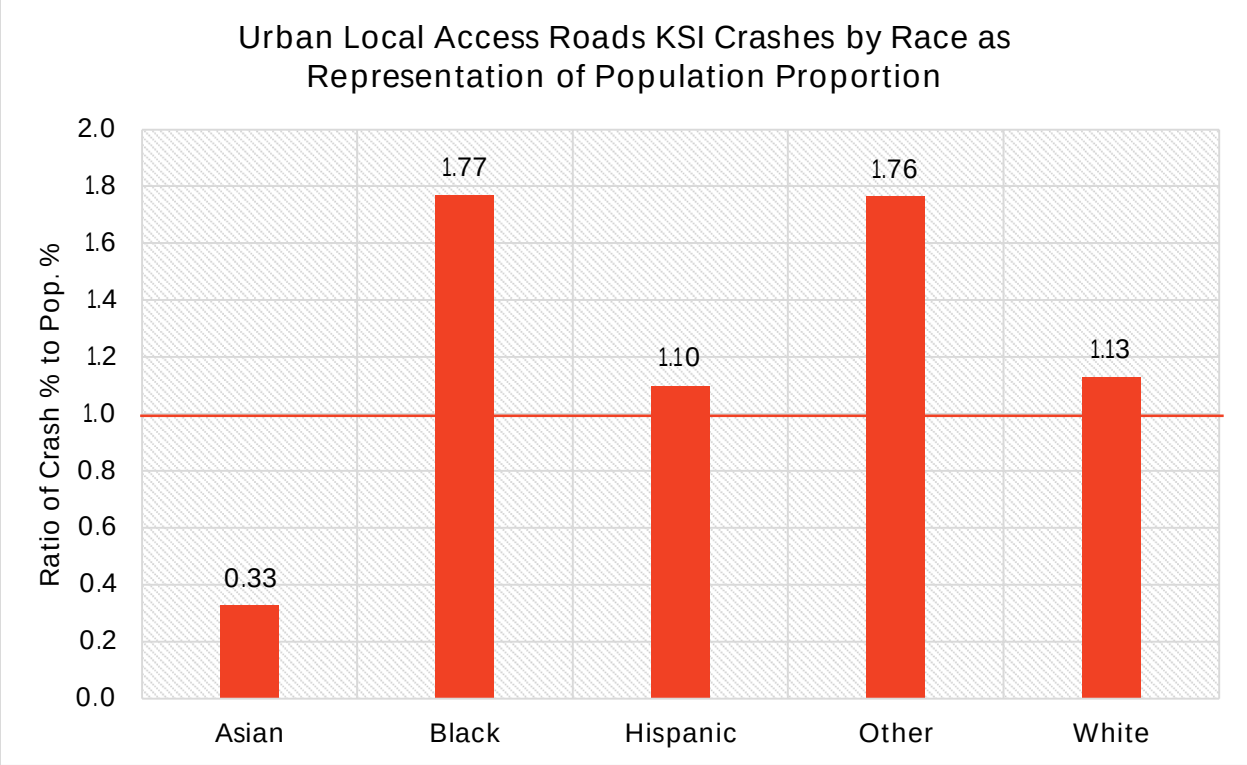


Figure 152 Urban Local Access Roads

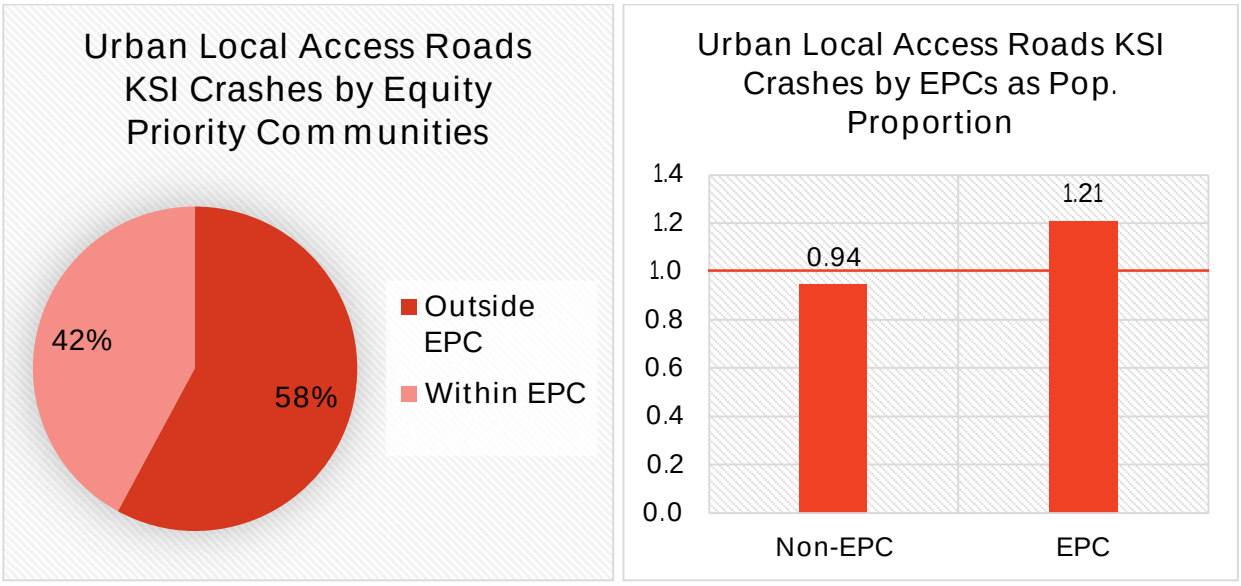


Figure 153: Urban KSI Crashes by Equity Priority Communities and Crashes by Equity Priority Communities as a Representation of Population (>1.0 = Over-Representation)

Age

Crashes in urban areas do not occur evenly across age groups.,. The groups that account for the largest number of crashes is still those in their 20s, with 20-24 accounting for 371 KSI crashes and 25-29 for 345. Normalizing for population, users in their 20s not only are involved in a high frequency of KSI crashes, but that these users are also highly over-represented. Users in the age group of 20-24 are 2.2 times more likely to be involved in a KSI crash than average.

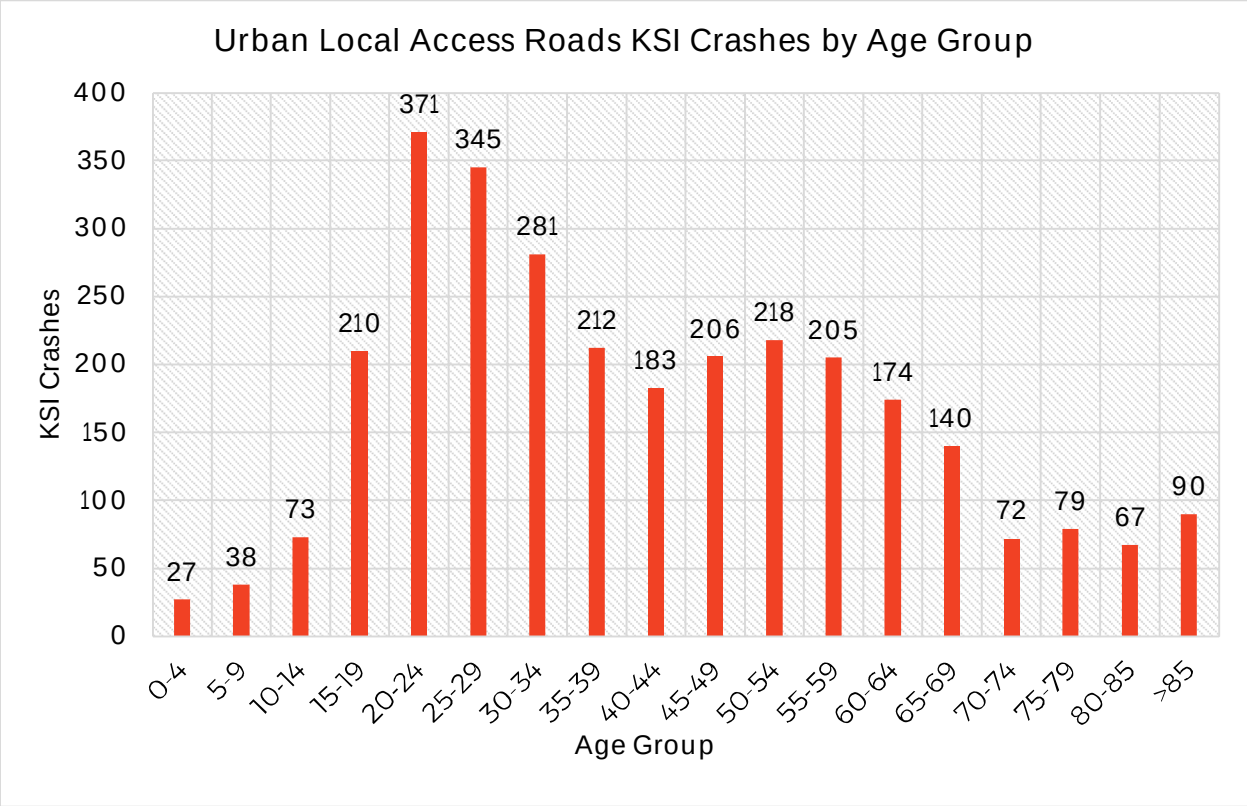


Figure 154: Urban Local Access Roads KSI Crashes by Age Group

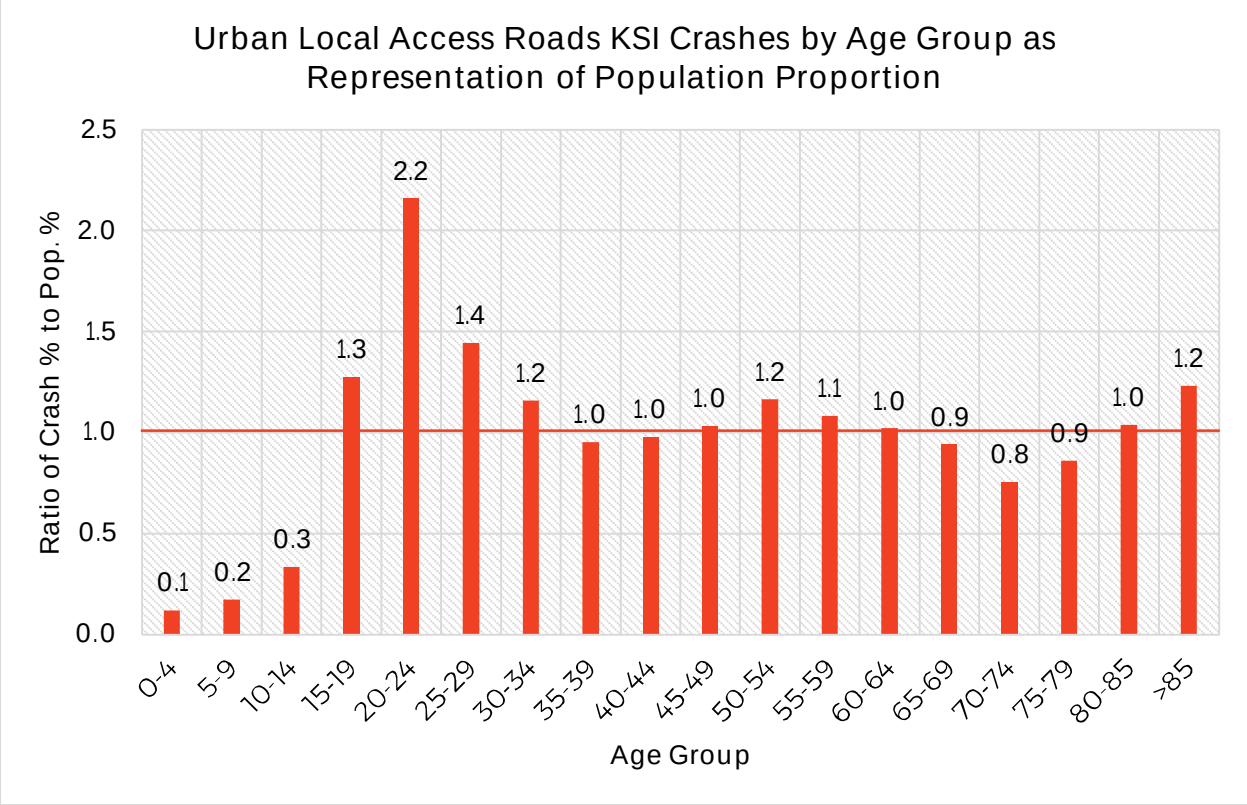


Figure 155 Rural Urban Local Access Roads KSI Crashes by Age Group as a Proportion of Population

Sex

Males currently account for 68% of crashes and are nearly 1.36 times as likely to be involved in a KSI crash compared to females on roads in urban areas. This data can be seen below.

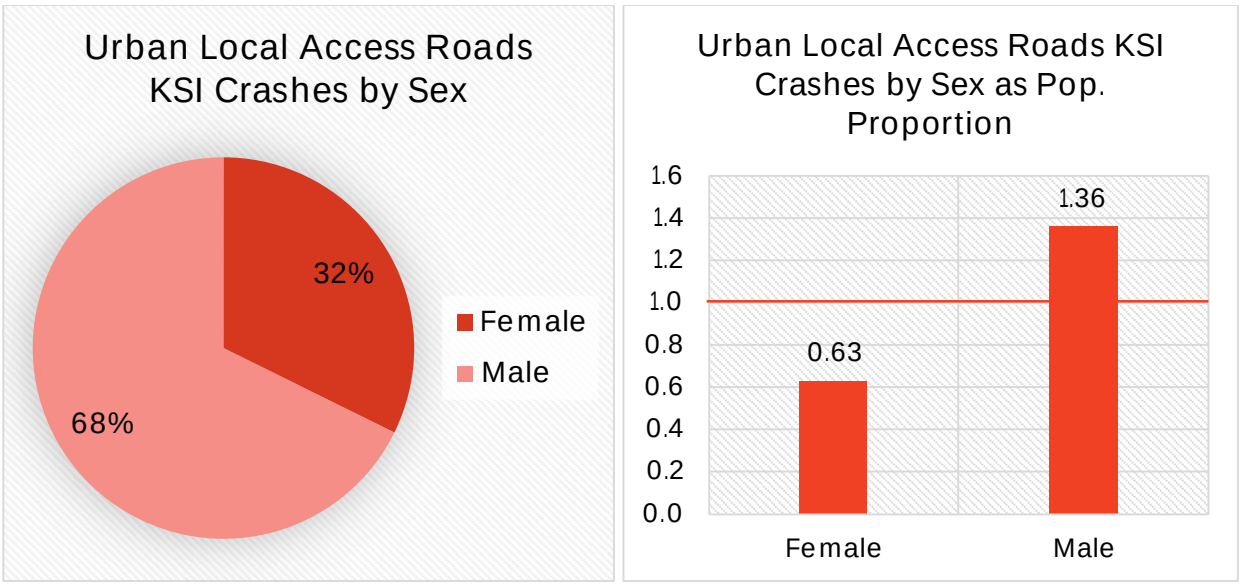


Figure 156: Urban Local Access Roads KSI Crashes by Sex and Crashes by Sex as a Representation of Population (>1.0 = Over-Representation)

Crash Locations and Types

The majority of KSI crashes in rural areas occur at non-intersection locations. Most of the non-intersection crashes involve crashes with pedestrians (333) hit object (114), and (92) cyclists. The large amount of ped and bike crashes points to an increase in interaction brought about by urban density and the need for better bike/ped infrastructure. On Urban Local roads crashes at intersection, pedestrians are by far and away the most common KSI crash type.

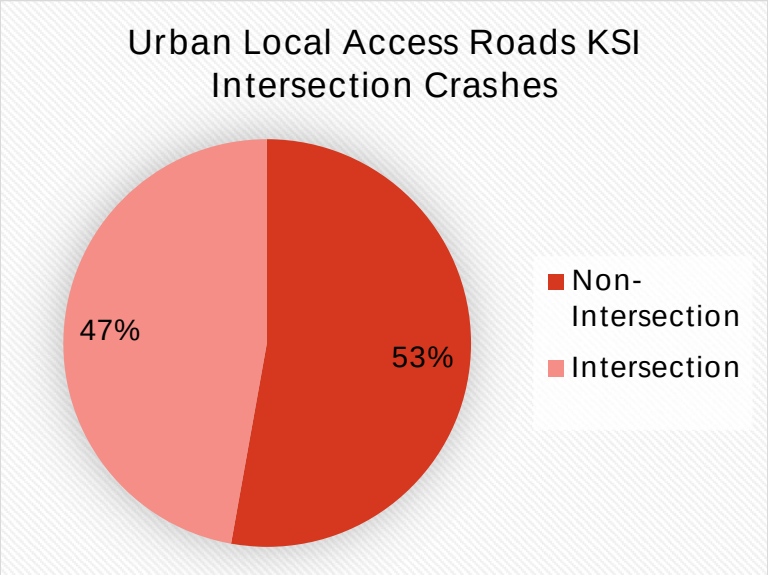


Figure 157: Urban Local Access Roads KSI Intersection vs Non-Intersection Crashes

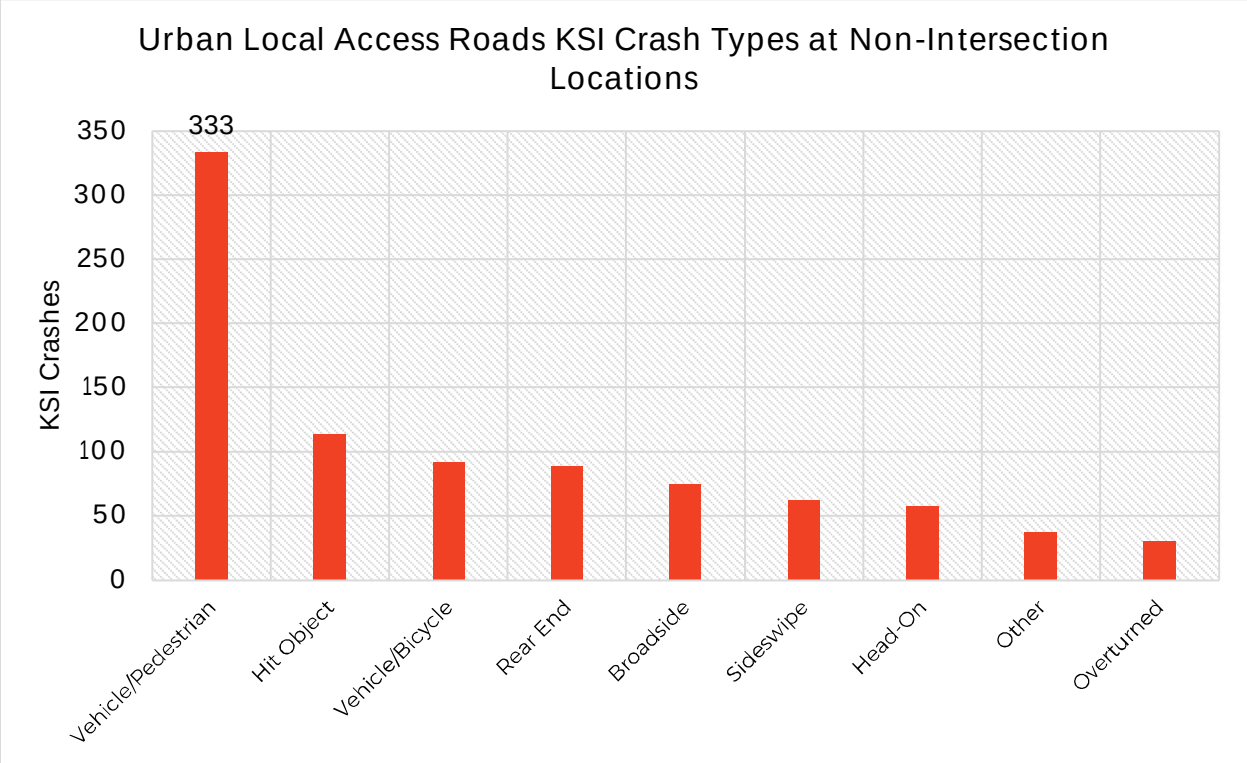


Figure 158: Urban Local Access Roads KSI Crash Types at Non-Intersection Locations

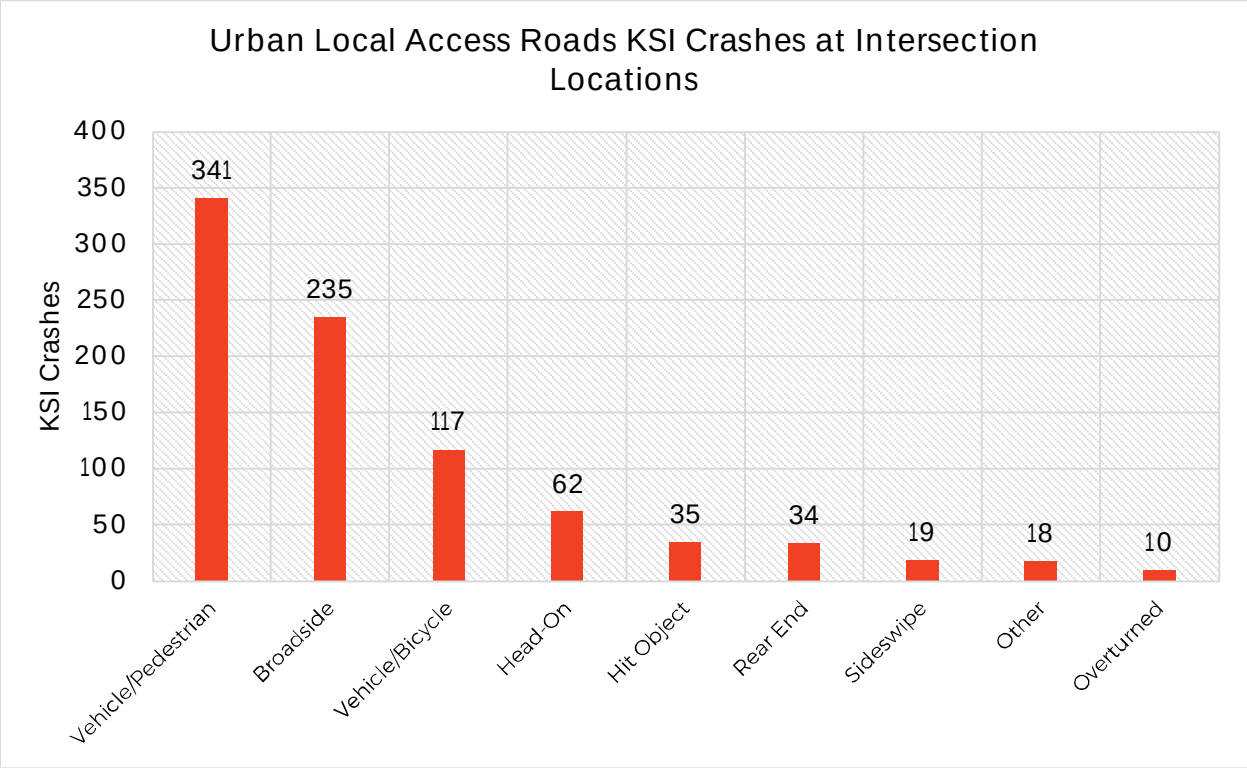


Figure 159: Urban Local Access Roads KSI Crash Types at Intersection Locations

Pedestrian and Bicycle Crash Locations and Types

Most pedestrian crashes happen at non-intersection locations (54%), but a substantial number also occur at intersections (46%). For cyclists, urban areas are likelier to have an intersection crash (51%). This follows the trend that as density increases more ped crashes occur at intersections. Most crossing crashes occurred while crossing a crosswalk; even at designated areas pedestrians are not always safe. More effective traffic calming measures are needed. At non-crossing locations most crashes occurred in the road on the shoulder.

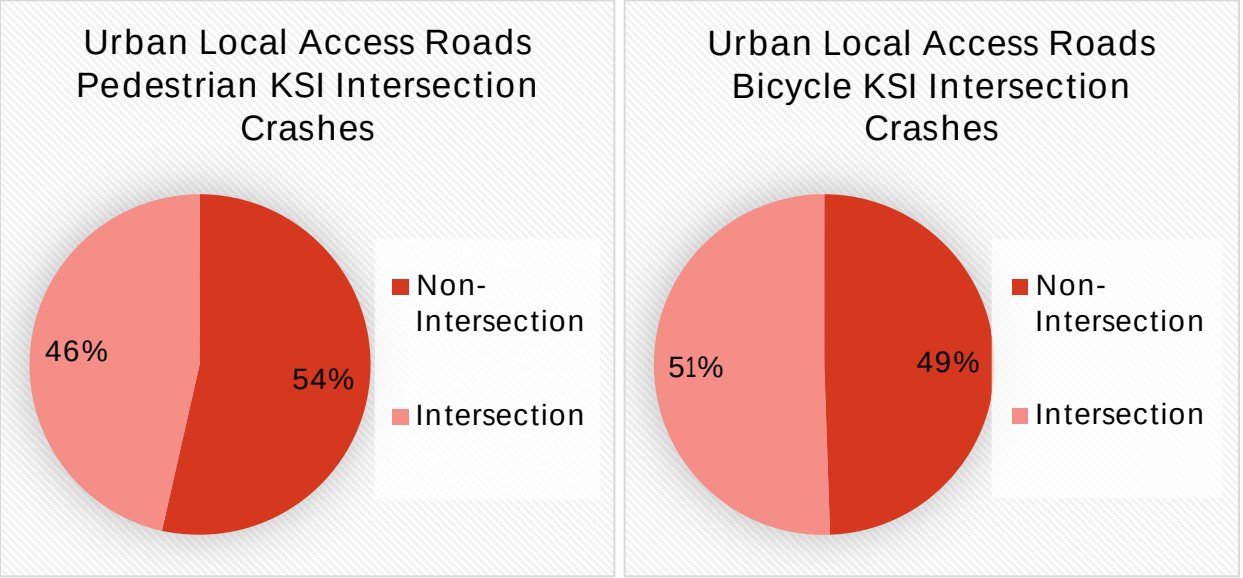


Figure 160: Urban roads Pedestrian and Bicycle KSI Intersection Crashes

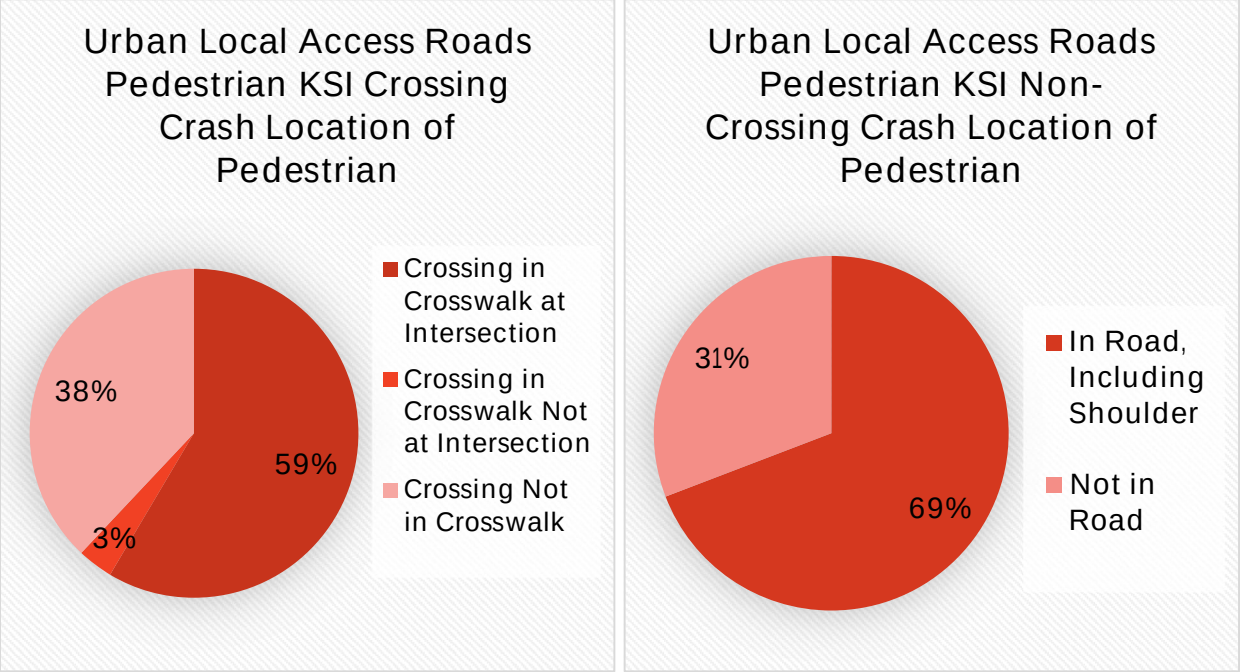


Figure 161: Urban Local Access Pedestrian KSI Crash Location of Pedestrian for Crossing Crashes and Non-Crossing Crashes

Contributing Circumstances

Contributing circumstances are the immediate identifiable cause of a crash as noted by the reporting law enforcement officer. These contributing circumstances can include things like driver behavior, weather, and pavement conditions. The contributing circumstances also note the part at fault in a crash as determined by the reporting law enforcement officer. The data in this section show that while many contributing circumstances exist, many crashes have no reported contributing

circumstances. The majority of KSI crashes do not involve adverse weather, dark lighting conditions, lack of seat belt usage, or negligent user behavior.

Occupant Protection

91% of KSI crashes were found to have been wearing seatbelts and in 67% percent of KSI the airbags deployed. Motorcyclist behavior was also examined and found that 92% of all motorcycle KSI crashes were wearing their helmets. This data clearly shows that utilizing all proper occupant protection equipment in a vehicle will not stop fatal and serious injury crashes from occurring in rural areas. While there may be a reduction in KSI crashes overall by use of occupant protection, but these ease symptoms do not cause.

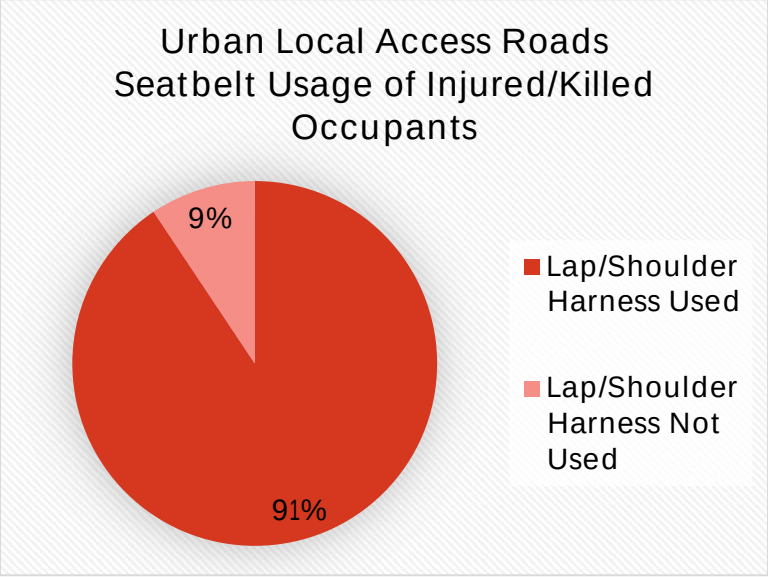


Figure 162: Urban Local Access Roads KSI Crash Seatbelt Usage

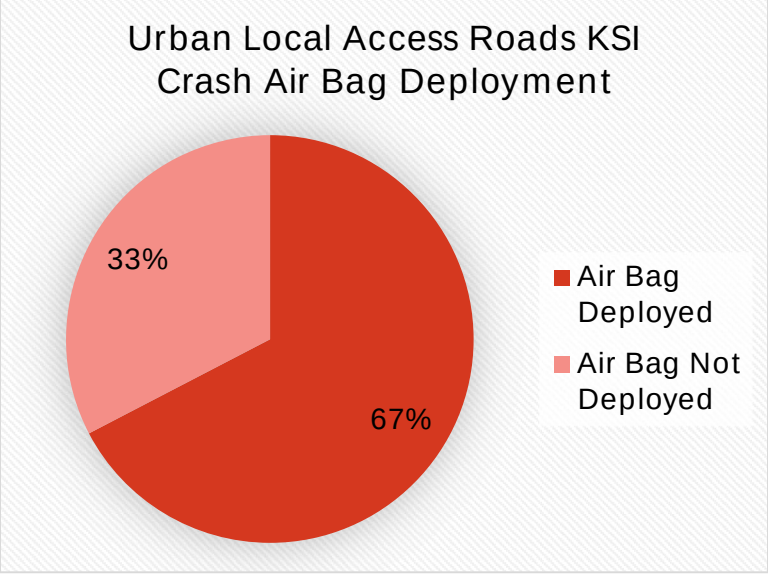


Figure 163: Urban Local Access Roads KSI Crash Air Bag Deployment

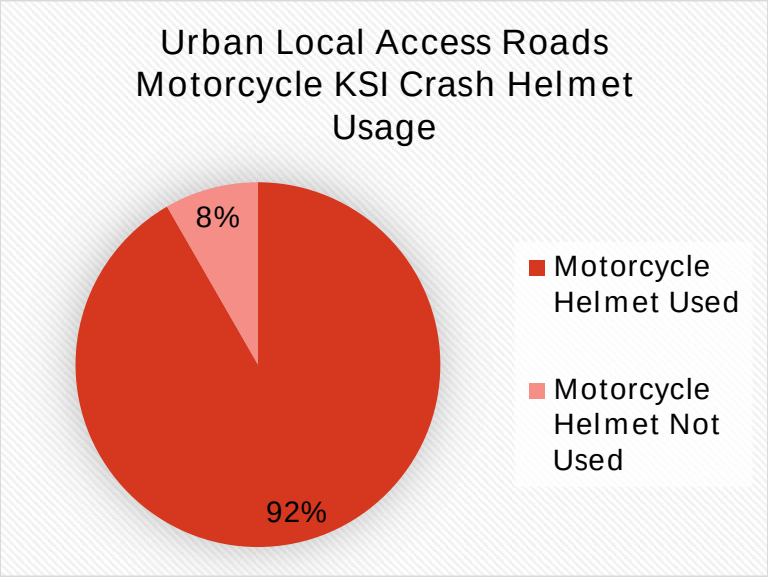


Figure 164: Urban Local Access Roads KSI Motorcycle Crash Helmet Usage

Time and Day

Crash trends throughout the week tend to correspond to traffic pattern trends with higher numbers of crashes happening in the morning and afternoon peak periods of traffic likely due to urban commuters. This trend holds true for both all users and for pedestrians and bicyclists. No major increase in crashes is seen in the weekend nights, suggesting impairment is not a major factor on weekend nights for any users.

Urban Local Access Roads KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	1.06%	0.28%	0.25%	0.50%	0.64%	0.32%	0.64%
1:00 AM	1.20%	0.21%	0.21%	0.25%	0.35%	0.18%	1.03%
2:00 AM	0.74%	0.28%	0.25%	0.18%	0.04%	0.46%	0.71%
3:00 AM	0.39%	0.21%	0.07%	0.18%	0.25%	0.28%	0.39%
4:00 AM	0.50%	0.18%	0.25%	0.46%	0.07%	0.39%	0.25%
5:00 AM	0.14%	0.25%	0.42%	0.18%	0.21%	0.14%	0.32%
6:00 AM	0.21%	0.42%	0.39%	0.46%	0.53%	0.39%	0.42%
7:00 AM	0.18%	0.64%	0.50%	0.53%	0.78%	0.50%	0.18%
8:00 AM	0.28%	0.81%	0.60%	0.99%	0.60%	0.92%	0.35%
9:00 AM	0.28%	0.28%	0.35%	0.35%	0.39%	0.50%	0.39%
10:00 AM	0.21%	0.71%	0.42%	0.60%	0.39%	0.32%	0.28%
11:00 AM	0.32%	0.60%	0.42%	0.21%	0.39%	0.71%	0.74%
Noon	0.46%	0.50%	0.46%	0.57%	0.39%	0.71%	0.50%
1:00 PM	0.78%	0.64%	0.42%	0.53%	0.60%	0.67%	0.42%
2:00 PM	0.85%	0.53%	0.64%	0.60%	0.50%	0.57%	0.60%
3:00 PM	0.67%	0.96%	0.57%	0.78%	0.39%	1.20%	0.64%
4:00 PM	0.46%	0.64%	0.92%	0.88%	0.78%	1.03%	0.99%
5:00 PM	1.10%	0.81%	1.10%	0.92%	1.03%	1.10%	0.99%
6:00 PM	0.67%	0.88%	1.63%	1.10%	1.13%	1.24%	0.99%
7:00 PM	0.64%	0.81%	1.06%	0.57%	0.85%	0.81%	0.85%
8:00 PM	0.71%	0.60%	0.92%	0.78%	0.92%	1.03%	0.88%
9:00 PM	0.88%	0.67%	0.88%	1.03%	1.06%	1.24%	0.71%
10:00 PM	0.46%	0.67%	0.74%	0.57%	0.53%	0.88%	0.78%
11:00 PM	0.60%	0.60%	0.32%	0.60%	0.67%	0.99%	1.10%

Figure 165: Urban roads KSI Crashes per Hour

Urban Local Access Roads Pedestrian KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.85%	0.21%	0.21%	0.64%	0.32%	0.32%	0.43%
1:00 AM	0.64%	0.32%	0.11%	0.11%	0.53%	0.11%	1.17%
2:00 AM	0.53%	0.32%	0.32%	0.11%		0.21%	0.85%
3:00 AM	0.21%		0.11%		0.11%	0.11%	0.43%
4:00 AM	0.32%	0.21%	0.43%	0.64%		0.53%	
5:00 AM	0.11%	0.32%	0.32%	0.21%	0.21%		0.21%
6:00 AM	0.21%	0.43%	0.64%	0.64%	0.43%	0.43%	0.53%
7:00 AM	0.21%	0.85%	0.85%	0.53%	1.06%	0.74%	0.32%
8:00 AM	0.32%	0.96%	0.64%	0.74%	0.74%	1.06%	0.32%
9:00 AM	0.53%	0.53%	0.43%	0.43%	0.32%	0.64%	0.21%
10:00 AM		0.85%	0.21%	0.43%	0.43%	0.43%	0.11%
11:00 AM	0.21%	0.64%	0.43%	0.11%	0.11%	0.96%	0.43%
Noon	0.64%	0.43%	0.43%	0.43%	0.64%	0.21%	0.11%
1:00 PM	0.43%	0.53%	0.32%	0.85%	0.43%	1.17%	0.53%
2:00 PM	0.74%	0.32%	0.53%	0.64%	0.53%	0.21%	0.32%
3:00 PM	0.43%	0.85%	0.74%	0.32%	0.43%	0.96%	0.53%
4:00 PM	0.53%	0.53%	0.53%	0.53%	0.74%	0.64%	0.74%
5:00 PM	1.28%	1.28%	1.70%	0.64%	0.74%	0.53%	0.85%
6:00 PM	0.53%	1.06%	2.44%	1.49%	1.70%	1.28%	0.96%
7:00 PM	0.32%	0.85%	1.38%	0.64%	1.06%	1.28%	1.17%
8:00 PM	0.96%	0.53%	0.85%	0.74%	1.06%	1.17%	1.38%
9:00 PM	0.96%	0.85%	1.38%	1.38%	1.17%	1.28%	0.74%
10:00 PM	0.21%	0.64%	0.85%	0.53%	0.85%	1.06%	0.85%
11:00 PM	0.64%	0.21%	0.43%	0.43%	1.06%	0.74%	0.85%

Figure 166: Urban roads Pedestrian KSI Crashes per Hour

Urban Local Access Roads Bicycle KSI Crashes per Hour

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.30%	0.30%	0.00%	0.30%	0.00%	0.30%	0.30%
1:00 AM	0.61%	0.00%	0.00%	0.00%	0.00%	0.00%	0.30%
2:00 AM	0.00%	0.30%	0.00%	0.00%	0.00%	0.00%	0.30%
3:00 AM	0.00%	0.00%	0.00%	0.00%	0.30%	0.30%	0.00%
4:00 AM	0.00%	0.00%	0.00%	0.30%	0.00%	0.61%	0.00%
5:00 AM	0.30%	0.00%	0.61%	0.00%	0.30%	0.30%	0.00%
6:00 AM	0.00%	0.30%	0.00%	0.30%	1.52%	0.30%	0.30%
7:00 AM	0.00%	1.22%	0.61%	0.91%	1.82%	1.22%	0.00%
8:00 AM	0.00%	0.91%	1.52%	2.13%	0.61%	2.13%	0.61%
9:00 AM	0.00%	0.30%	0.00%	0.61%	0.30%	0.61%	0.91%
10:00 AM	1.52%	1.22%	0.30%	1.82%	0.30%	0.00%	0.30%
11:00 AM	0.00%	0.91%	0.30%	0.91%	0.30%	0.61%	1.82%
Noon	0.61%	1.22%	0.30%	0.61%	0.30%	0.30%	1.22%
1:00 PM	1.82%	0.91%	0.61%	0.00%	0.30%	0.00%	0.91%
2:00 PM	0.91%	0.91%	1.22%	0.61%	0.61%	0.30%	0.91%
3:00 PM	0.00%	0.00%	0.00%	0.91%	0.91%	1.82%	0.91%
4:00 PM	0.91%	0.61%	1.52%	1.22%	0.91%	0.91%	1.82%
5:00 PM	0.91%	1.22%	1.52%	1.52%	0.61%	1.82%	0.61%
6:00 PM	0.61%	0.91%	1.22%	1.22%	0.61%	0.61%	0.91%
7:00 PM	0.30%	0.61%	1.22%	0.61%	0.91%	1.52%	0.61%
8:00 PM	0.00%	1.22%	0.30%	0.61%	0.61%	0.91%	0.91%
9:00 PM	0.30%	0.00%	0.30%	1.22%	0.30%	1.52%	0.30%
10:00 PM	0.30%	0.91%	1.22%	0.61%	0.30%	1.22%	1.22%
11:00 PM	0.30%	0.00%	0.30%	0.61%	0.00%	0.91%	0.91%

Figure 167: Urban Local Access Roads Bicycle KSI Crashes per Hour

Weather, Road, and Lighting Conditions

95% of urban KSI crashes occurred with clear or cloudy weather and only 3% with rain or some other adverse weather condition active. Similarly, 90% of KSI crashes occurred on dry pavement and 96% of KSI crashes occurred on well-maintained pavement. Lighting factors are also shown. The majority of KSI crashes happened in daylight hours, or at night with streetlights on. Only 1% of crashes occurred at night without streetlights which in urban areas would seem rare. Overall, most KSI crashes in urban areas have little to do with road condition.

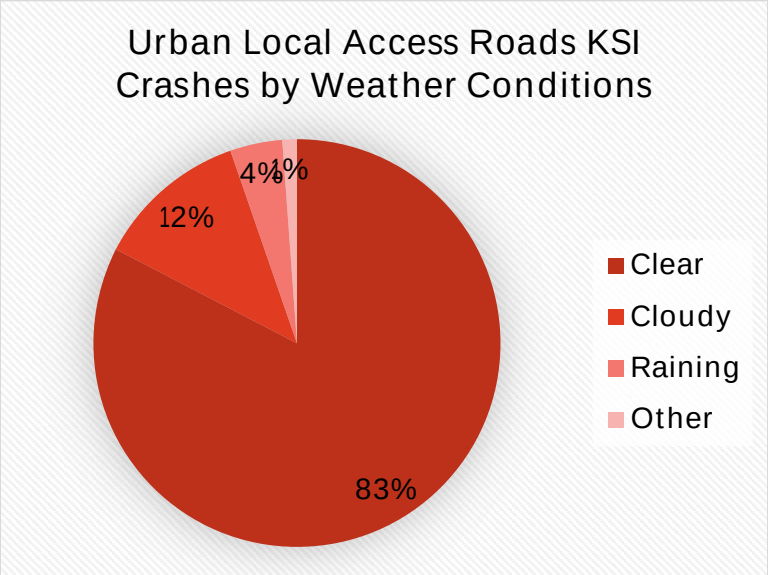


Figure 168: Urban Local Access Roads KSI Crashes by Weather Conditions

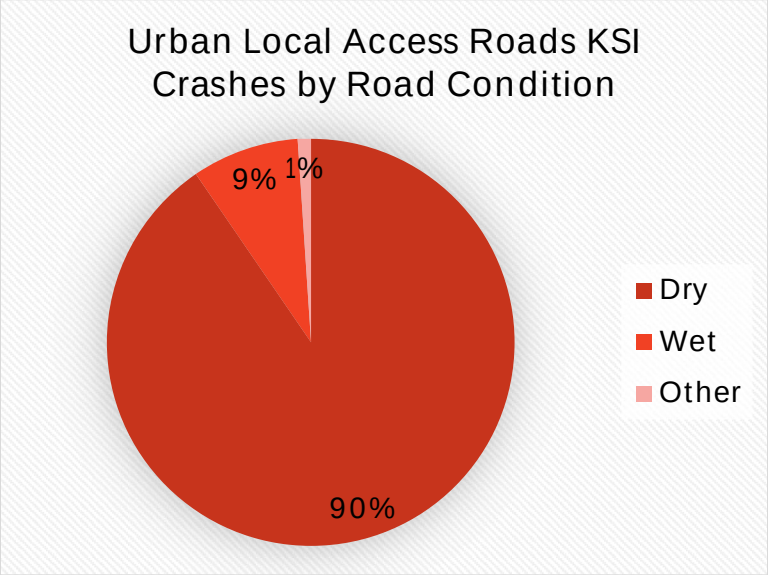


Figure 169: Urban Local Access Roads KSI Crashes by Road Condition

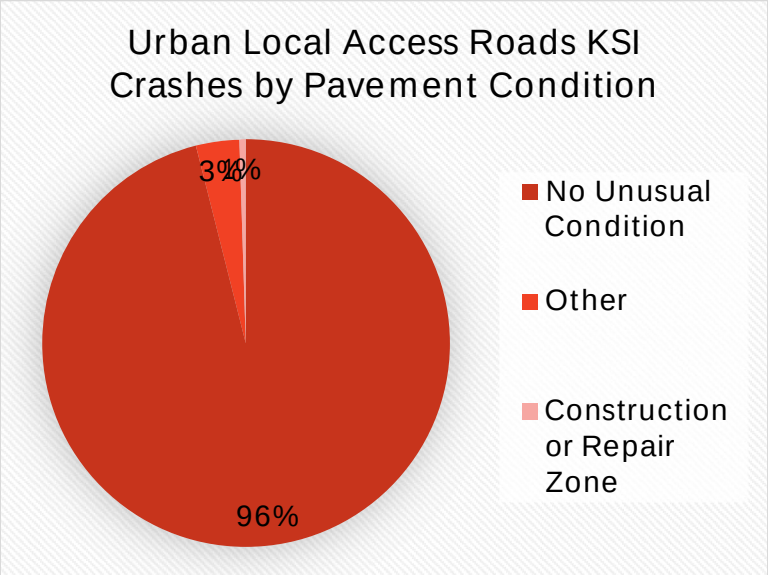


Figure 170 Urban Local Access Roads KSI Crashes by Pavement Condition

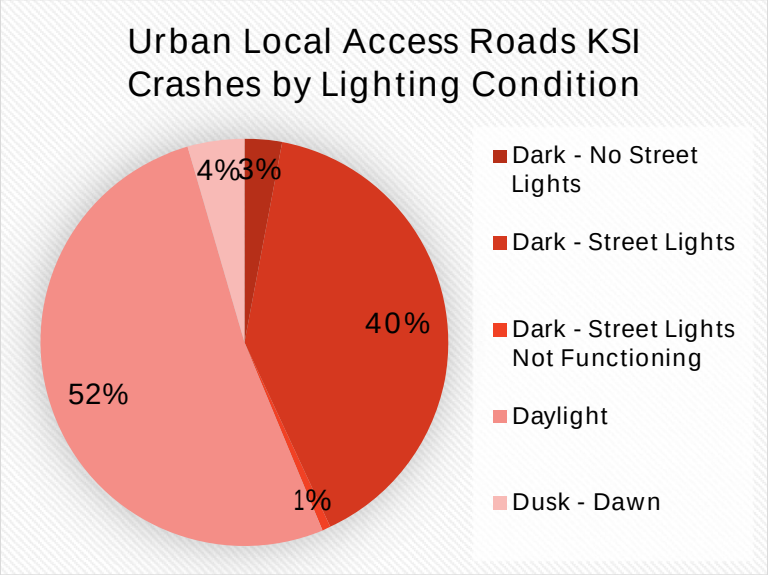


Figure 171: Urban Local Access Roads KSI Crashes by Lighting Condition

Inattention and Impairment

Inattentive or "distracted" driving is often cited as an important contributing circumstance for crashes in common literature. However, the data shows that only 1% of drivers and 1% of bicyclists and pedestrians involved in KSI crashes in the Bay Area on urban roads were inattentive. More users are impaired, but even still only 17% of drivers and 8% of cyclists and pedestrians were impaired with either alcohol or drugs. Campaigns to curb driving under the influence have been successes to the point that expansion of a focus results in diminishing returns. This does not mean there should not be any attempt to educate or enforcement but that focus on discrete action should be seen as ancillary to a more systemic vision zero approach. The majority of KSI crashes in the bay area involve non-impaired and attentive drivers. In both cases of

inattention and intoxication, drivers are more likely to be inattentive or intoxicated than pedestrians or cyclists. In fact, in urban areas, it is very likely that the lower rate of KSI impairment crashes is due to less reliance on driving.

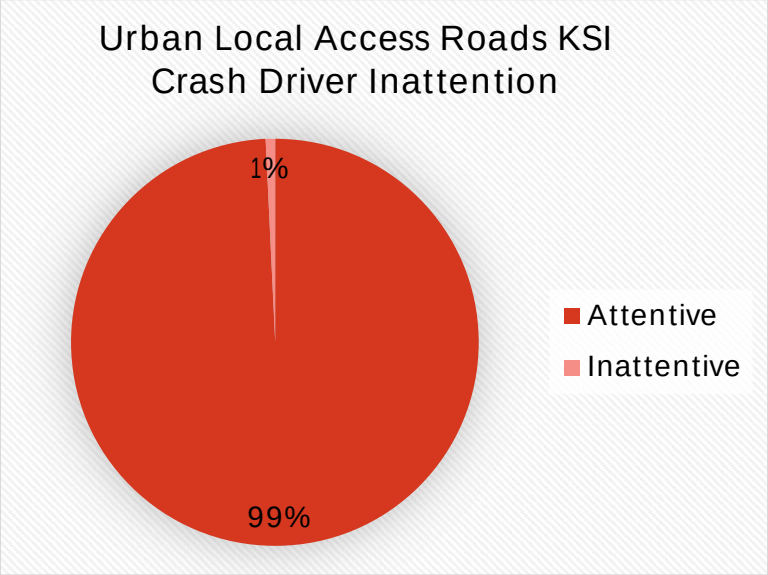


Figure 172: Urban Local Access Roads KSI Crash Driver Inattention

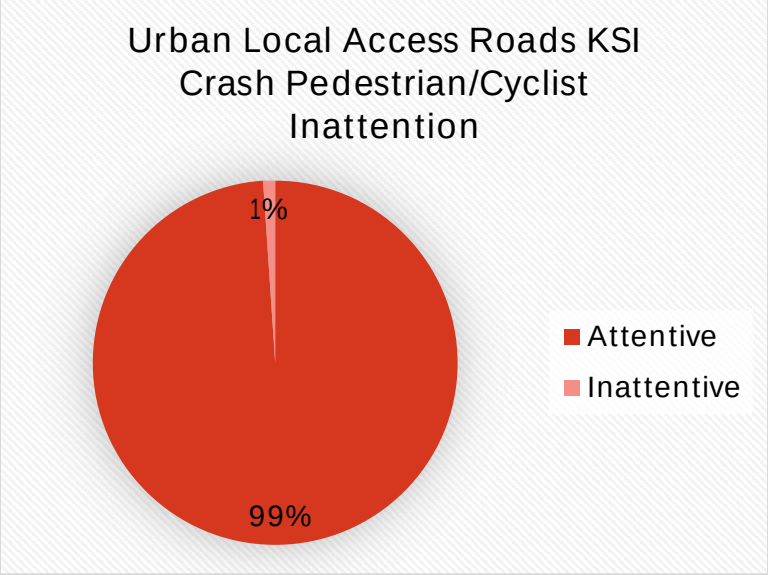


Figure 173: Urban Local Access Roads KSI Crash Pedestrian/Cyclist Inattention

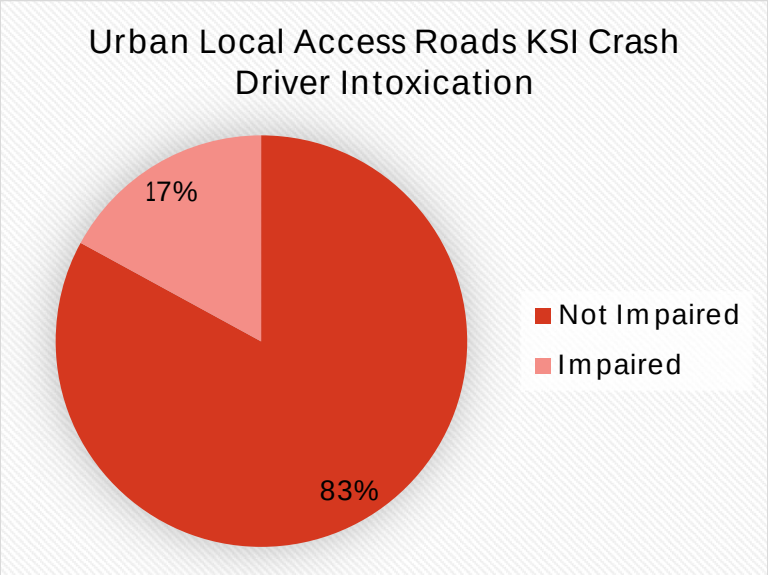


Figure 174: Urban Local Access Roads KSI Crash Driver Intoxication

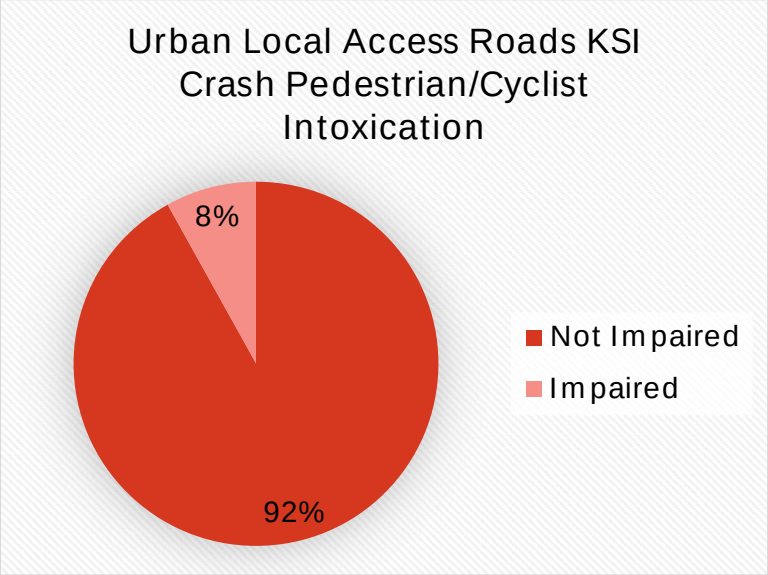


Figure 175: Urban Local Access Roads KSI Crash Pedestrian/Cyclist Intoxication

Urban Core Areas KSI Crash Summary

Trends

Urban core areas include urban business, regional core, and central business district. KSI crashes on these roads in the Bay Area are the only type to not see and increase over the decade period 2010 – 2019. Fatal crashes did not change though serious injury crashes have increased 59%.

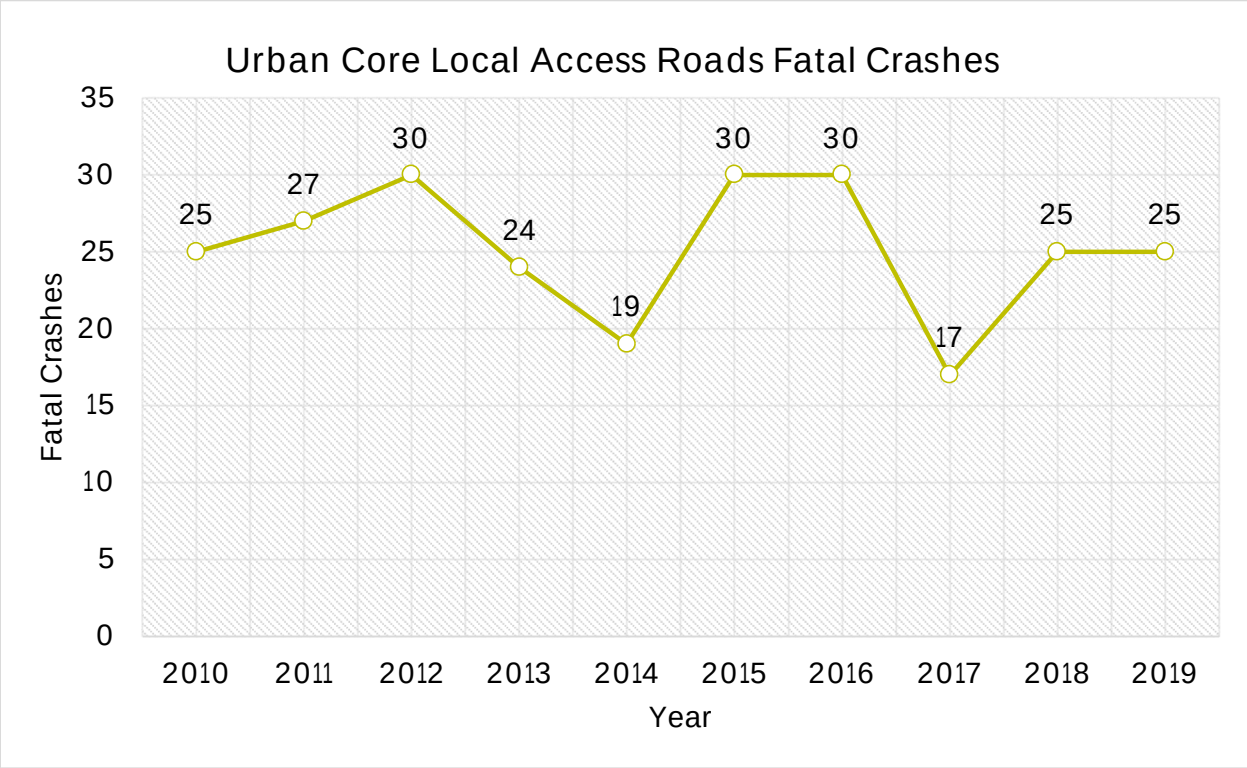


Figure 176: Urban Core Local Access Roads Fatal Crashes

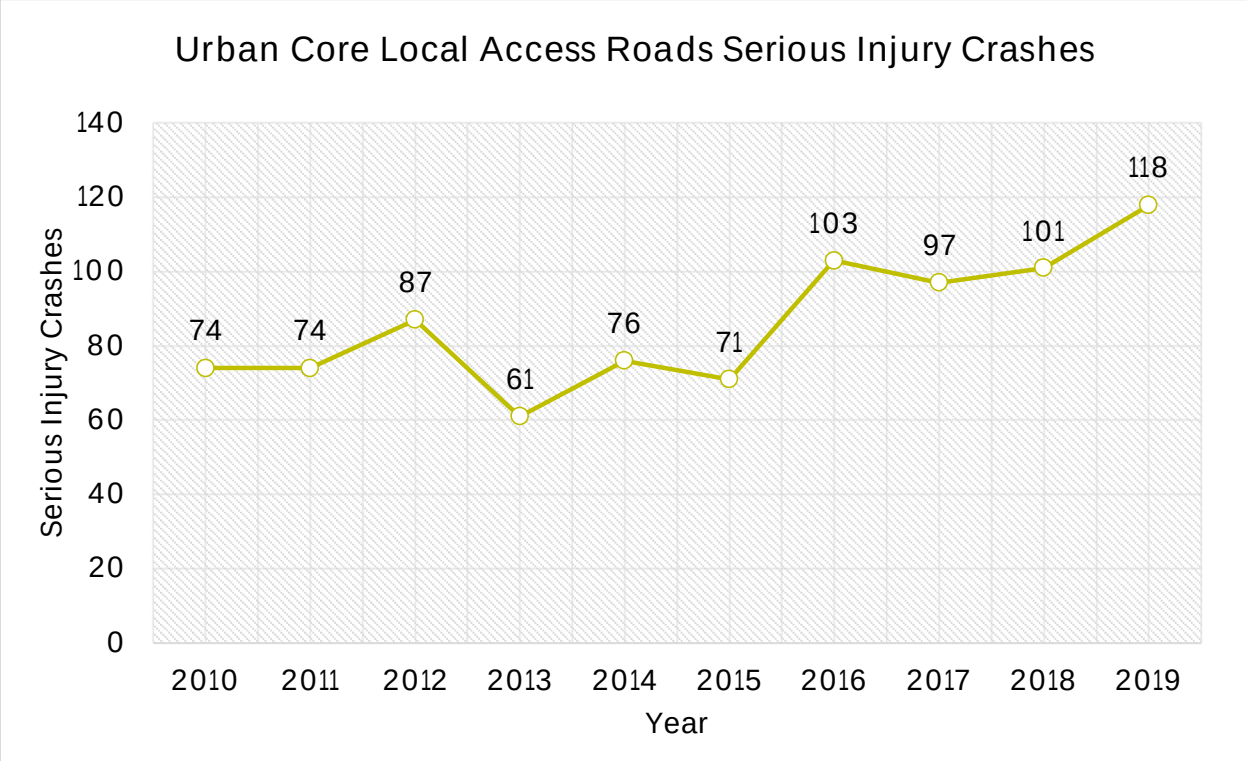


Figure 177: Urban Core Local Access Roads Serious Injury Crashes

Transportation Modes

Dense urban areas often some of the most accessible to other forms of transportation. The Urban core crashes transportation mode is walking with 44%, followed by car with 36% then cycling with 20%. Overall local roads in dense urban areas are the most diverse in terms of mode share.

KSI crashes on dense urban roads in the Bay Area have been increasing dramatically. Since 2010, vehicle KSI crashes have increased 76% between 2010 and 2019. Pedestrian KSI crashes have increased 48% and bicycle crashes have increased 18% over the years between 2010 and 2019.

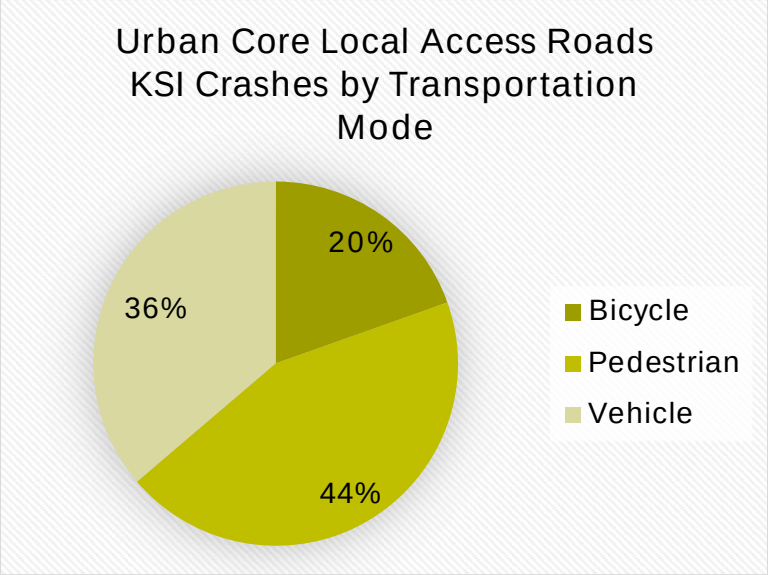


Figure 178: Urban Core Local Access Roads Road KSI Crashes by Transportation Mode

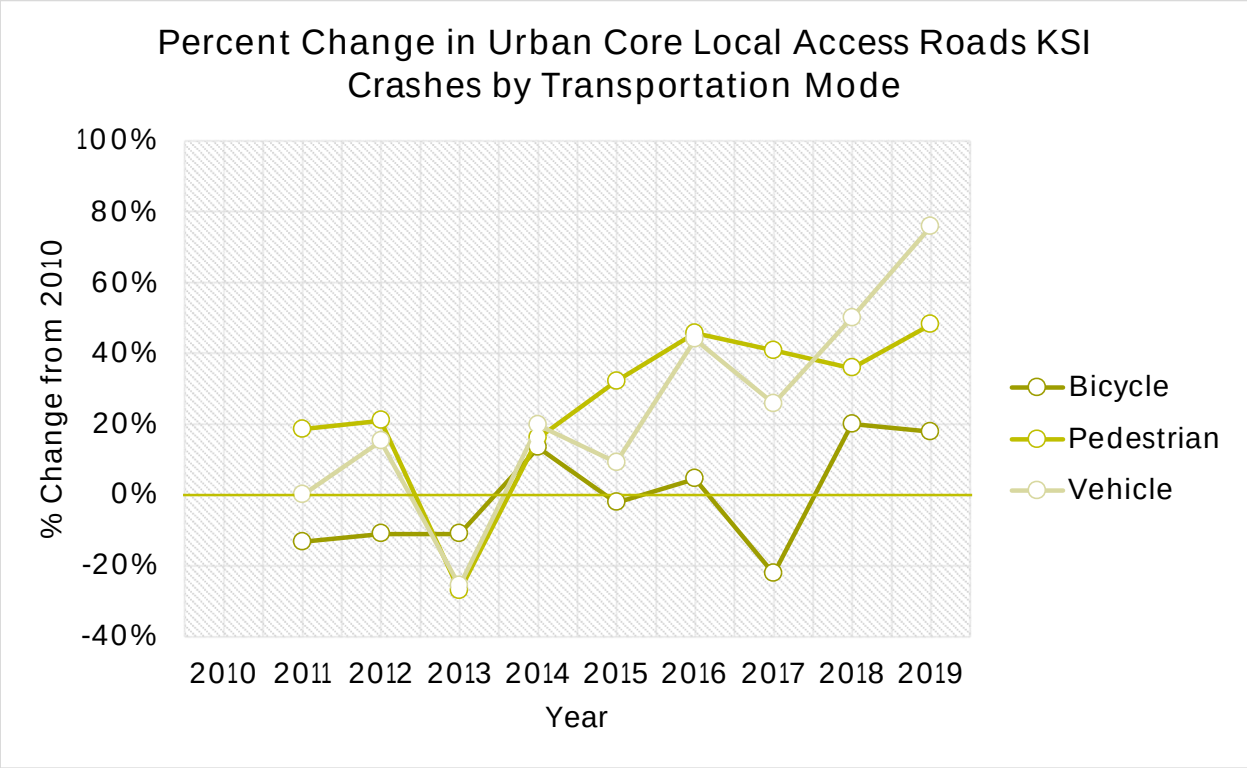


Figure 179: Urban Core Local Access Roads Percent Change in Local access roads KSI Crashes by Transportation Mode

Users and Equity

Dense urban areas are some of the most vibrant and diverse places in the bay. However, it is still subject to much of the same systemic racial problems which plague the country. The data below shows KSI crashes by race, which shows that roughly half of all KSI crashes involve white individuals and only 20% involve black or indigenous peoples. Despite this, black and indigenous people are significantly more likely to be involved in a KSI crash with both being overrepresented by a factor of 1.8.

Equity priority areas as defined by MTC were also examined for KSI crashes. These areas are of special focus as they are areas in which are affected disproportionally by safety issues affecting roadways and include the most vulnerable users. When looking at crashes in equity priority communities vs crashes not in equity priority communities, 42% of all crashes occur in equity priority communities; however, when adjusted for population proportion, there is a 2 times higher chance of a KSI crash happening in an equity priority community than outside an equity priority community. As such, it is

important that any steps taken towards safety improvements keep equity as a key consideration even in rural areas.

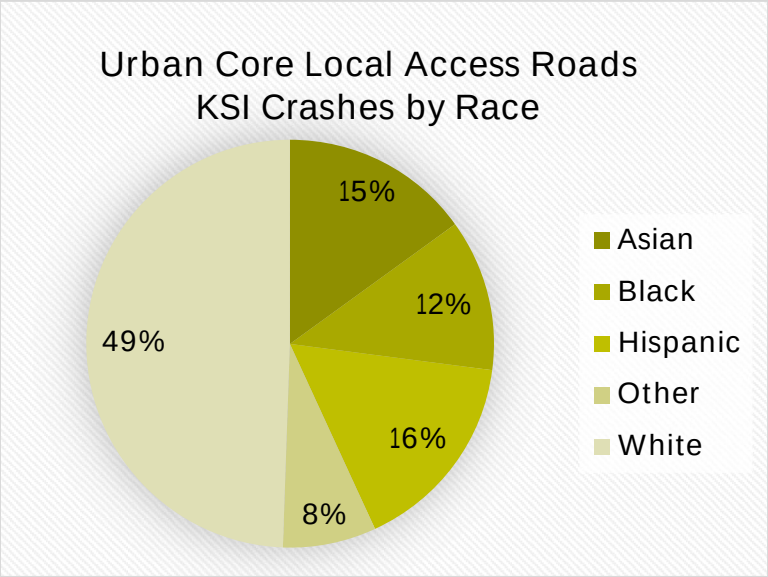


Figure 180: Urban Core Local Access Roads KSI Crashes by Race

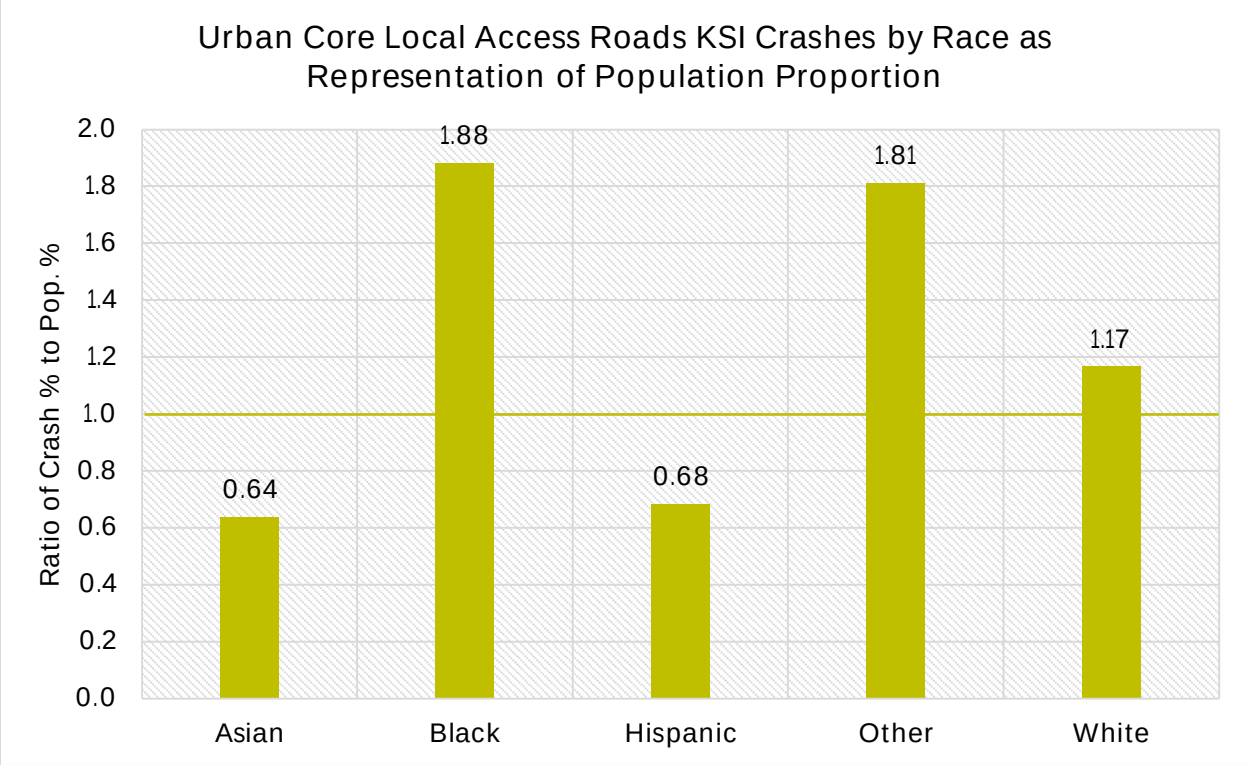
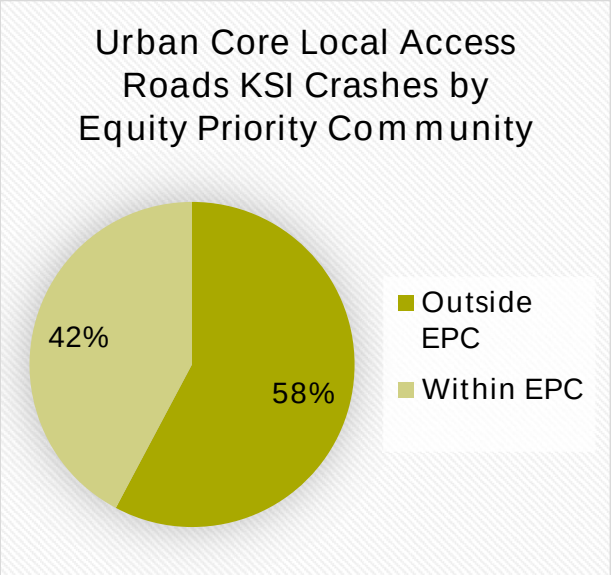


Figure 181: Urban Core Local Access Roads KSI Crashes by Race as Representation of Population Proportion



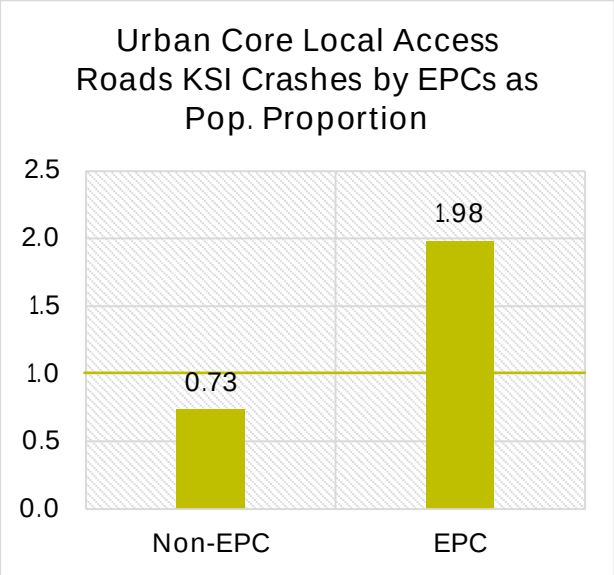


Figure 182: Urban Core Local Roads KSI Crashes by Equity Priority Community and Crashes by Equity Priority Communities as a Representation of Population (>1.0 = Over-Representation)

Age

Crashes in rural areas do not occur evenly across age groups, as young people move away from these areas, this is reflected by having a relatively older group for KSI crash data, with 25-29 leading in crashes and 30-34 being 2nd with 25-29 accounting for 286 KSI crashes and 30-34 with 283 crashes. Normalizing for population, users in their 20s not only are involved in a high frequency of KSI crashes, but these users are also highly over-represented. Users in the age group of 25-29 are 1.9 times more likely to be involved in a KSI crash than the average driver. However, users 85+ are not far behind as the 2nd most over-represented group and the highest of any group over 30 as seen in Figure 183.

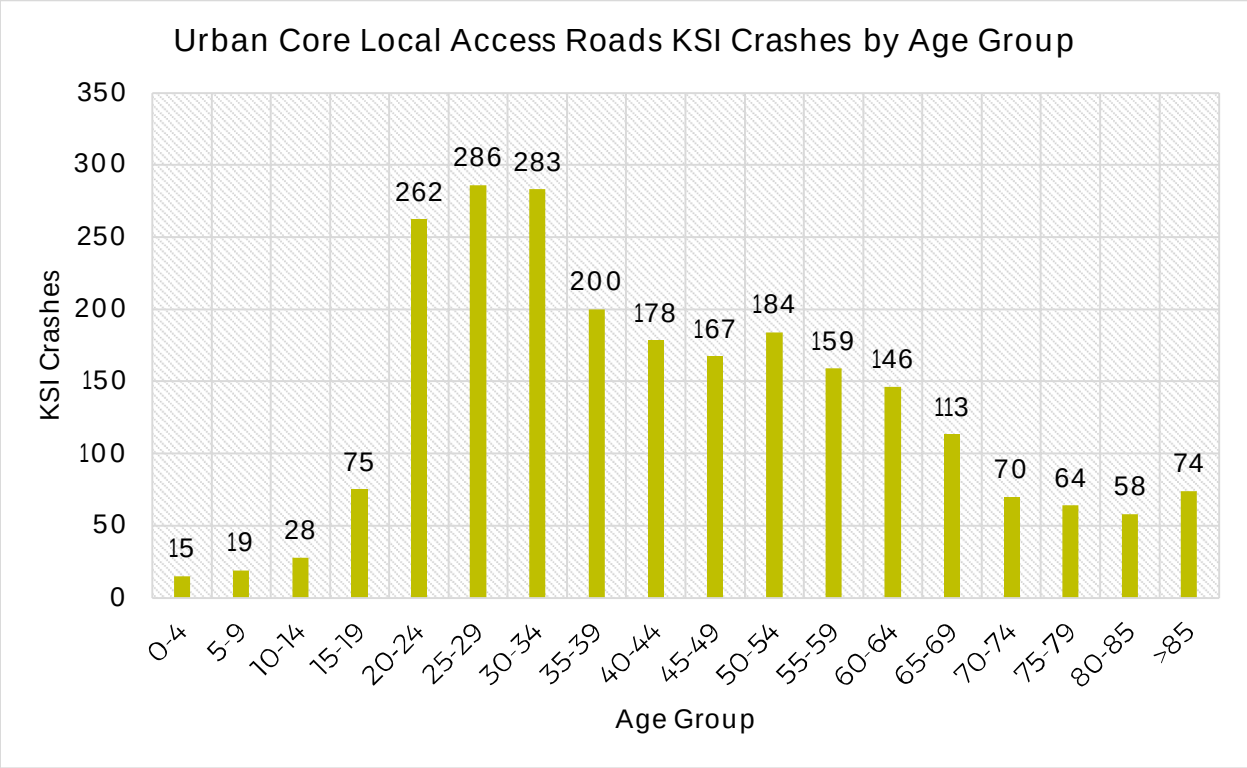


Figure 183: Urban Core Local Access Roads KSI Crashes by Age Group

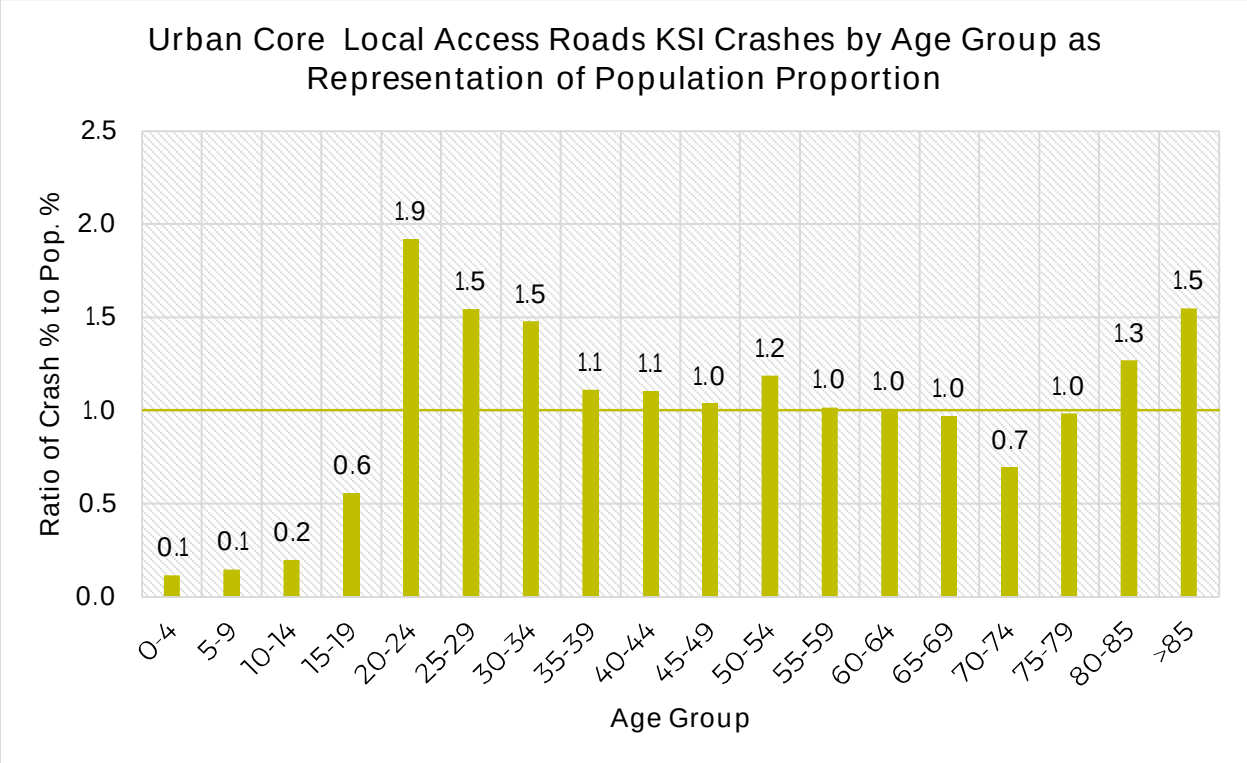


Figure 184: Urban Core Local Access Roads KSI Crashes by Age Group as a Proportion of Population

Sex

Males currently account for 67% of crashes and are nearly 1.36 times as likely to be involved in a KSI crash compared to females on roads in rural areas. This data can be seen in Figure 185.

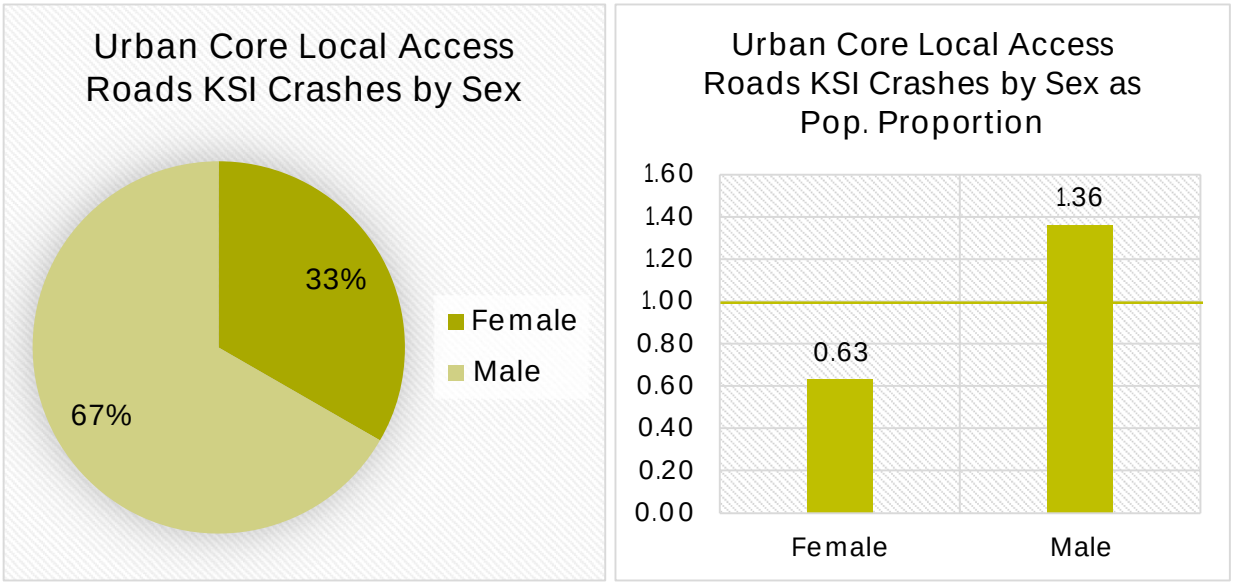


Figure 185: Urban Core Local access roads KSI Crashes by Sex and Crashes by Sex as a Representation of Population (>1.0 = Over-Representation)

Crash Locations and Types

The majority of KSI crashes in rural areas occur at non-intersection locations. Most of the non-intersection crashes involve crashes with pedestrians (276) and cyclists (77). Most of the crashes at intersections also involve pedestrians (270), rear ends (70) and cyclists (45). The high number of ped/bike crashes is to be expected for dense urban roads. However, a vision zero approach must be encouraged for all users of the road and there needs to be a focus on creating separated and safe facilities for cyclists and pedestrians via protected lanes.

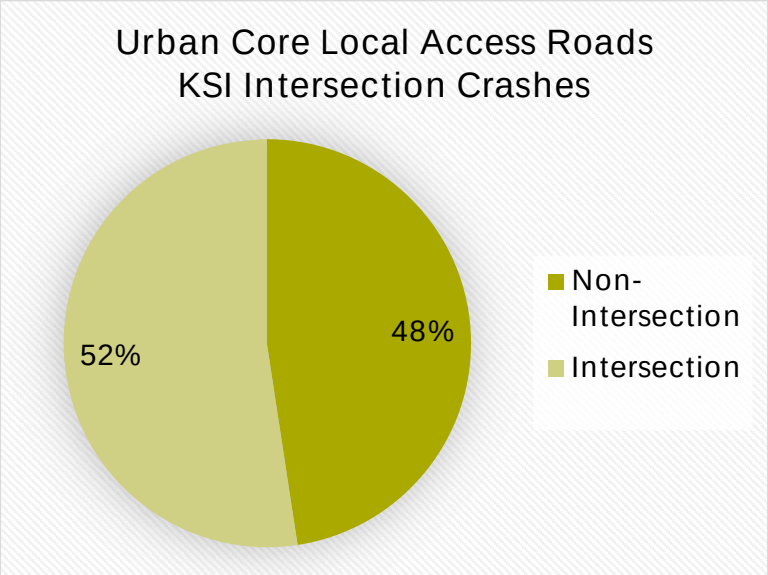


Figure 186: Urban Core Local Access Roads KSI Intersection vs Non-Intersection Crashes

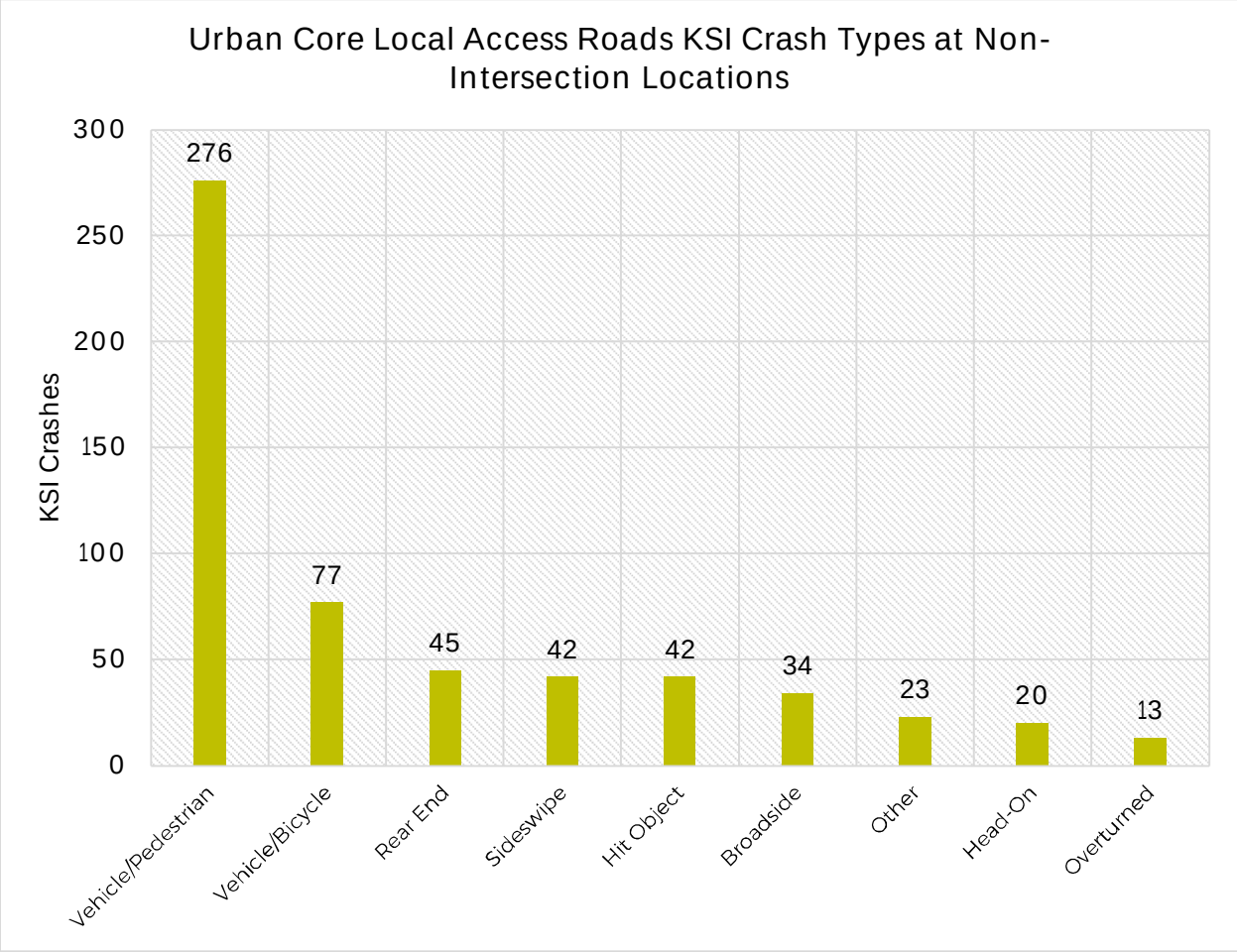


Figure 187: Urban Core Local Access Roads KSI Crash Types at Non-Intersection Locations

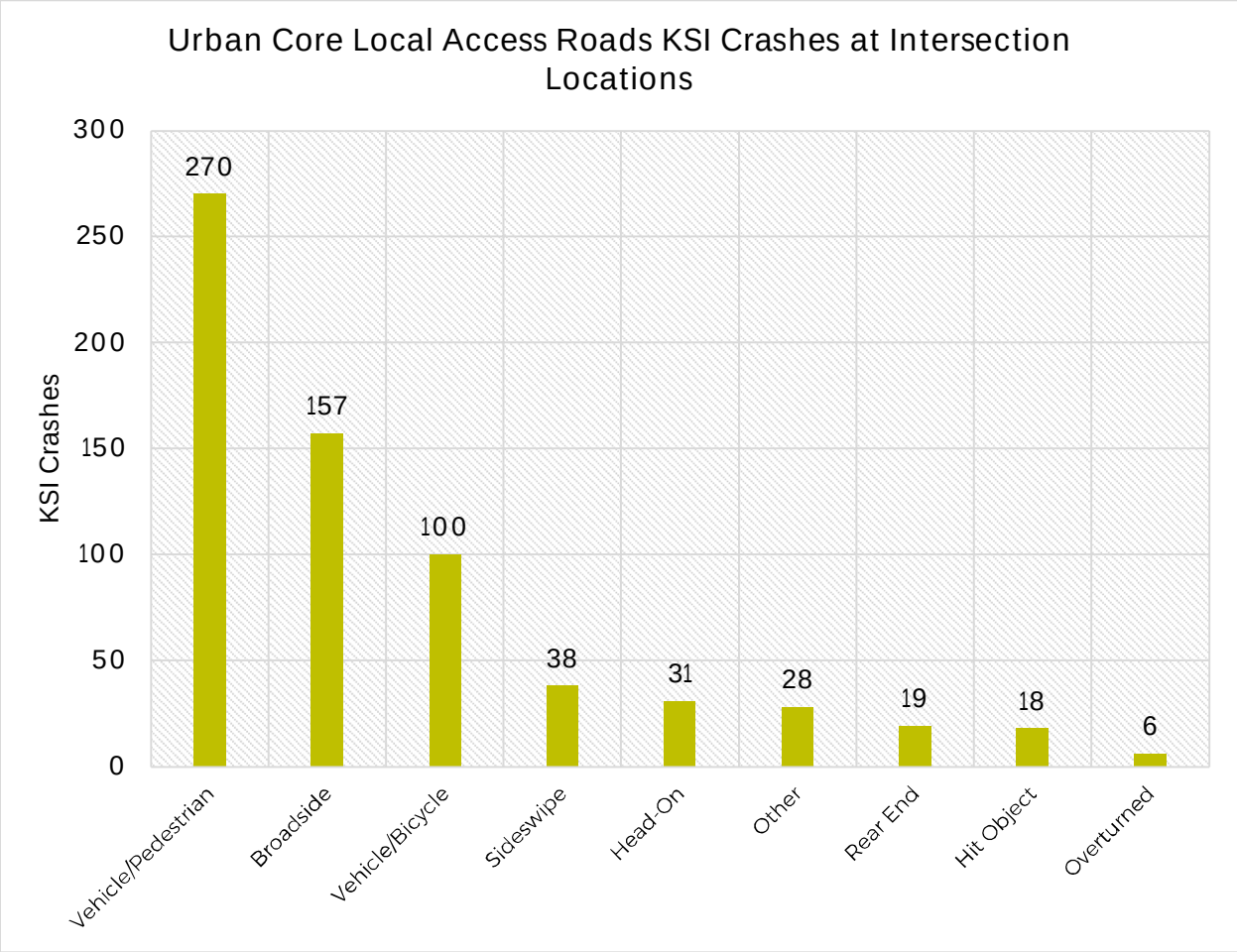


Figure 188: Urban Core Local Access Roads KSI Crash Types at Intersection Locations

Pedestrian and Bicycle Crash Locations and Types

Most pedestrian crashes happen at non-intersection locations (53%), but a substantial number also occurs at intersections (47%). For bicycle crashes most occurred at intersections (54%). Most pedestrian KSI crashes occurred crossing in crosswalks (65%) with (66%) of the non-crosswalk KSI crashes occurring in the shoulder.

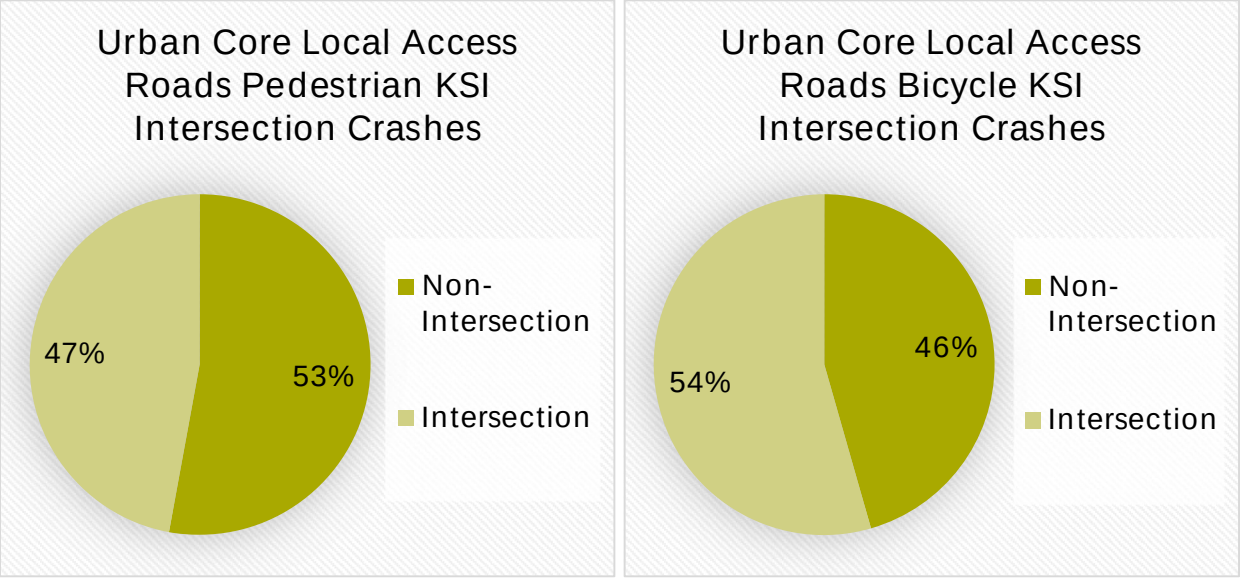


Figure 189: Urban Core Local Access Roads Pedestrian and Bicycle KSI Intersection Crashes

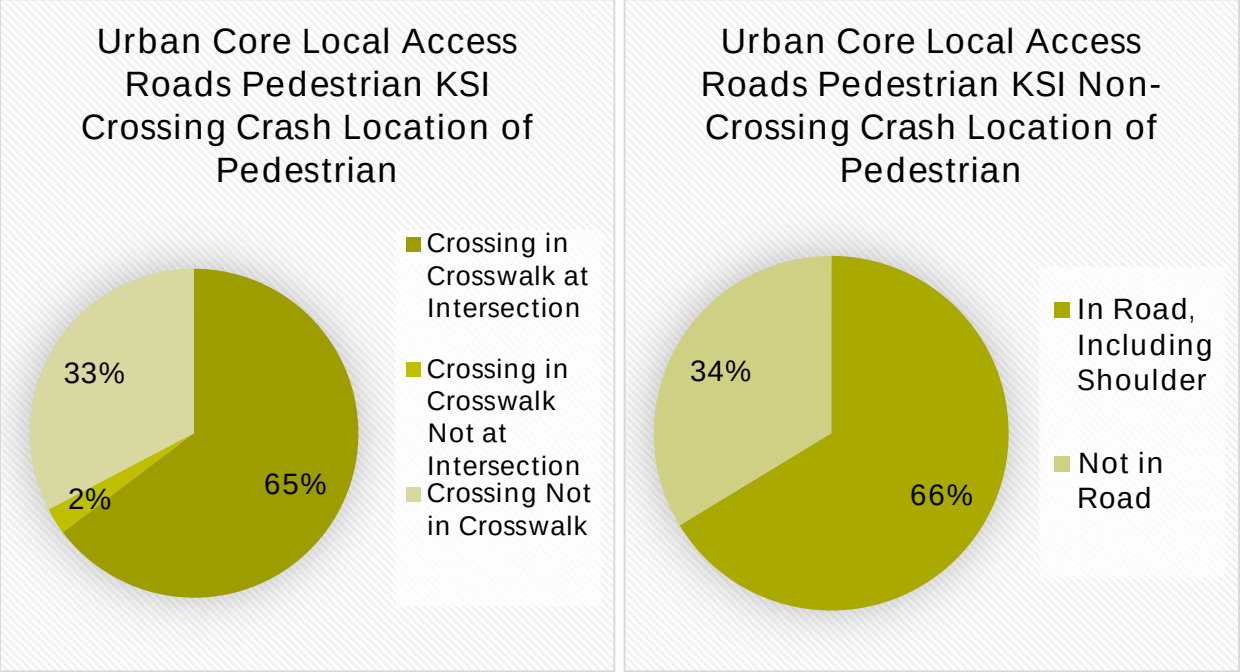


Figure 190: Urban Core Pedestrian KSI Crash Location of Pedestrian for Crossing Crashes and Non-Crossing Crashes

Contributing Circumstances

Contributing circumstances are the immediate identifiable cause of a crash as noted by the reporting law enforcement officer. These contributing circumstances can include things like driver behavior, weather, and pavement conditions. The contributing circumstances also note the part at fault in a crash as determined by the reporting law enforcement officer. The data in this section show that while many contributing circumstances exist, many crashes have no reported contributing

circumstances. The majority of KSI crashes do not involve adverse weather, dark lighting conditions, lack of seat belt usage, or negligent user behavior. Alcohol intoxication is one of the few behaviors that contributes to a substantial number of KSI crashes

Occupant Protection

92% of KSI crashes were found to have been wearing seatbelts and in 61% percent of KSI the airbags deployed. Motorcyclist behavior was also examined and found that 95% of all motorcycle KSI crashes were wearing their helmets. This data clearly shows that utilizing all proper occupant protection equipment in a vehicle will not stop fatal and serious injury crashes from occurring. While there may be a reduction in KSI crashes overall by use of occupant protection but these ease symptoms not causes.

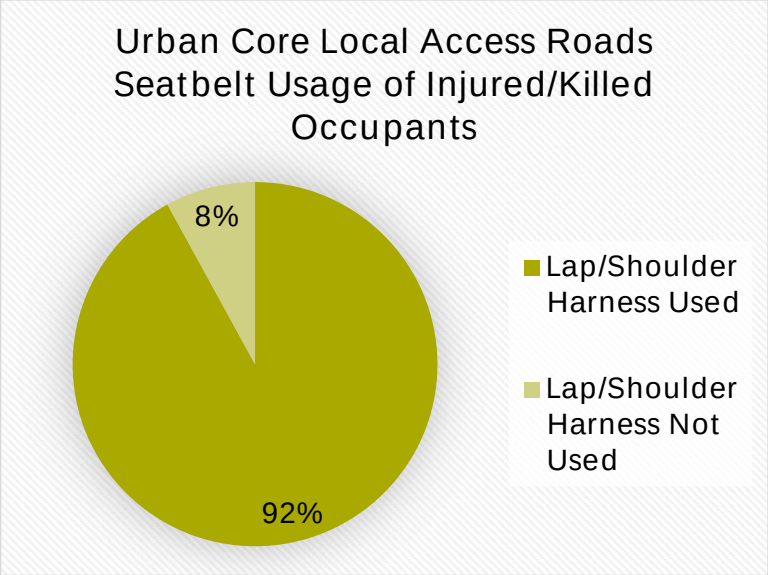


Figure 191: Urban Core Local Access Roads Seatbelt Usage of Injured/Killed Occupants

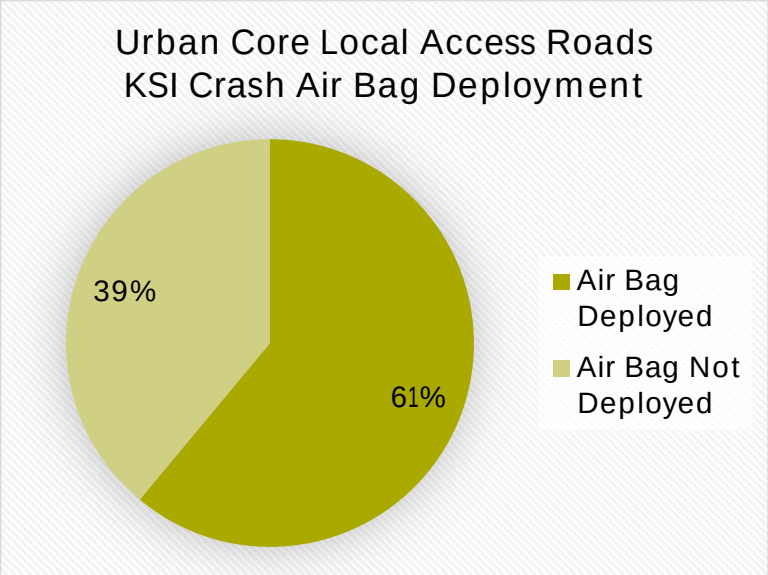


Figure 192: Urban Core Local Access Roads KSI Crash Air Bag Deployment

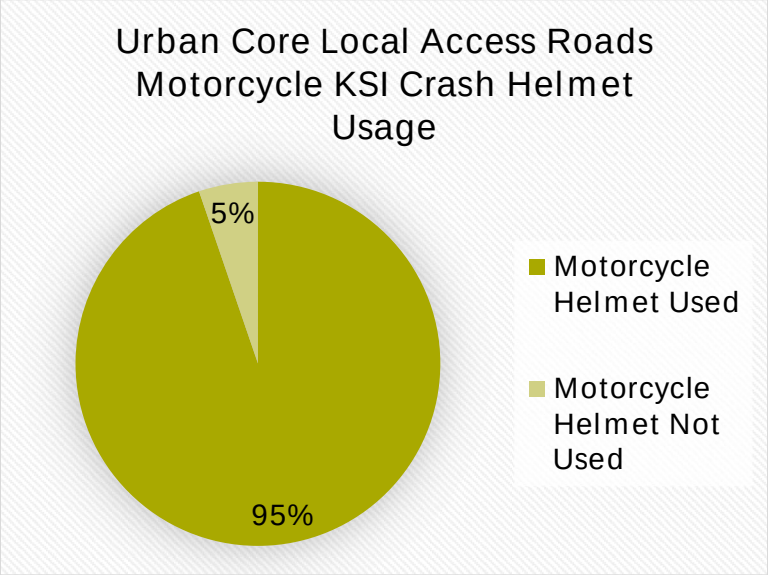


Figure 193: Urban Core Local Access Roads Motorcycle KSI Crash Helmet Usage

Time and Day

Crash trends throughout the week tend to correspond to traffic pattern trends with higher numbers of crashes happening in the morning and afternoon peak periods of traffic. This trend holds true for both all users and for pedestrians and bicyclists. No major increase in crashes is seen in the weekend nights, suggesting impairment is not a major factor on weekend nights for any users. There is an increase in bicycle KSI crashes on Saturday and Sunday mornings, which is likely a result of recreational cyclists riding at these times.

Dense Urban Local Access Roads KSI Crashes per Hour							
hour	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.26%	0.26%	0.26%	0.13%	0.39%	0.52%	1.03%
1:00 AM	0.65%	0.39%	0.13%	0.65%	0.26%	0.26%	1.03%
2:00 AM	1.29%	0.13%	0.39%	0.13%	0.13%	0.65%	0.39%
3:00 AM	0.39%	0.26%	0.13%	0.26%	0.13%	0.13%	0.52%
4:00 AM	0.65%	0.26%	0.13%	0.39%	0.13%	0.00%	0.13%
5:00 AM	0.13%	0.39%	0.13%	0.52%	0.52%	0.13%	0.00%
6:00 AM	0.00%	0.26%	0.77%	0.00%	0.13%	0.00%	0.13%
7:00 AM	0.13%	0.52%	0.26%	0.13%	0.77%	0.90%	0.65%
8:00 AM	0.52%	1.16%	0.90%	0.39%	0.52%	1.16%	0.39%
9:00 AM	0.39%	0.13%	0.77%	1.03%	0.13%	0.77%	0.39%
10:00 AM	0.13%	0.26%	0.39%	0.26%	0.90%	0.13%	0.52%
11:00 AM	0.39%	1.29%	0.65%	0.39%	0.77%	0.39%	0.65%
Noon	0.26%	0.52%	0.90%	1.29%	0.65%	0.52%	0.65%
1:00 PM	0.39%	0.65%	0.65%	0.39%	0.52%	0.77%	0.52%
2:00 PM	0.52%	0.65%	0.65%	0.52%	0.52%	0.13%	0.39%
3:00 PM	0.13%	0.39%	0.77%	0.90%	0.65%	0.65%	0.26%
4:00 PM	1.16%	1.42%	1.42%	1.03%	0.90%	1.03%	0.52%
5:00 PM	0.52%	1.29%	2.06%	1.94%	1.16%	1.29%	0.65%
6:00 PM	1.03%	0.77%	1.42%	0.90%	1.94%	0.90%	0.77%
7:00 PM	0.26%	0.39%	0.77%	1.03%	1.81%	1.42%	0.65%
8:00 PM	0.77%	0.39%	0.39%	1.03%	1.03%	0.39%	0.65%
9:00 PM	0.52%	0.52%	0.90%	0.26%	0.77%	1.16%	0.77%
10:00 PM	0.90%	0.39%	0.77%	0.65%	0.26%	0.39%	1.29%
11:00 PM	0.52%	0.52%	0.39%	0.52%	0.65%	1.16%	0.90%

Figure 194: Urban Core Local Access Roads KSI Crashes per Hour

Dense Urban Local Access Roads Pedestrian KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.00%	0.61%	0.61%	0.00%	0.31%	0.92%	0.31%
1:00 AM	0.61%	0.61%	0.00%	0.61%	0.61%	0.00%	1.23%
2:00 AM	2.45%	0.00%	0.31%	0.00%	0.00%	0.31%	0.31%
3:00 AM	0.31%	0.61%	0.31%	0.00%	0.00%	0.00%	0.31%
4:00 AM	0.92%	0.00%	0.00%	0.31%	0.31%	0.00%	0.00%
5:00 AM	0.31%	0.61%	0.00%	0.31%	0.92%	0.31%	0.00%
6:00 AM	0.00%	0.00%	1.23%	0.00%	0.00%	0.00%	0.31%
7:00 AM	0.31%	0.31%	0.31%	0.31%	0.61%	0.92%	0.00%
8:00 AM	0.31%	0.61%	0.92%	0.00%	0.31%	1.84%	0.61%
9:00 AM	0.31%	0.31%	1.23%	1.23%	0.00%	1.53%	0.61%
10:00 AM	0.00%	0.61%	0.00%	0.31%	1.53%	0.00%	0.92%
11:00 AM	0.31%	0.92%	0.00%	0.00%	0.92%	0.31%	0.31%
Noon	0.61%	0.61%	1.53%	0.61%	0.92%	0.00%	0.61%
1:00 PM	0.31%	0.92%	0.31%	0.31%	0.31%	0.61%	0.61%
2:00 PM	0.31%	0.61%	0.92%	0.31%	0.31%	0.31%	0.00%
3:00 PM	0.00%	0.31%	1.23%	0.92%	0.61%	0.61%	0.31%
4:00 PM	0.61%	0.92%	1.23%	0.92%	1.23%	0.61%	0.00%
5:00 PM	0.92%	0.92%	1.23%	1.23%	0.31%	1.23%	1.23%
6:00 PM	0.61%	1.23%	2.15%	0.61%	1.53%	1.23%	0.92%
7:00 PM	0.00%	0.92%	0.92%	0.61%	2.15%	2.15%	1.23%
8:00 PM	1.23%	0.00%	0.61%	0.92%	0.61%	0.31%	1.53%
9:00 PM	0.61%	0.61%	0.92%	0.31%	0.31%	0.61%	0.92%
10:00 PM	1.23%	0.31%	0.92%	0.61%	0.31%	0.61%	1.84%
11:00 PM	0.31%	0.61%	0.31%	0.92%	0.92%	0.92%	1.23%

Figure 195: Urban Core Local Access Roads Pedestrian KSI Crashes per Hour

Dense Urban Local Access Roads Bicycle KSI Crashes per Hour							
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Midnight	0.00%	0.00%	0.68%	0.00%	0.00%	0.00%	0.00%
1:00 AM	0.68%	0.00%	0.00%	0.68%	0.00%	0.00%	0.00%
2:00 AM	1.36%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3:00 AM	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
4:00 AM	0.00%	0.00%	0.00%	0.68%	0.00%	0.00%	0.00%
5:00 AM	0.00%	0.00%	0.68%	0.68%	0.00%	0.00%	0.00%
6:00 AM	0.00%	0.00%	0.68%	0.00%	0.00%	0.00%	0.00%
7:00 AM	0.00%	0.00%	0.00%	0.00%	0.68%	1.36%	0.00%
8:00 AM	2.04%	2.04%	1.36%	0.68%	0.00%	2.04%	0.00%
9:00 AM	0.00%	0.00%	0.68%	2.72%	0.68%	0.68%	0.00%
10:00 AM	0.00%	0.00%	0.68%	0.00%	0.00%	0.68%	0.00%
11:00 AM	0.68%	1.36%	0.00%	2.04%	0.68%	0.68%	0.68%
Noon	0.00%	0.68%	0.68%	2.04%	1.36%	1.36%	0.00%
1:00 PM	0.00%	0.00%	0.68%	0.68%	1.36%	0.68%	0.00%
2:00 PM	0.68%	0.00%	0.00%	0.00%	0.68%	0.00%	1.36%
3:00 PM	0.00%	0.00%	0.00%	1.36%	0.68%	0.68%	0.00%
4:00 PM	2.04%	2.04%	1.36%	0.68%	0.00%	2.72%	2.04%
5:00 PM	0.00%	0.68%	4.76%	4.76%	2.72%	2.04%	0.00%
6:00 PM	1.36%	0.68%	2.72%	1.36%	1.36%	2.72%	0.68%
7:00 PM	0.00%	0.00%	1.36%	0.68%	1.36%	1.36%	0.00%
8:00 PM	0.00%	0.00%	0.68%	2.04%	1.36%	0.00%	0.68%
9:00 PM	0.00%	0.68%	0.68%	0.68%	0.68%	0.00%	0.00%
10:00 PM	0.68%	0.00%	0.00%	0.68%	0.68%	0.00%	0.00%
11:00 PM	1.36%	0.68%	0.68%	0.00%	1.36%	0.68%	0.68%

Figure 196: Urban Core Local Access Roads Bicycle KSI Crashes per Hour

Weather, Road, and Lighting Conditions

93% of rural KSI crashes occurred with clear or cloudy weather and only 7% with rain or some other adverse weather condition active. Similarly, 90% of KSI crashes occurred on dry pavement and 94% of KSI crashes occurred on well-maintained pavement. Lighting factors are also shown. The majority of KSI crashes happened in daylight hours, or at night with streetlights on. Adverse weather, wet pavement, poor pavement quality, and dark/unlit roadways contribute relatively little to overall KSI crash risk especially in dense urban areas where slower traffic speeds and more comprehensive road designs exist.

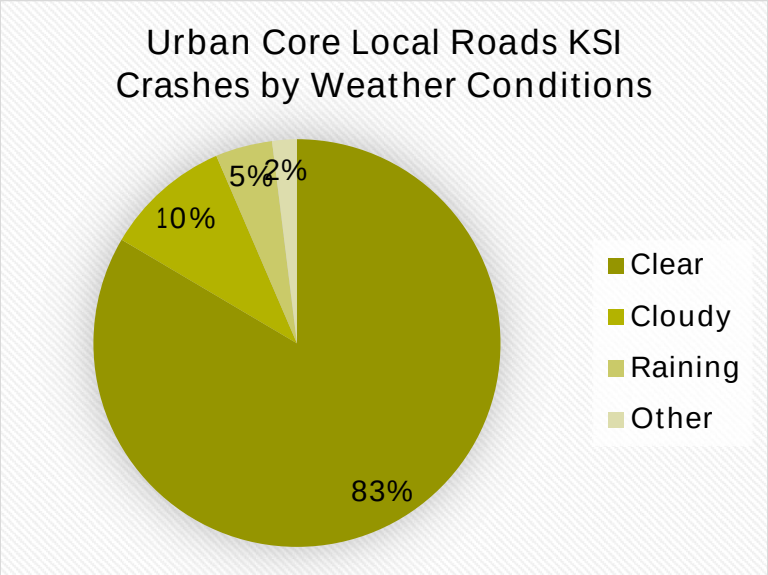


Figure 197: Urban Core Local Roads KSI Crashes by Weather Conditions

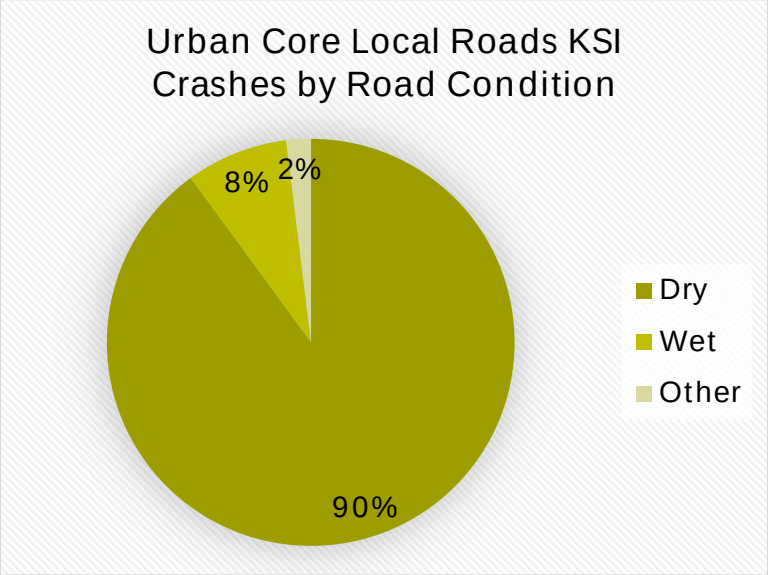


Figure 198: Urban Core Local Roads KSI Crashes by Road Condition

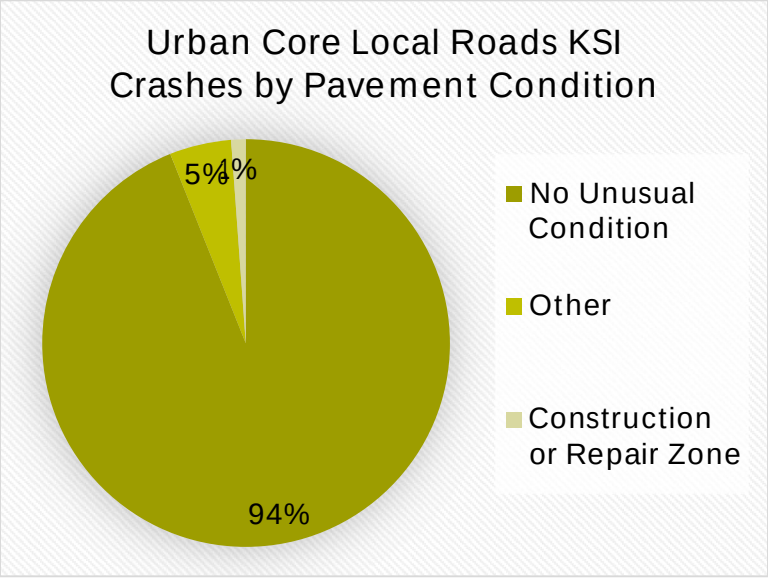


Figure 199: Urban Core Local Roads KSI Crashes by Road Condition

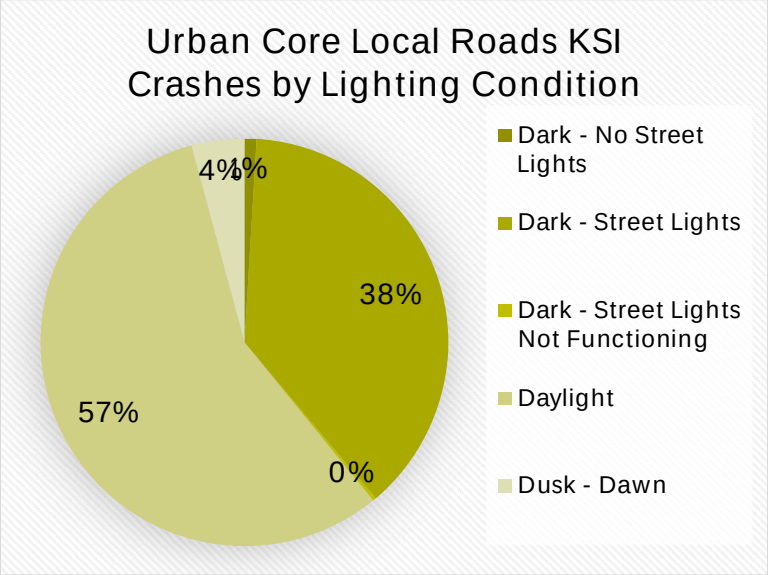


Figure 200: Urban Core Local Roads KSI Crashes by Lighting Condition

Inattention and Impairment

Inattentive or "distracted" driving is often cited as an important contributing circumstance for crashes in common literature. However, the data shows that roughly 0% of drivers and 1% of bicyclists and pedestrians involved in KSI crashes in the Bay Area on dense urban roads were inattentive. More users are impaired, but even still only 11% of drivers and 6% of cyclists and pedestrians were impaired with either alcohol or drugs. Campaigns to curb driving under the influence have been successes to the point that expansion of a focus results in diminishing returns. This does not mean there should not be any attempt to educate or enforcement but that focus on

discrete action should be seen as ancillary to a more systemic vision zero approach. The majority of KSI crashes in the bay area involve non-impaired and attentive drivers. In both cases of inattention and intoxication, drivers are more likely to be inattentive or intoxicated than pedestrians or cyclists.

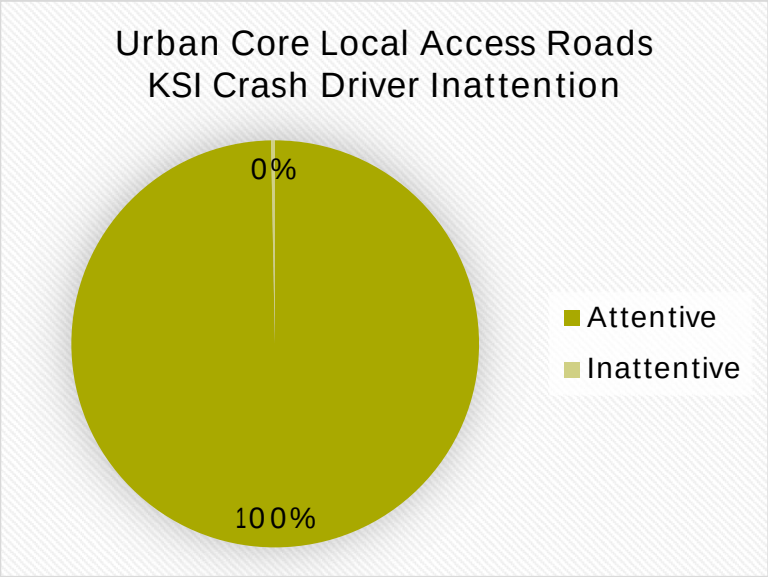


Figure 201: Urban Core Local Access Roads KSI Crash Driver Inattention

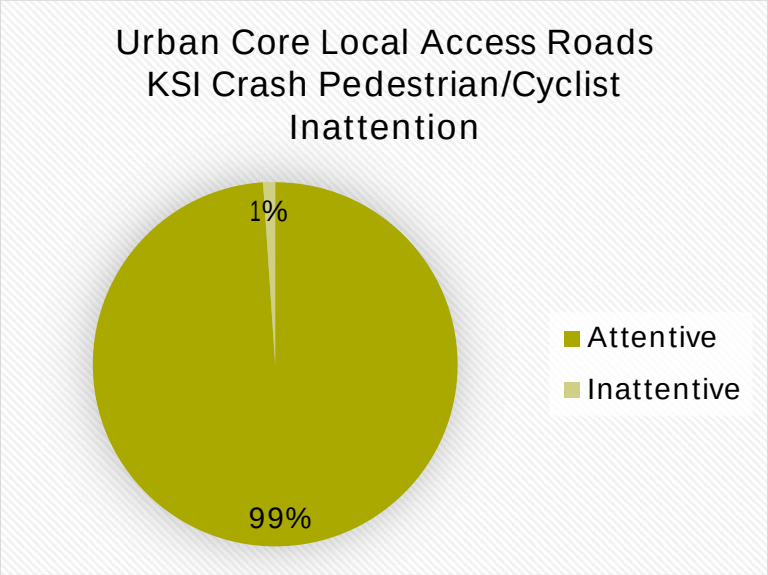


Figure 202: Urban Core Local Access Roads KSI Crash Pedestrian/Cyclist Inattention

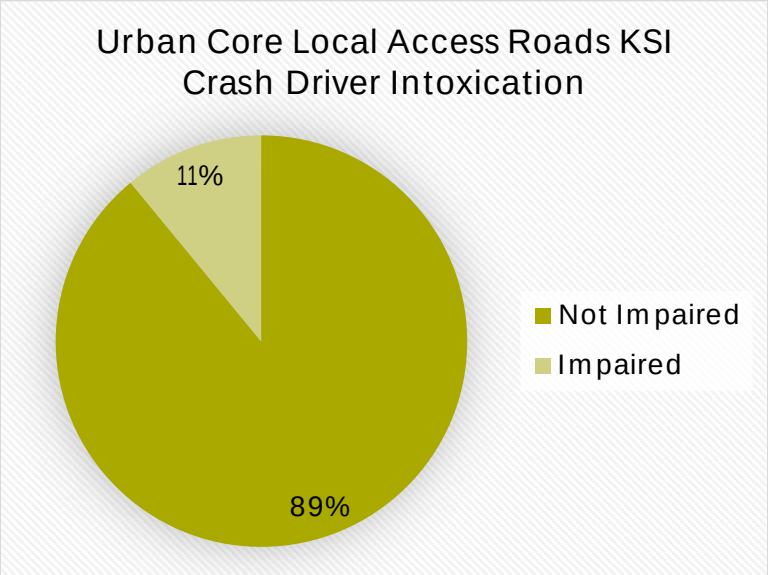


Figure 203: Urban Core Local Access Roads KSI Crash Driver Intoxication

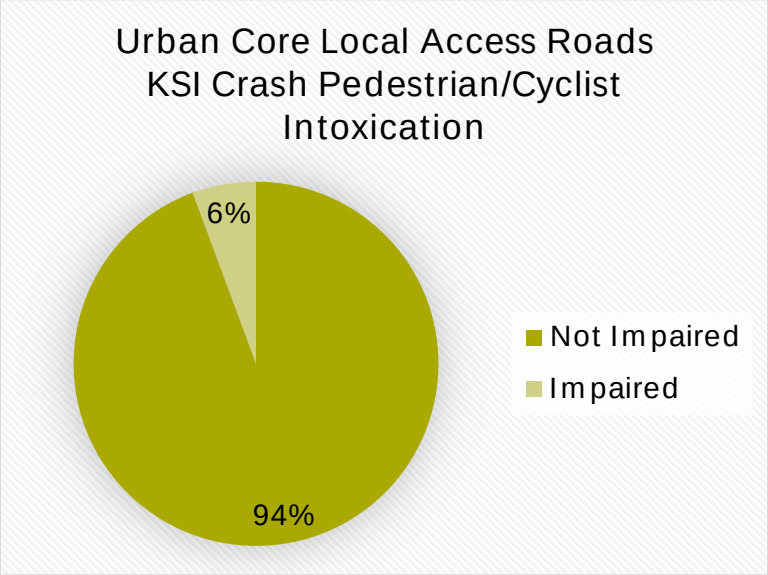


Figure 204: Urban Core Local Access Roads KSI Crash Pedestrian/Cyclist Intoxication

Systemic Crash Risk Analysis

Fatal and serious injury crashes are rare events, but they are not random. Because of the relative rarity of these events, it is difficult to draw broad conclusions using traditional safety analysis methods. To identify specific risk factors in crashes, a systemic analysis approach can be used. This approach uses large data sets of crashes joined with contextual factors and roadway feature.

This analysis was done by comparing the relative number of KSI crashes compared to a specific feature compared to the proportion of roadway miles that feature represents on the roadway network. For each feature, a "representation ratio" was calculated. This

is the proportion of crashes on that feature divided by the proportion of roadway miles. Overall, for the whole area the normalized value is 1.0 (100% of the KSI crashes happen on 100% of the roads), therefore any values above 1.0 show places where crashes are over-represented. If 50% of the KSI crashes happen on roads with a certain feature, but roads with that feature only make up 10% of the roadway network, then that representation ratio would be 5.0. The following sections detail the systemic risk analysis.

This analysis was used for three primary purposes:

- Identify the elements leading to the highest risk of fatal and serious injury crashes on Bay Area roads
- Create crash trees showing the relative over or under-representation of crashes and risk based on specific roadway elements and contexts
- Create a High Risk Network of streets with elevated risk elements

Only local access roads were utilized in this systemic risk analysis. Controlled access highways were excluded from the analysis.

Regional High Risk Elements

Roadway Context and Equity

There were several keys take away from the systemic analysis. First and foremost, were the risk differences based on roadway context. The density of an area is a major determinant of crash risk, with urban core areas 2.30x over-represented compared to average as seen in Figure 205. Similarly, equity priority communities are 1.90x over-represented compared to average as seen in Figure 206.

Many of the Bay Area equity priority communities are in denser urban and urban core areas, so it may be easy to assume that because these denser areas are over-represented, and many equity priority communities are in urban core areas, that they are over-represented simply because of this. But this is not the case. Figure 207 shows that equity priority communities are over-represented regardless of the area type context whether rural, suburban, urban, or urban core.

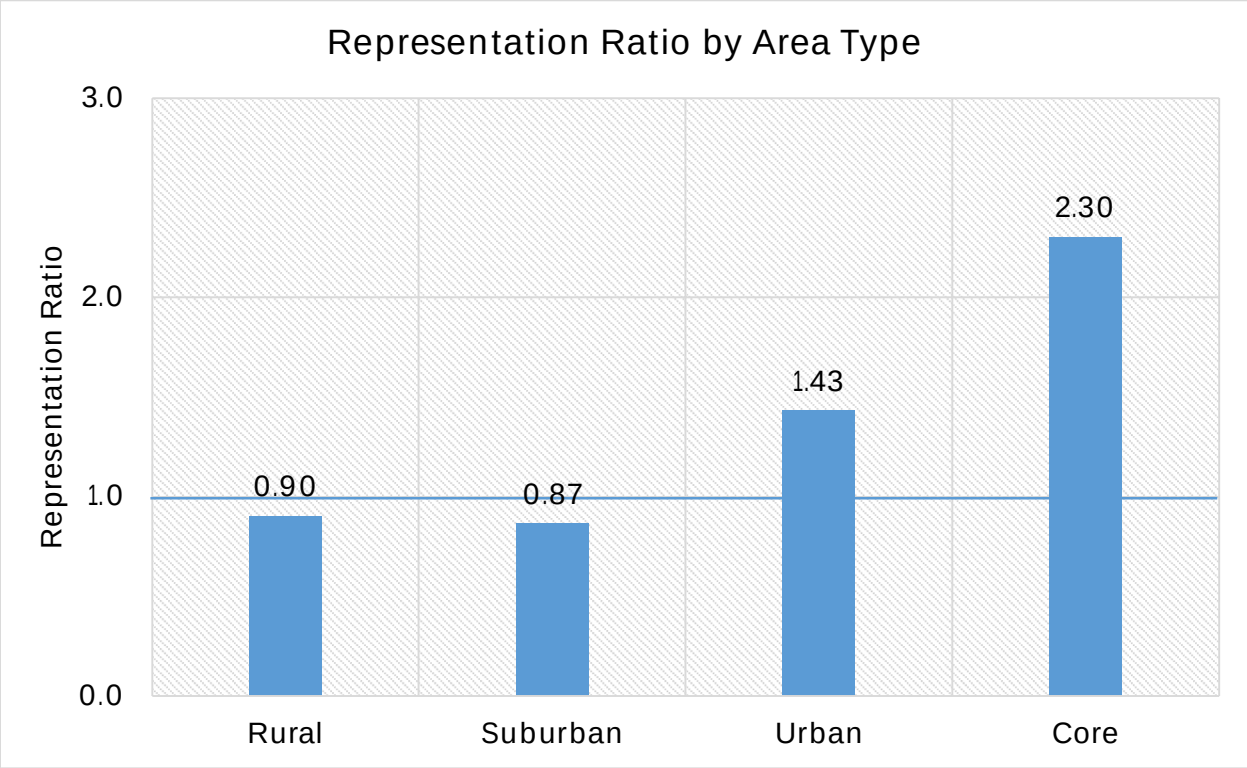


Figure 205: Segment Representation by Area Type

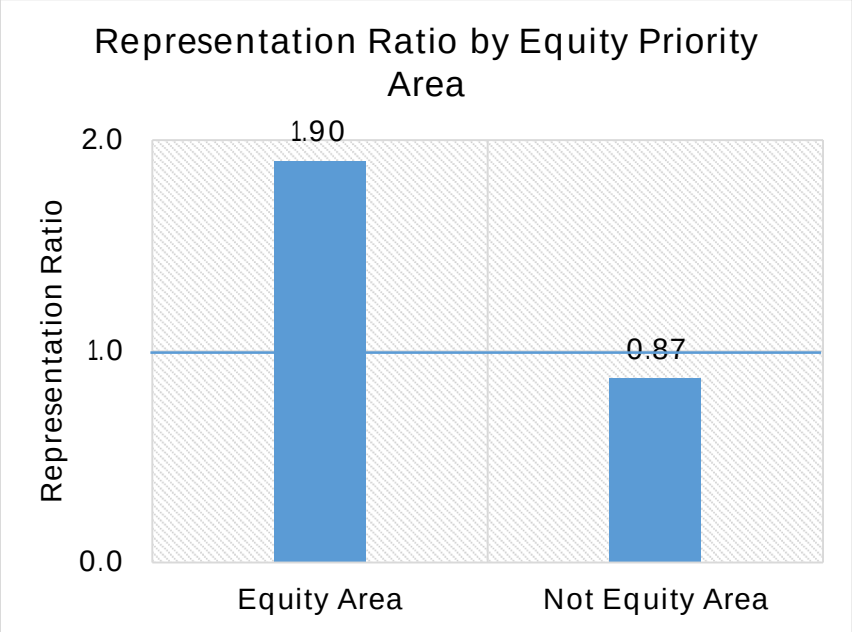


Figure 206: Segment Representation by Equity Priority Area

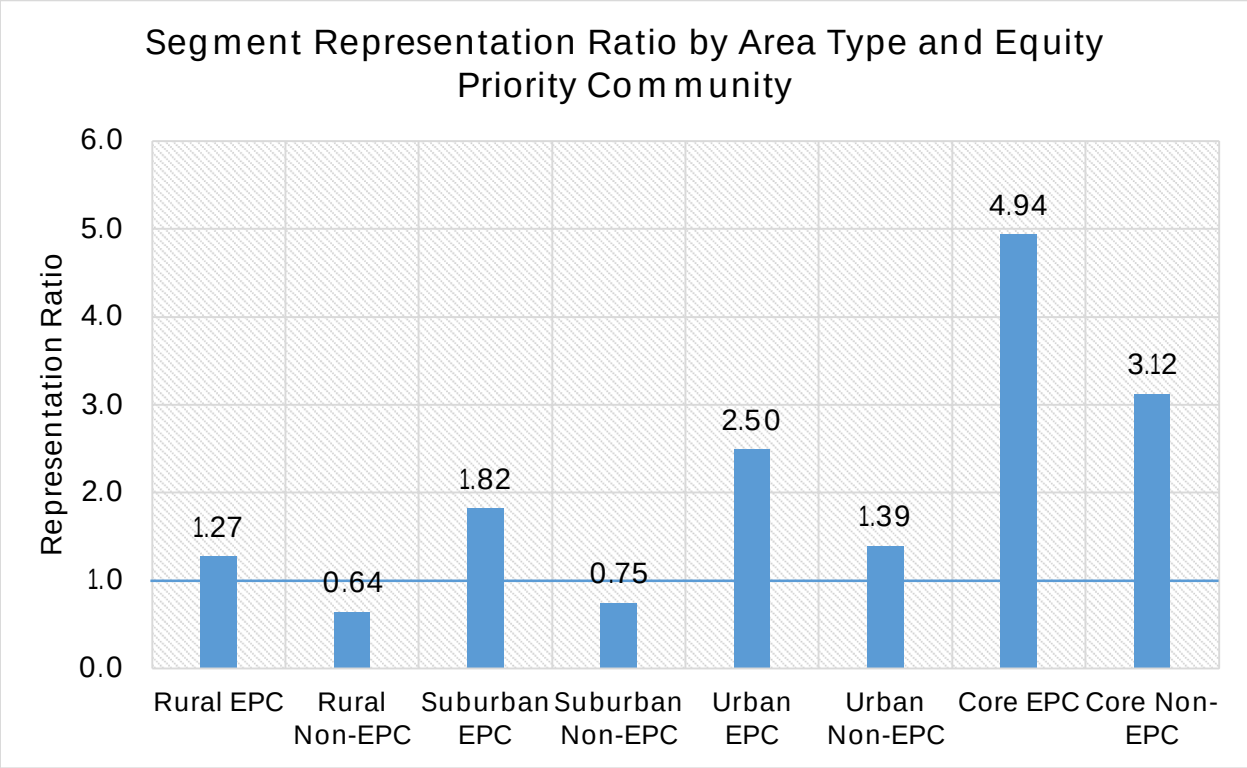


Figure 207: Segment Representation by Area Type and Equity Priority Area

Roadway Factors

Roadway factors, such as number of lanes, traffic volume, and speeds were analyzed to determine infrastructure and operational risk factors. Of these, the number of lanes, whether a road was divided or undivided, and speeds show the greatest positive correlation to risk. As the number of lanes increases, the risk increases. Roads with four or more lanes have the highest risk, with four lane undivided roads having the highest risk of all two-way road types with a 5.36x over-representation compared to average. One-way roads with more than one lane also have elevated risk. Three lane one-way roads have a 13.00x over-representation of crashes compared to average.

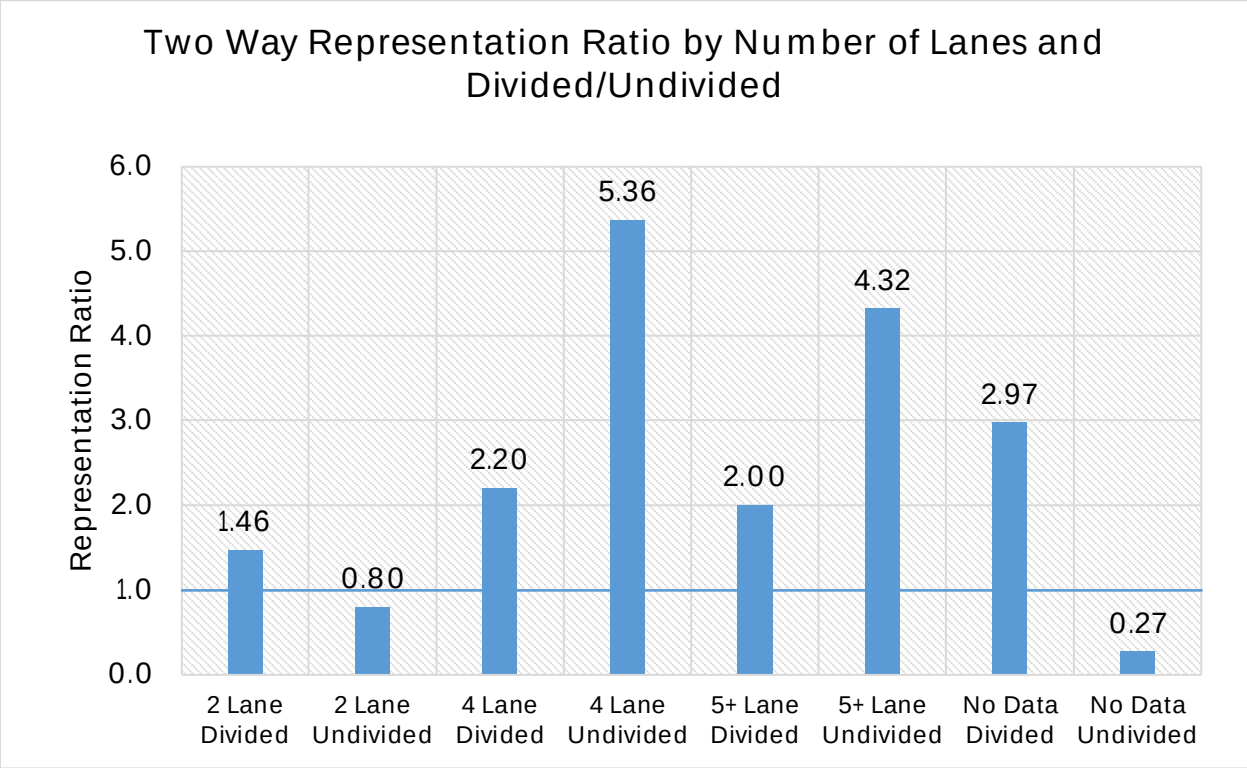


Figure 208: Segment Representation Ratio by Number of Lanes (Two-Way Roads)

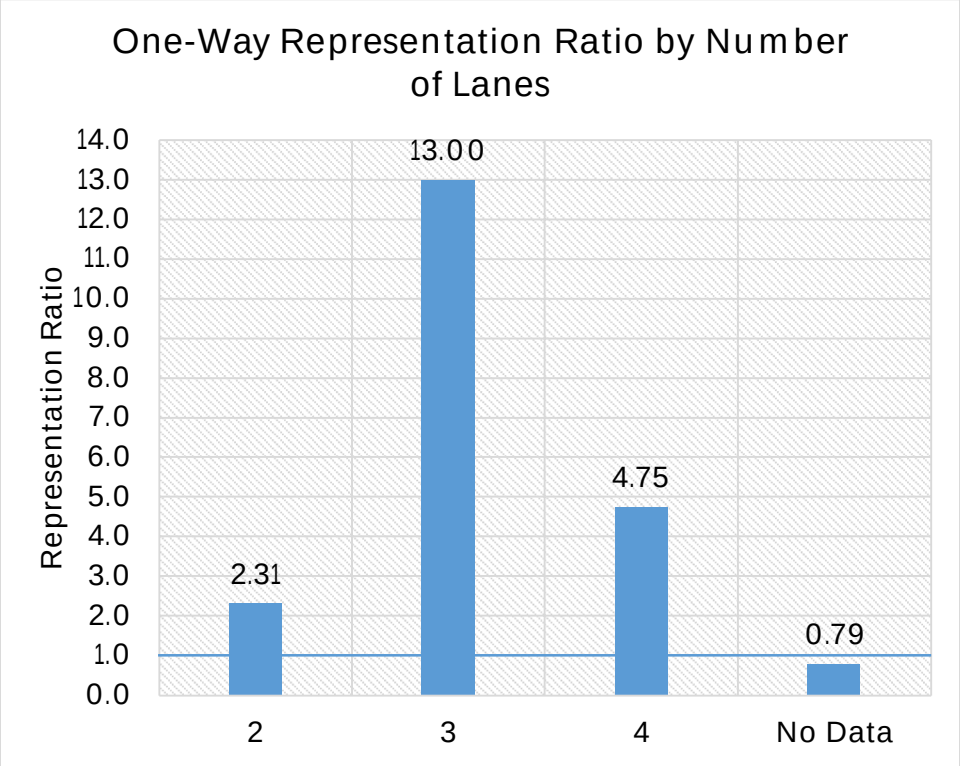


Figure 209: Segment Representation Ratio by Number of Lanes (One-Way Roads)

The systemic analysis observed that KSI Crashes occurred relatively independently of vehicle AADT which shows that higher volume roads are not necessarily a higher risk. Lower volume roads have lower risk ratios, but at this moderate to high volume, the risk is independent of traffic volume. In fact, the highest representation ratio for roads is in the 10,000 – 40,000 AADT range but ratios for these roads are relatively constant. This data can be seen in below in Figure 210.

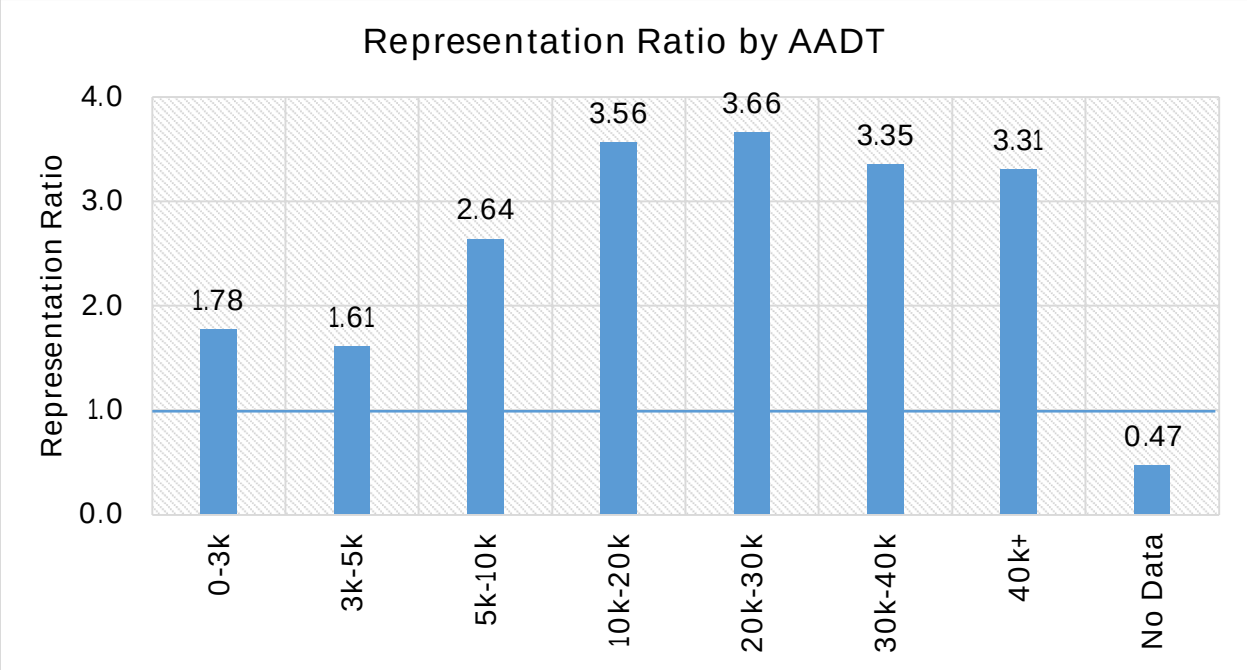


Figure 210: Segment Representation Ratio by AADT

Prevailing speed was measured to evaluate its impact to risk. The prevailing speed was measured based on the free flow speed using the INRIX data set. INRIX uses location based cell phone data to measure speeds on roads using billions of data points. Data from INRIX was averaged for Tuesday mid-morning for all streets in the Bay Area, using this as a good corollary for free flow speed when vehicles speeds are not encumbered by traffic congestion.

For cyclists and pedestrians, there is a strong negative correlation of crash risk to increasing speed. The highest risk for pedestrians occurs with the lowest prevailing speeds. This is almost certainly a function of exposure—many more pedestrian and cyclists are on streets with low speed limits compared to streets with very high speed limits. Pedestrian and cyclist traffic volumes aren't yet available in the BAYVIZ system to fully understand this relationship. This can be seen in Figure 211.

Motor vehicle speeds are positively correlated to higher crash risk. As prevailing speeds go up, crash representation also goes up. Figure 212 includes motor vehicle crash risk by speed for suburban areas (suburban areas were chosen for this chart because these areas have the largest range of speeds—urban and urban core areas lack higher speed roads and rural areas lack lower speed roads).

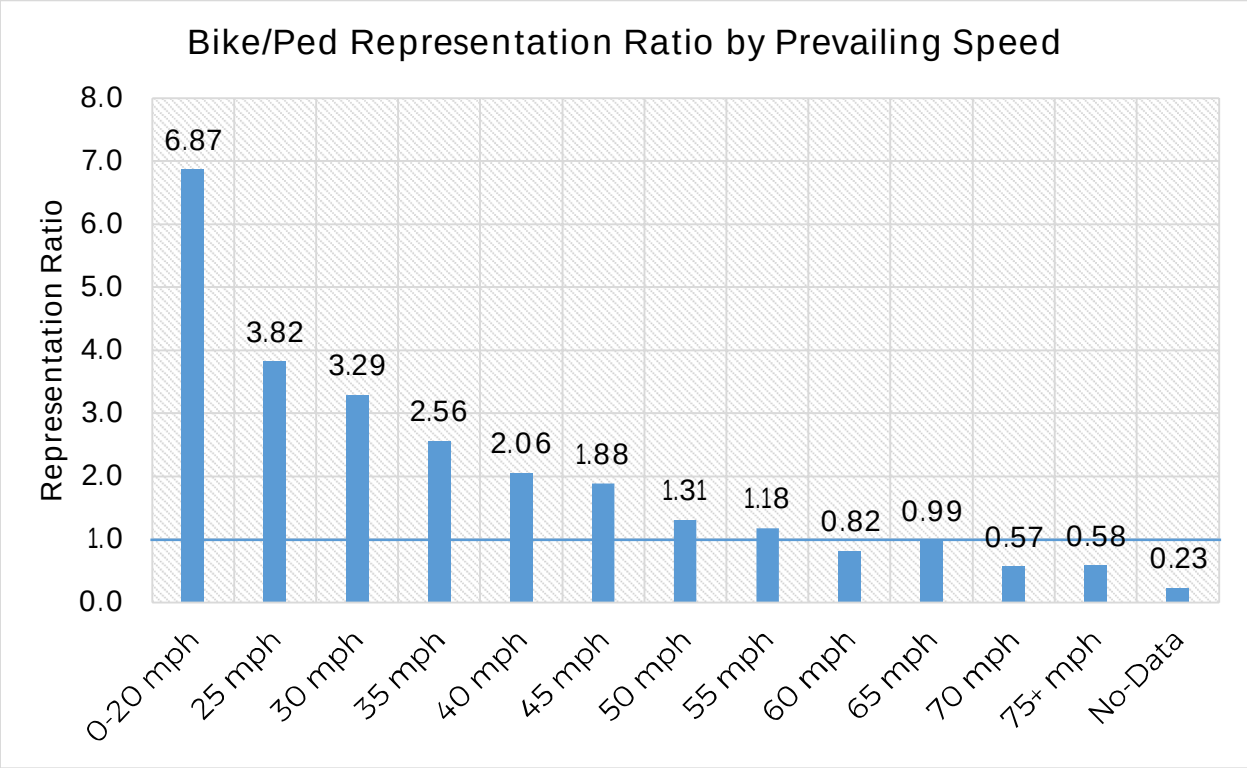


Figure 211: Segment Representation Ratio for Bike/Ped Crashes by Prevailing Speed

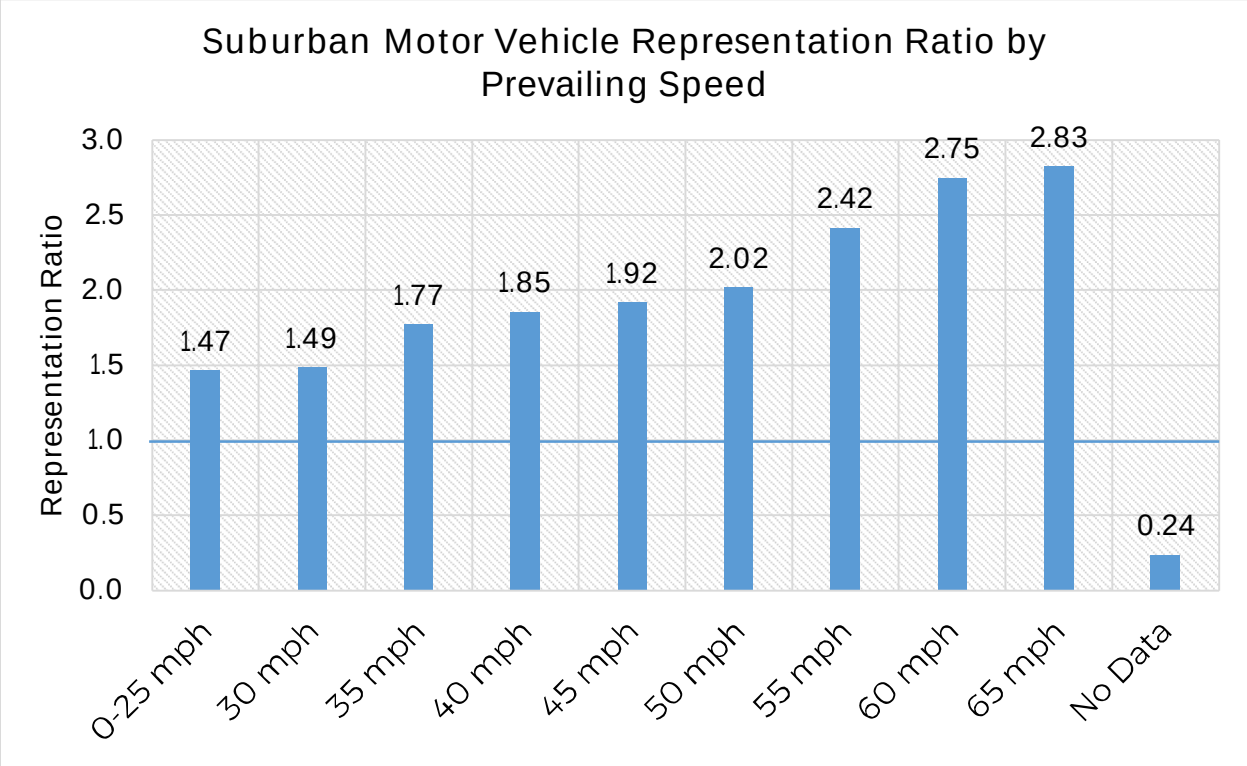


Figure 212: Segment Representation Ratio for Motor Vehicle Crashes by Prevailing Speed in Suburban Areas

Intersection Factors

The singular factor that showed the strongest risk profile at intersections was based on the intersection control. Specifically, traffic signals have risk levels much higher than stop sign control or roundabouts. Traffic signals are 7.51x over-represented than the average intersection in the Bay Area as seen in Figure 213. Roundabouts have the lowest representation ratio of intersections at 0.48.

To identify factors related to traffic signals, the traffic volume and number of approach lanes at signals were also analyzed. Figure 214 and Figure 215 show the representation ratio for traffic signals based on traffic volume and approach lane. The risk profile changes very little based on these factors at signals. In general, any traffic signal, regardless of the traffic volume or approach lanes has a significantly elevated risk profile.

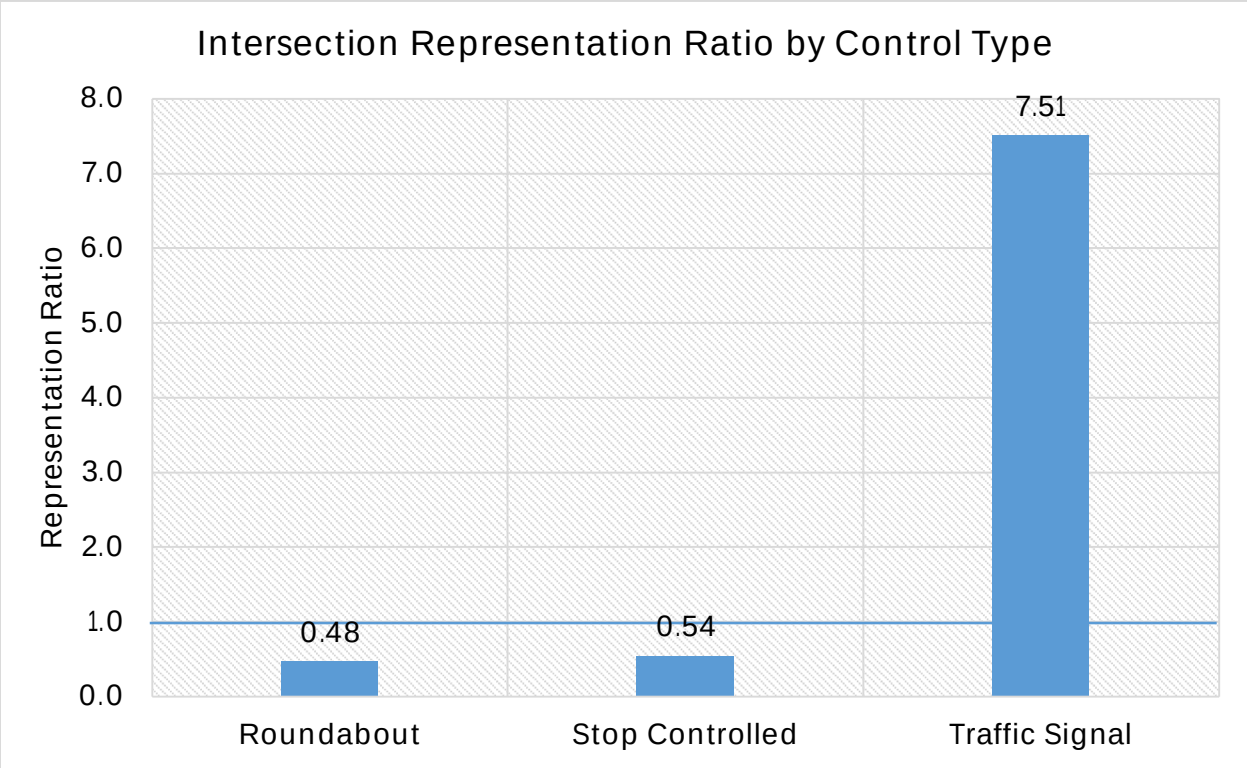


Figure 213: Intersection Representation Ratio by Control Type

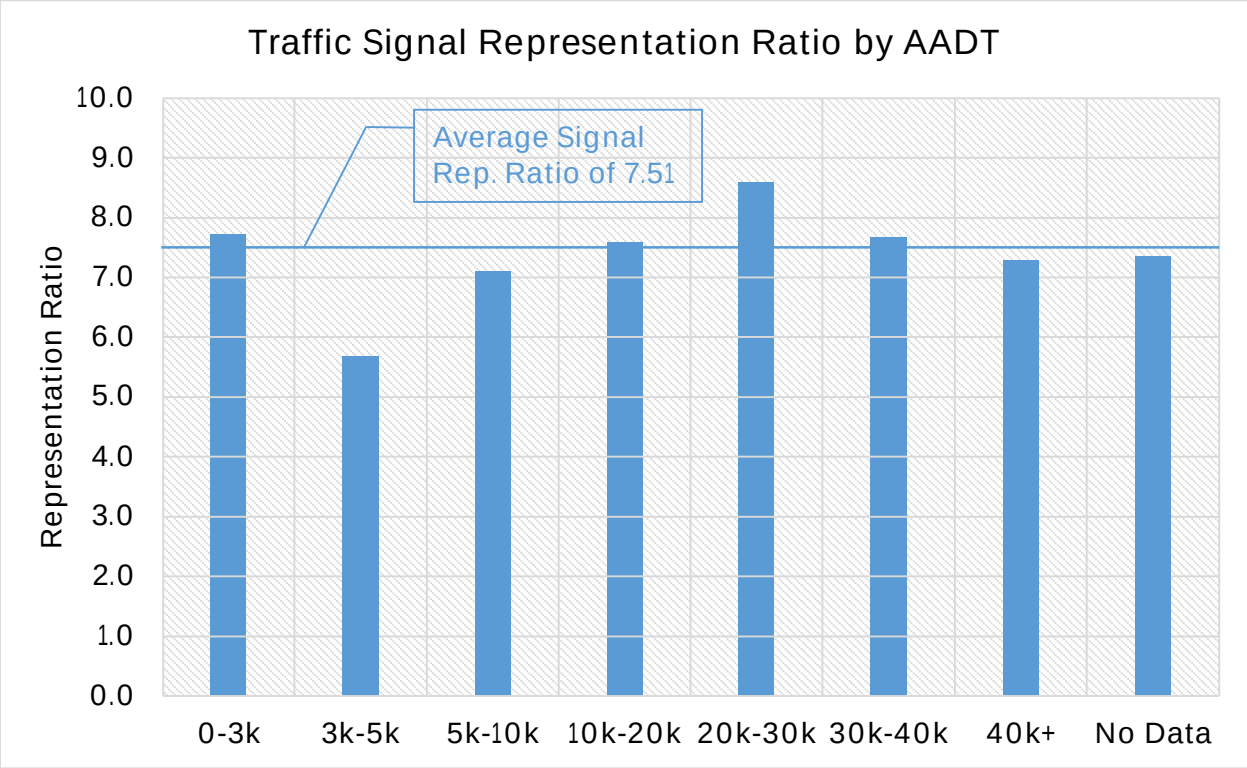


Figure 214: Traffic Signal Representation Ratio by AADT

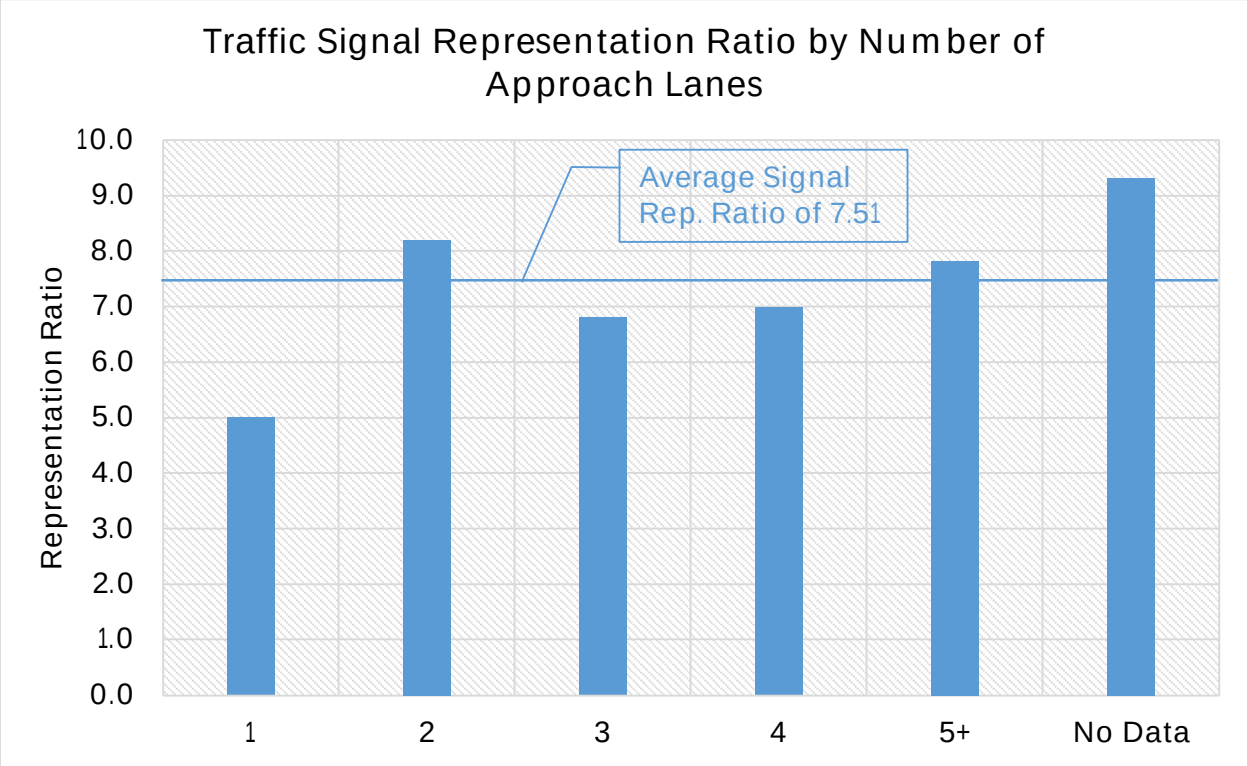


Figure 215: Traffic Signal Representation Ratio by Number of Approach Lanes

Crash Trees

To understand the risk profile more fully in specific locations with specific roadway factors, crash trees were developed. These crash trees show the representation ratio based on the land use and equity factors linked with the roadway and intersection factors. These trees can be used to identify the relative risk of a specific type of street in a specific area by following down the levels of the branching tree. These trees are broken down into two sections of segment and intersection crashes each with 2 sub-sections which differentiate between vehicle vs bike/ped KSI crashes.

The crash trees shown are broken down by the labeled sub area type and then by whether they reflect motor vehicles only crashes or bike/ped crashes of a specific sub area. Separate crash trees are shown for those crashes which occurred at intersections versus those which occurred on roadway segments. From that point the branches label the crashes in sub areas which occurred in equity priority communities compared to those that did not.

The intersection crashes within sub areas are then broken down by the type of intersection at which the crashes occurred; roundabout, stop controlled, or traffic signal. These are then split and labeled depending on certain roadway metrics such as the traffic volume, the number of lanes, and the direction of traffic. The branches are also color coded with the light green meaning a low representation ratio and a dark red meaning a high representation ratio. If there did not exist enough data for a specific box to be meaningful it was removed.

The limiting factor in this type of analysis is the number of crashes and length of roadway available. If only a few crashes happen on a few miles of road in the entire Bay Area, little conclusions can be drawn. But if there are only a few crashes on a large number of road miles, those roads can be identified as low risk. Conversely, if a large number of crashes are on only a few miles of roads, those roads can be identified as high risk. The limiting factor used for limited sample size where conclusions cannot be drawn were features that represented both less than 200 total roadway miles and less than 50 total KSI crashes were flagged as “limited data” but still included in crash trees. The full crash trees are included in the Appendix of this plan. The following section shows the excerpts from the crash trees with sufficient data to draw conclusions.

Segment Crash Trees

The following pages include excerpts from the full crash trees related to segment crashes that did not occur at intersections in the Bay Area.

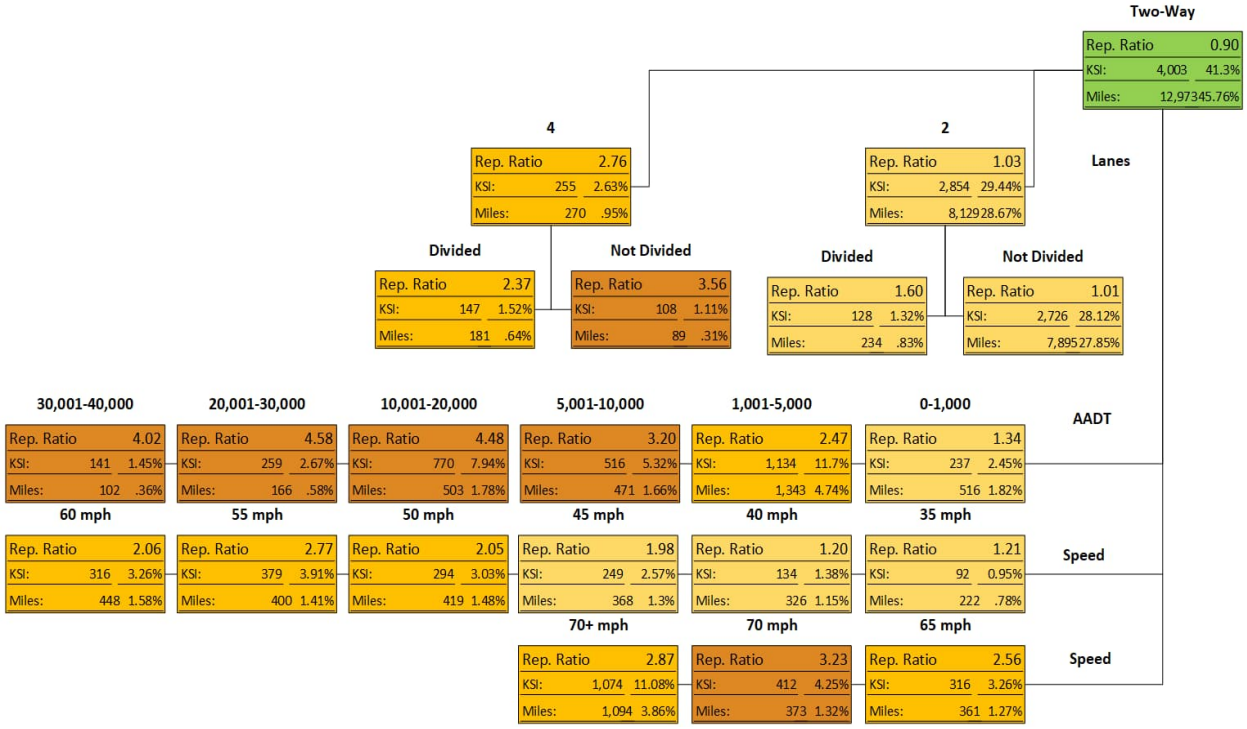


Figure 216: Rural Vehicle Only Crashes Segment Crash Tree



Figure 217: Rural Bike/Ped Crash Segment Crash Tree

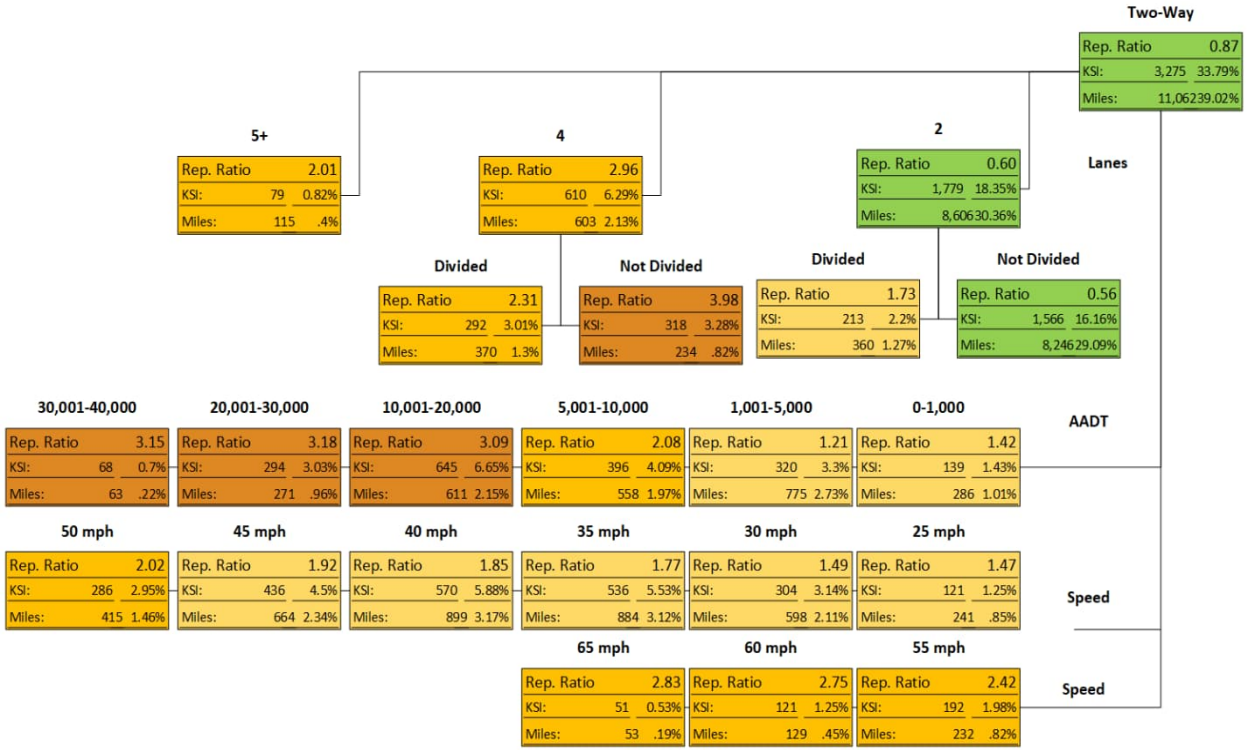


Figure 218: Suburban Vehicle Only Crashes Segment Crash Tree

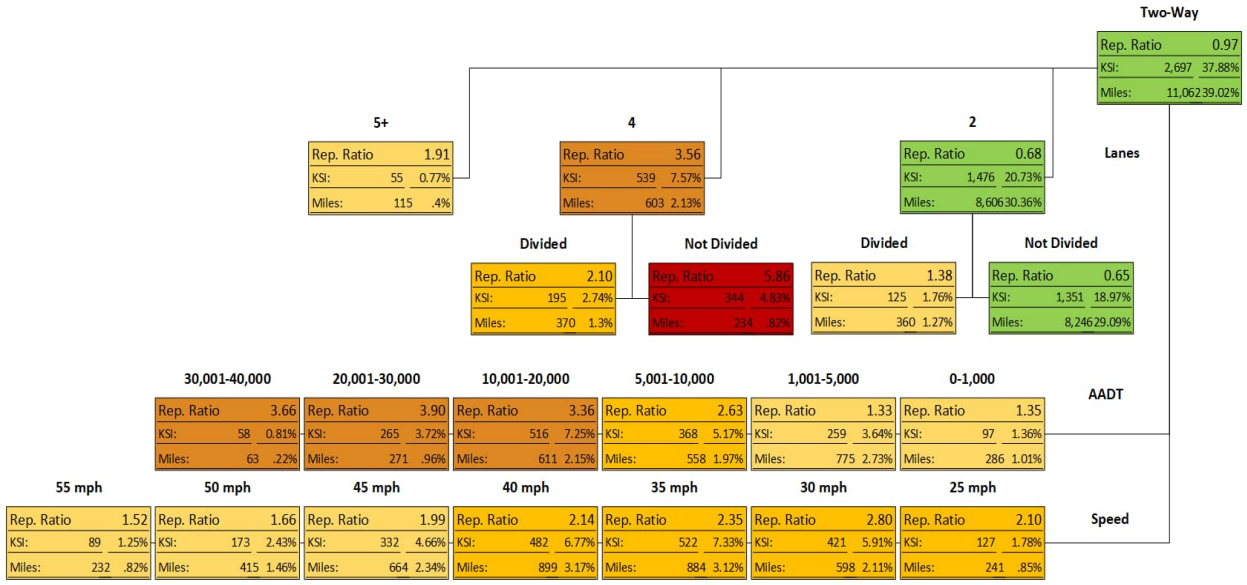


Figure 219: Suburban Bike/Ped Crashes Segment Crash Tree

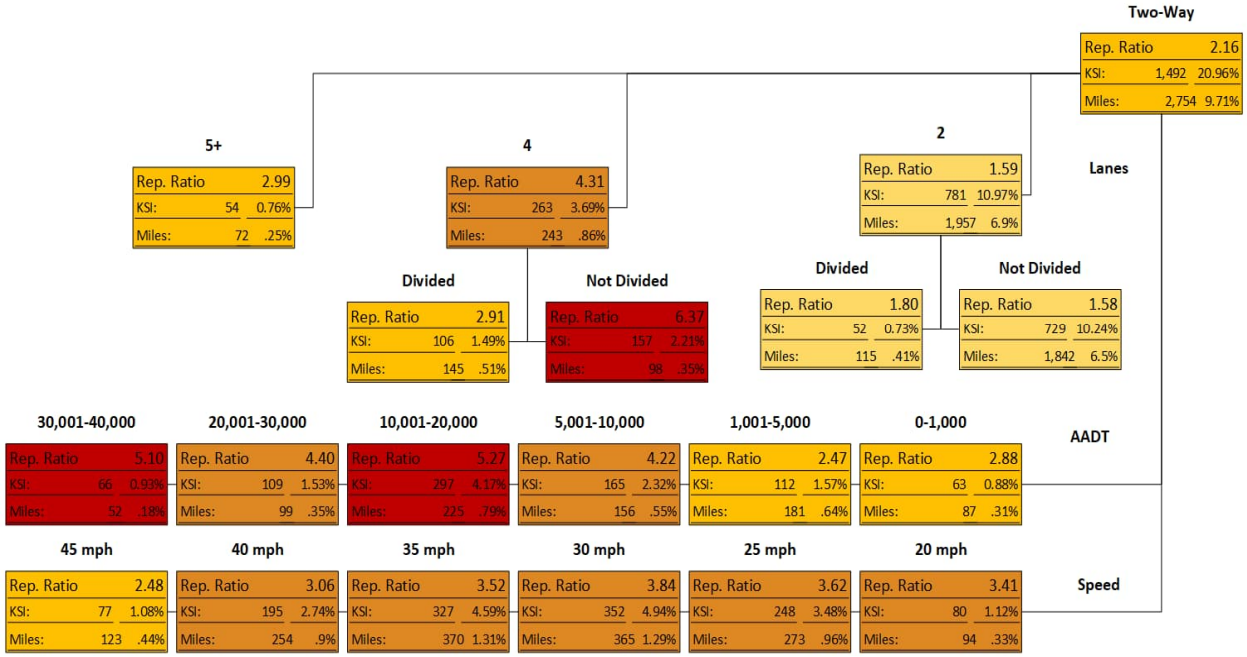


Figure 220: Urban Vehicle Only Crashes Segment Crash Tree

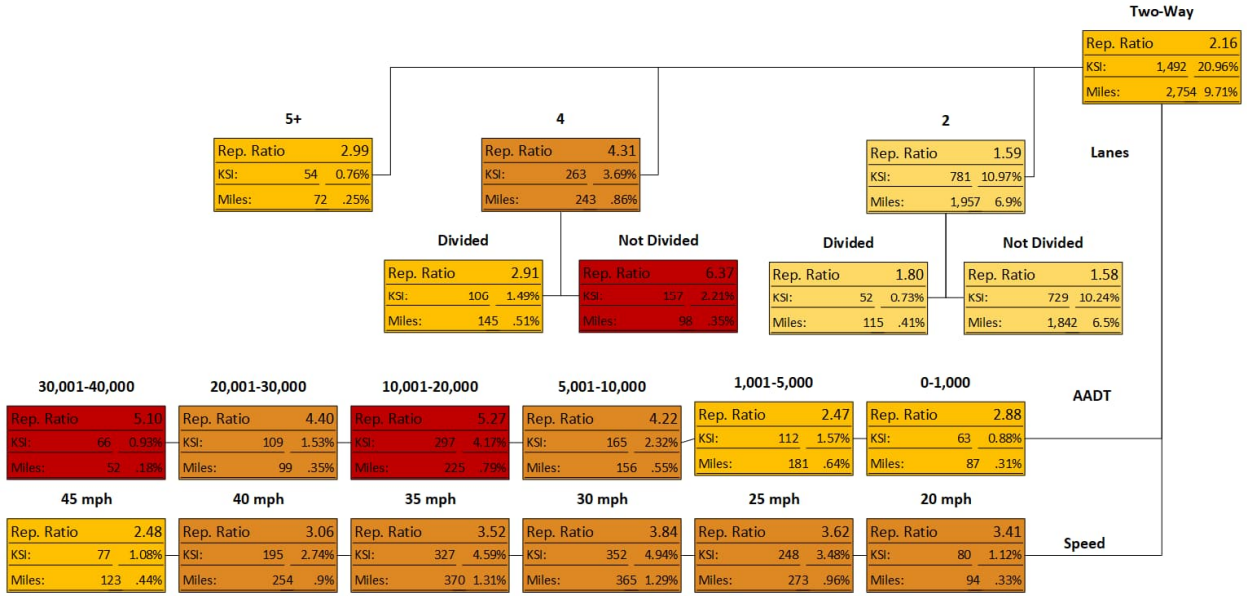


Figure 221: Urban Bike/Ped Segment Crash Tree

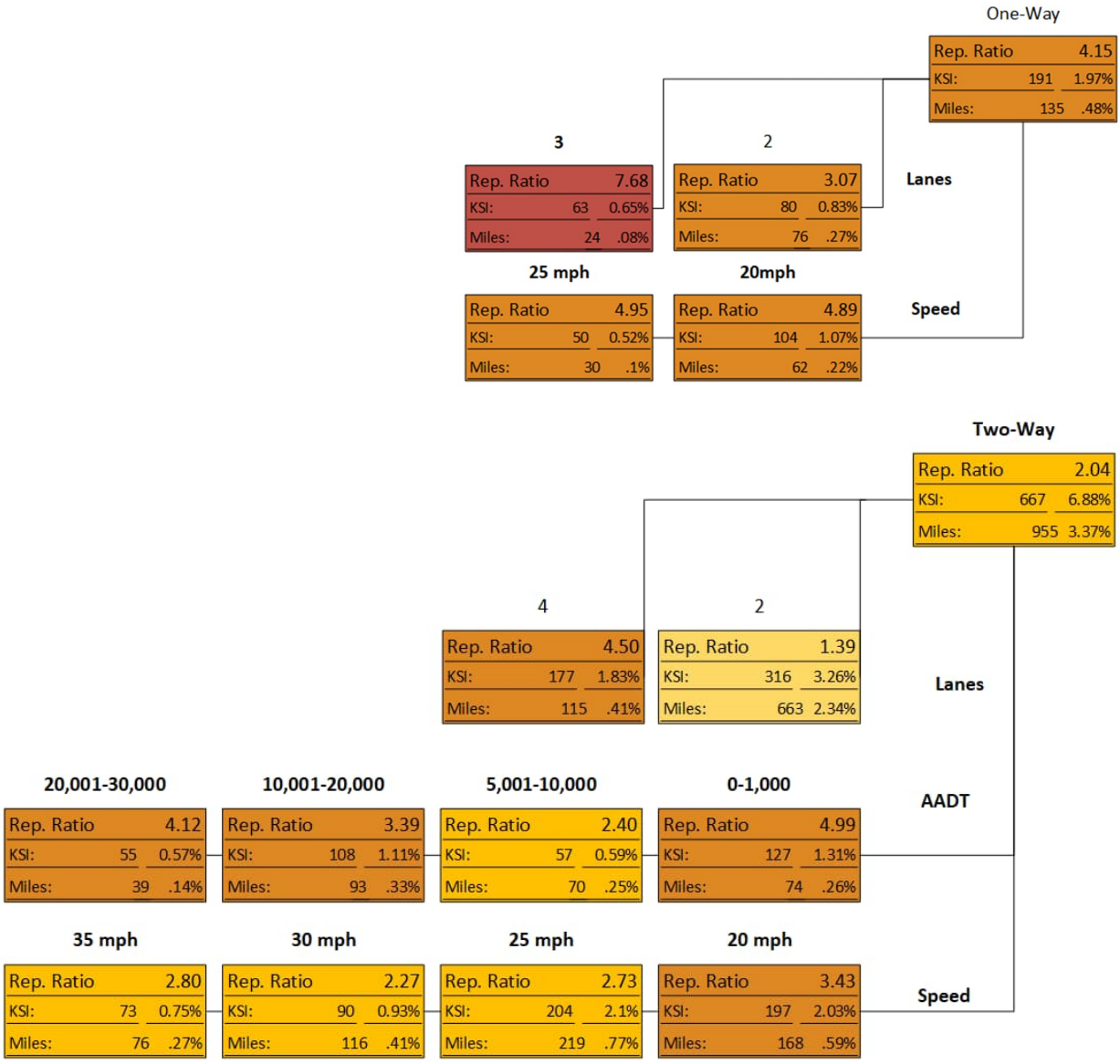


Figure 222: Urban Core Vehicle Only Crashes Segment Crash Tree

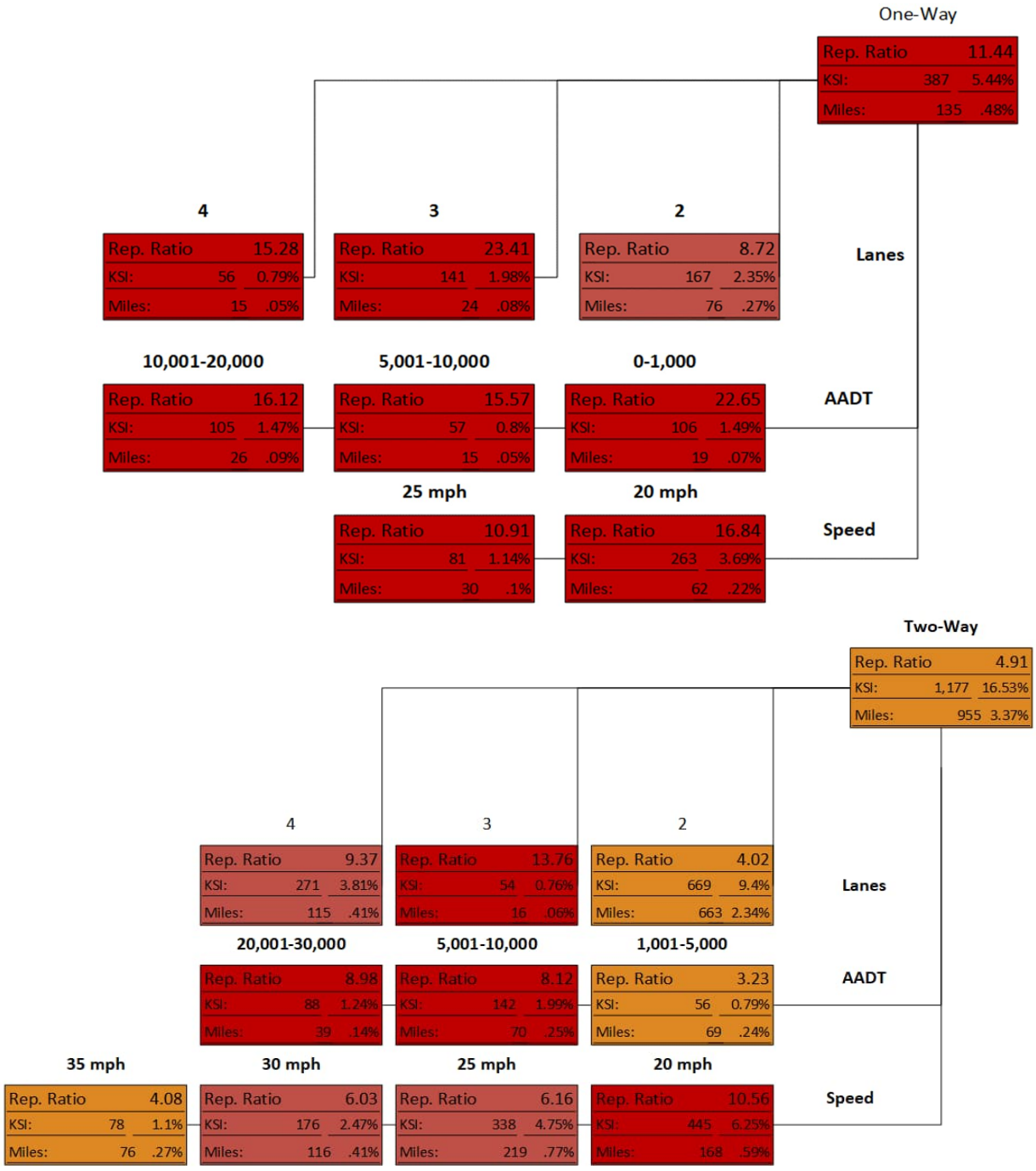


Figure 223: Urban Core Bike/Ped Crashes Segment Crash Tree

Intersection Crash Trees

The following pages include excerpts from the full crash trees related to intersection crashes that occurred at intersections in the Bay Area.

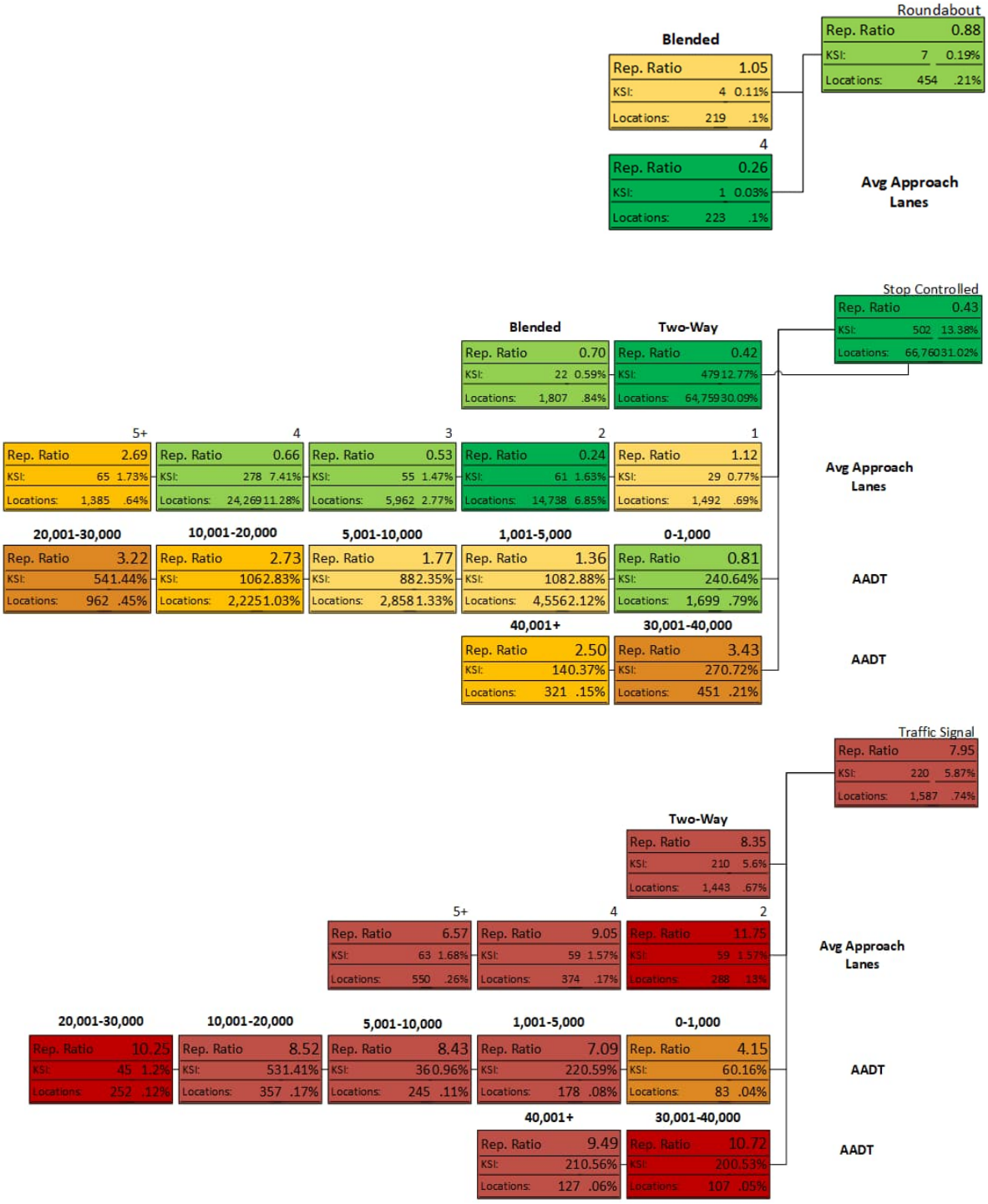


Figure 224: Rural Area Vehicle Only Intersection Crash Tree



Figure 225: Rural Bike/Ped Crash Intersection Crash Tree

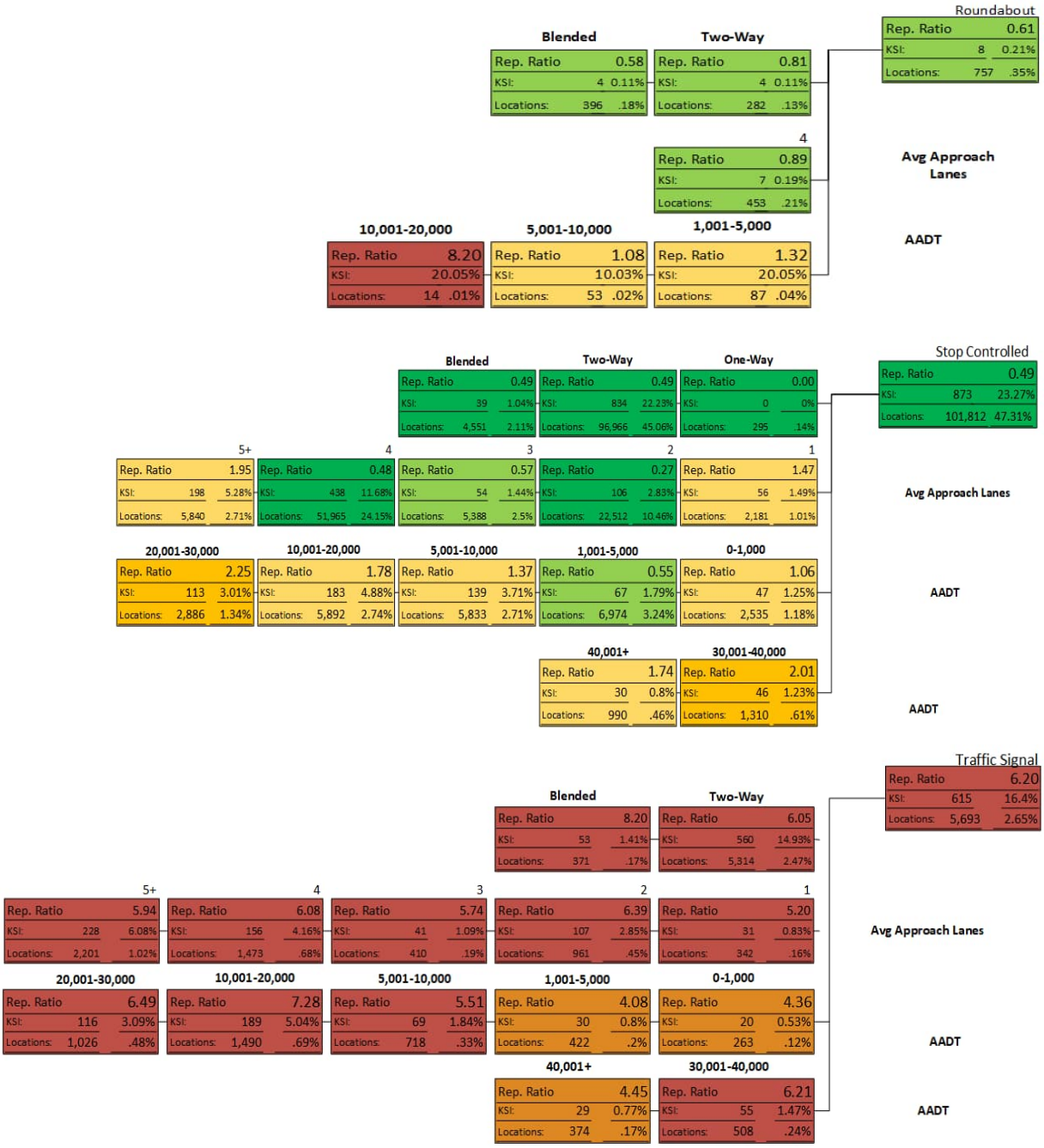


Figure 226: Suburban Vehicle Only Crashes Intersection Crash Tree

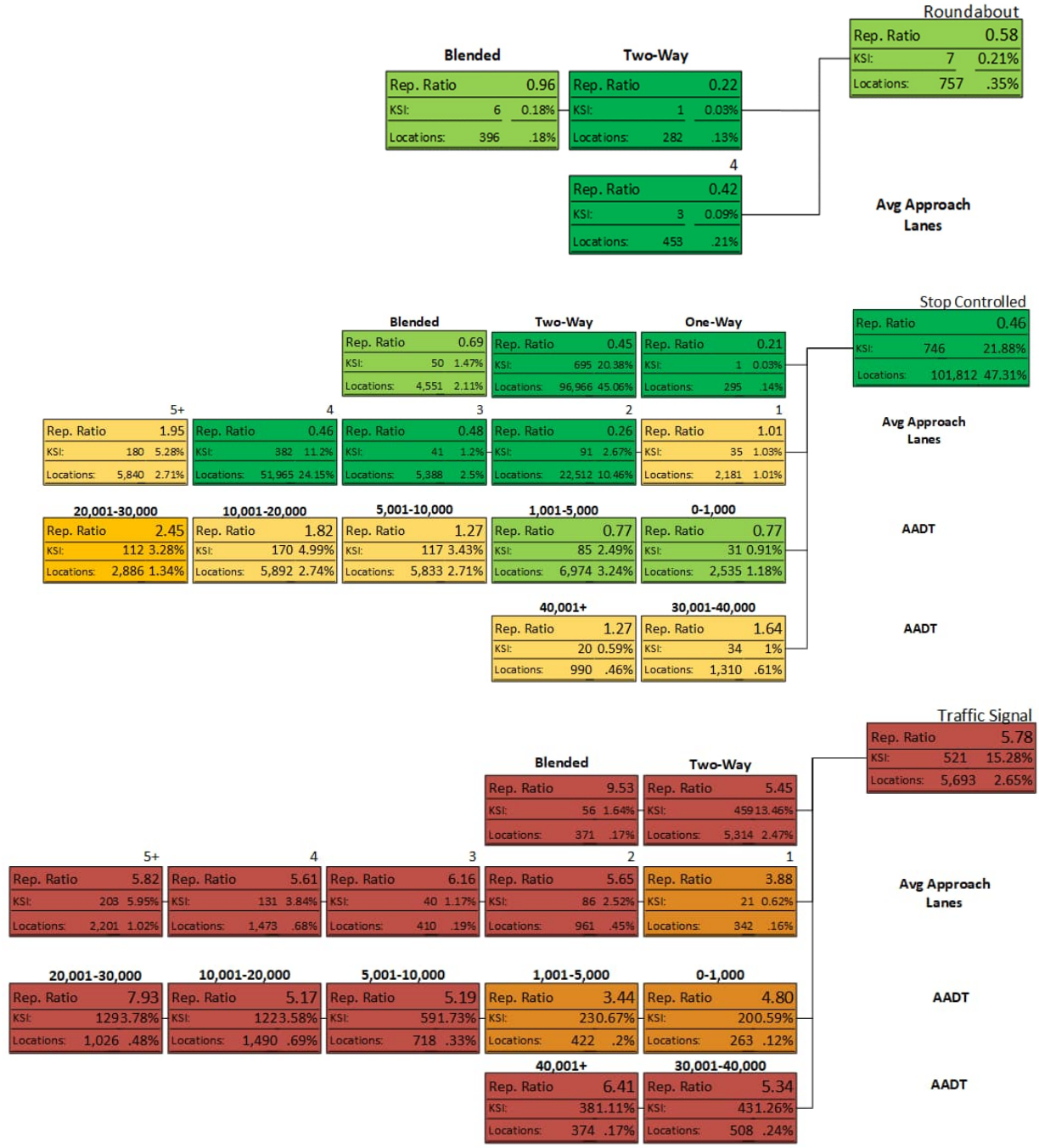


Figure 227: Suburban Bike/Ped Crashes Intersection Crash Tree

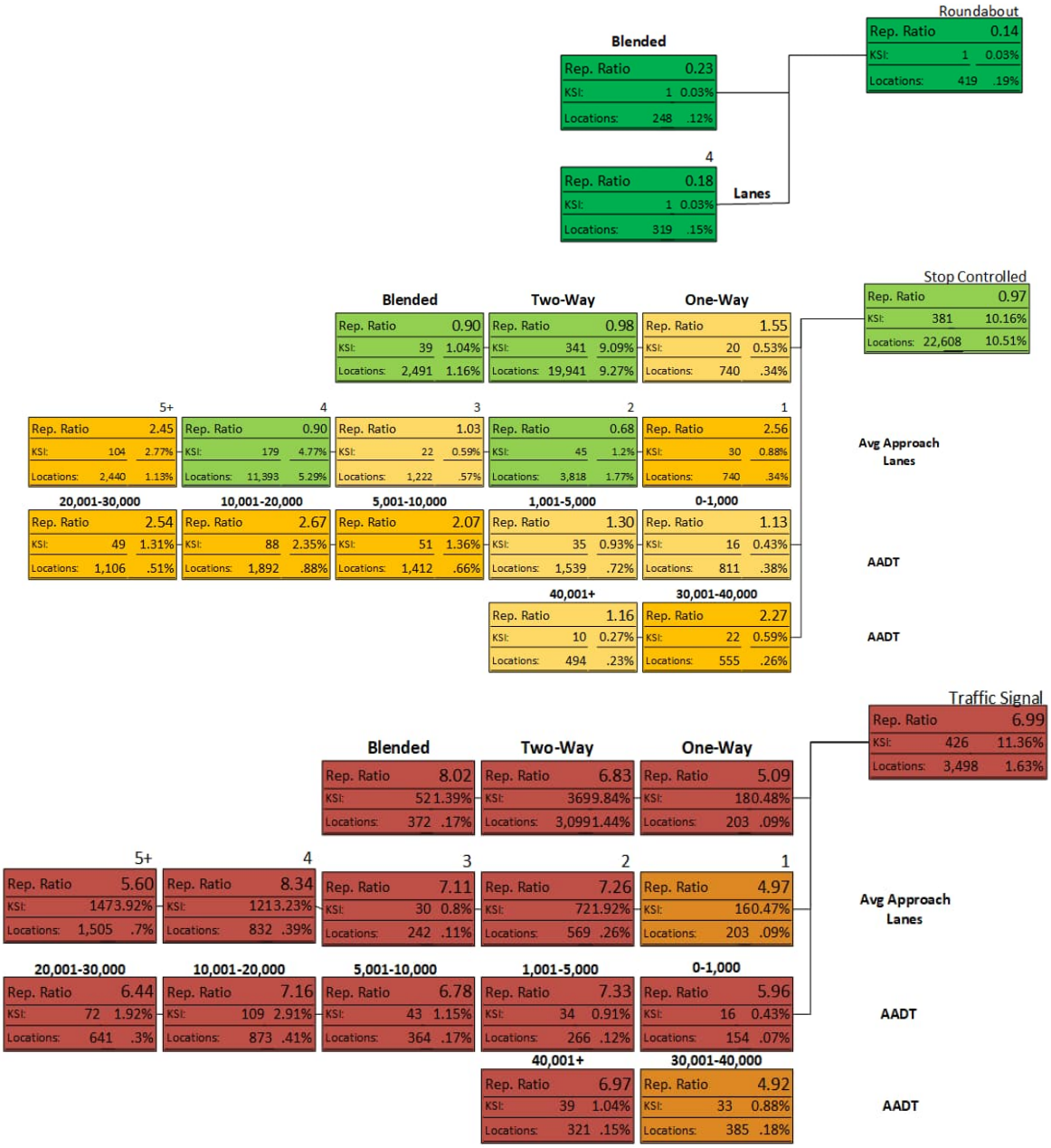


Figure 228: Urban Vehicle Only Crashes Intersection Crash Tree



Figure 229: Urban Bike/Ped Crashes Intersection Crash Tree

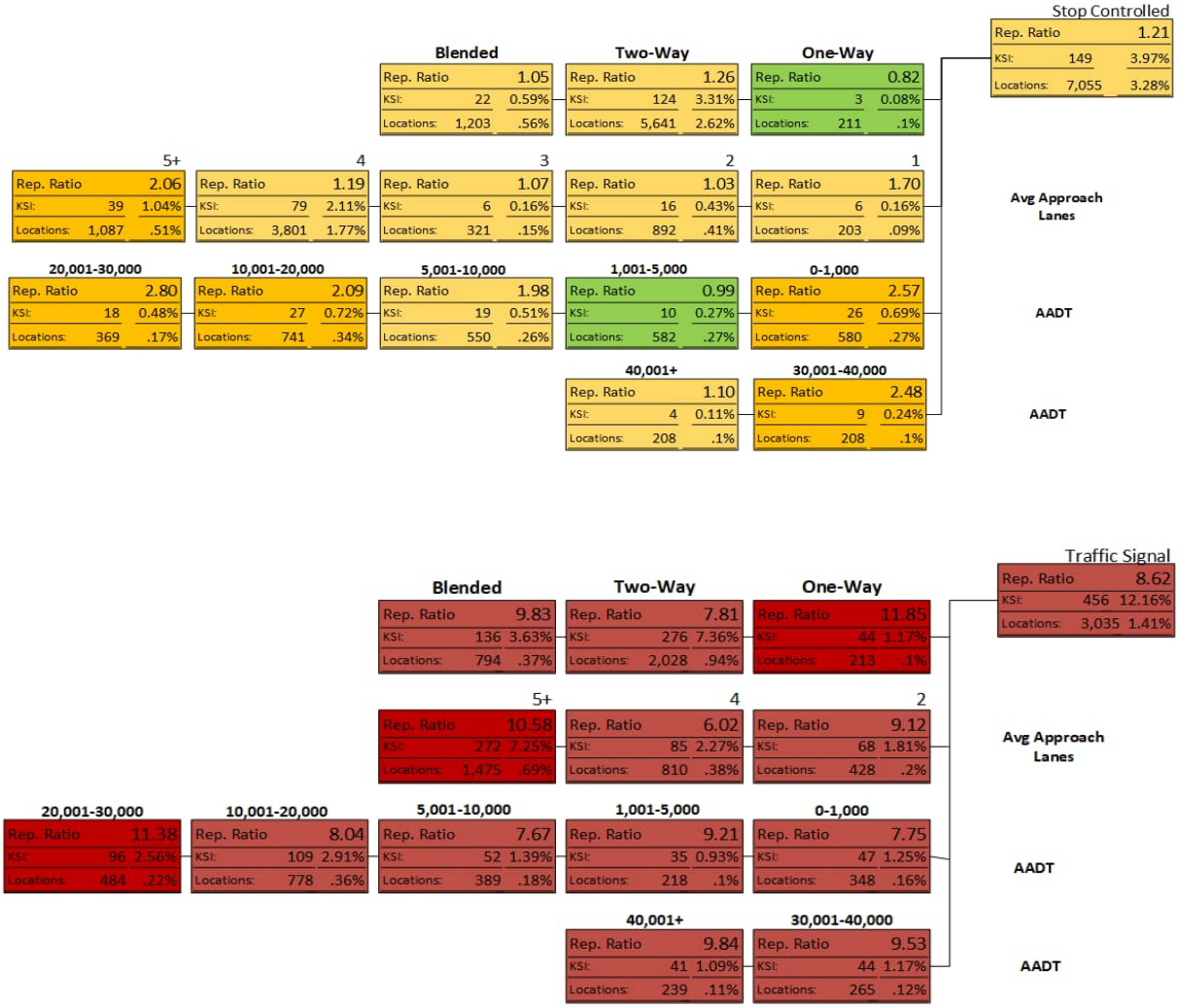


Figure 230: Urban Core Vehicle Only Crashes Intersection Crash Tree

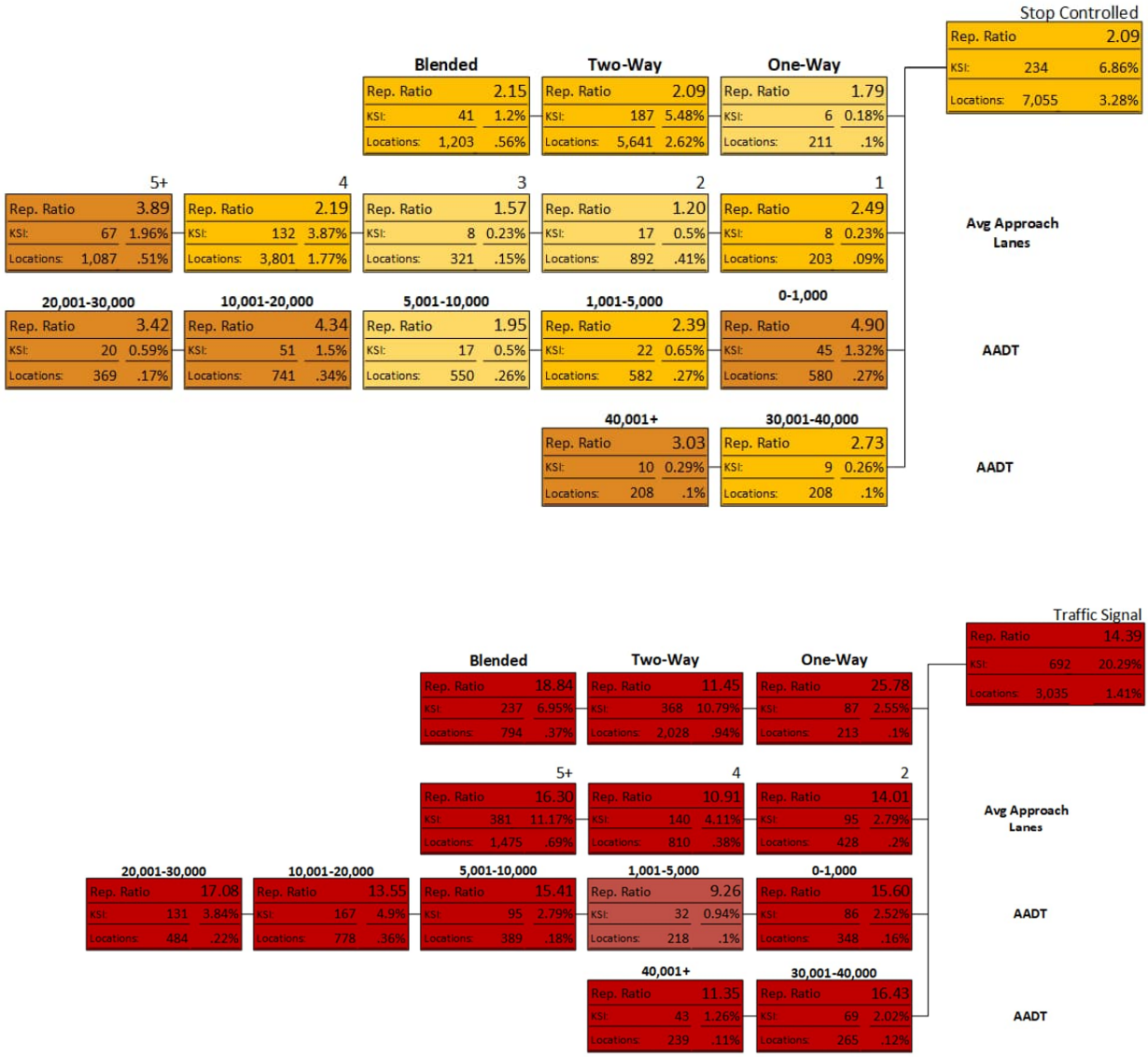


Figure 231: Urban Core Bike/Ped Crashes Intersection Crash Tree

High Risk Network Development

As part of the systemic analysis a high-risk network was identified by identifying the top risk factors and then selecting streets based on those risk factors. The risk factors used to identify the high risk network included:

- Motor Vehicle High Risk Network:
    - All Area Types 4-Lane, Two-Way Undivided Roads
    - Urban Core Areas: 2-4 Lane One-Way Roads
    - Suburban & Rural 4-Lane Roads >= 35mph average speeds with 4 lanes (any configuration)
    - Urban and Urban Core Areas with =<40 mph speeds on streets with 4 lanes (any configuration)

- Bike/Ped High Risk Network:
    - All Area Types 4-Lane, Two-Way Undivided Roads
    - Urban Core Areas: 2-4 Lane One-Way Roads
    - All Area Types with average speeds <= 40 mph on streets with 4 lanes (any configuration)

After the high risk network was generated, statistics were taken from that network. These are the highlight statistics of the high risk network:

- Motor Vehicle High Risk Network:
    - 1,359 KSI crashes on network (16.3% of all MV KSI crashes)
    - 1,189 miles (4.4% of all miles)
    - 1.14 KSI crashes per mile on network vs 0.31 crashes per mile off-network
    - Generalized representation ratio of 3.70 (i.e., these roads are 3.7 times more likely to have a KSI crash than average)
- Bike/Ped High Risk Network:
    - 1,286 KSI crashes on network (22.0% of all BP KSI crashes)
    - 977 miles (3.6% of all miles)
    - 1.32 KSI crashes per mile on network vs 0.21 crashes per mile off-network
    - Generalized representation ratio of 6.11 (i.e., these roads are 6.11 times more likely to have a KSI crash than average)

In addition to these statistics, Table 9 shows statistics related to equity. Approximately 23% of the high risk network segments are in equity priority communities, but only 12% of our Bay Area roads are in equity priority communities. This means that these communities have nearly double the amount of high risk infrastructure than the Bay Area on average.

Table 9: High Risk Network Statistics

Mode	Length (mi)	Length in EPC	Percent in EPC	Percent All Roads in EPCs
Motor Vehicle HRN	1188.65	276.35	23.2%	12.1%
Bike/ Ped HRN	976.9	225.02	23.0%	

High Risk Network Maps

The risk factors presented in the previous section were used to create high risk network (HRN) maps. Streets were queried in the BAYVIZ system to identify which streets within the Bay Area contained the risk factors noted. Only local access roads were queried for this exercise. Controlled access highways are not included in the HRN map development. The streets and risk factors were queried separately for rural areas and

urban areas, but the maps have been combined to provide one HRN map for vehicle-only crashes and one HRN map for bicycle and pedestrian crashes. These maps are included on the following pages as Figure 232 and Figure 233. The maps can also be viewed online using this link: https://reports.mysidewalk.com/413fcf7619

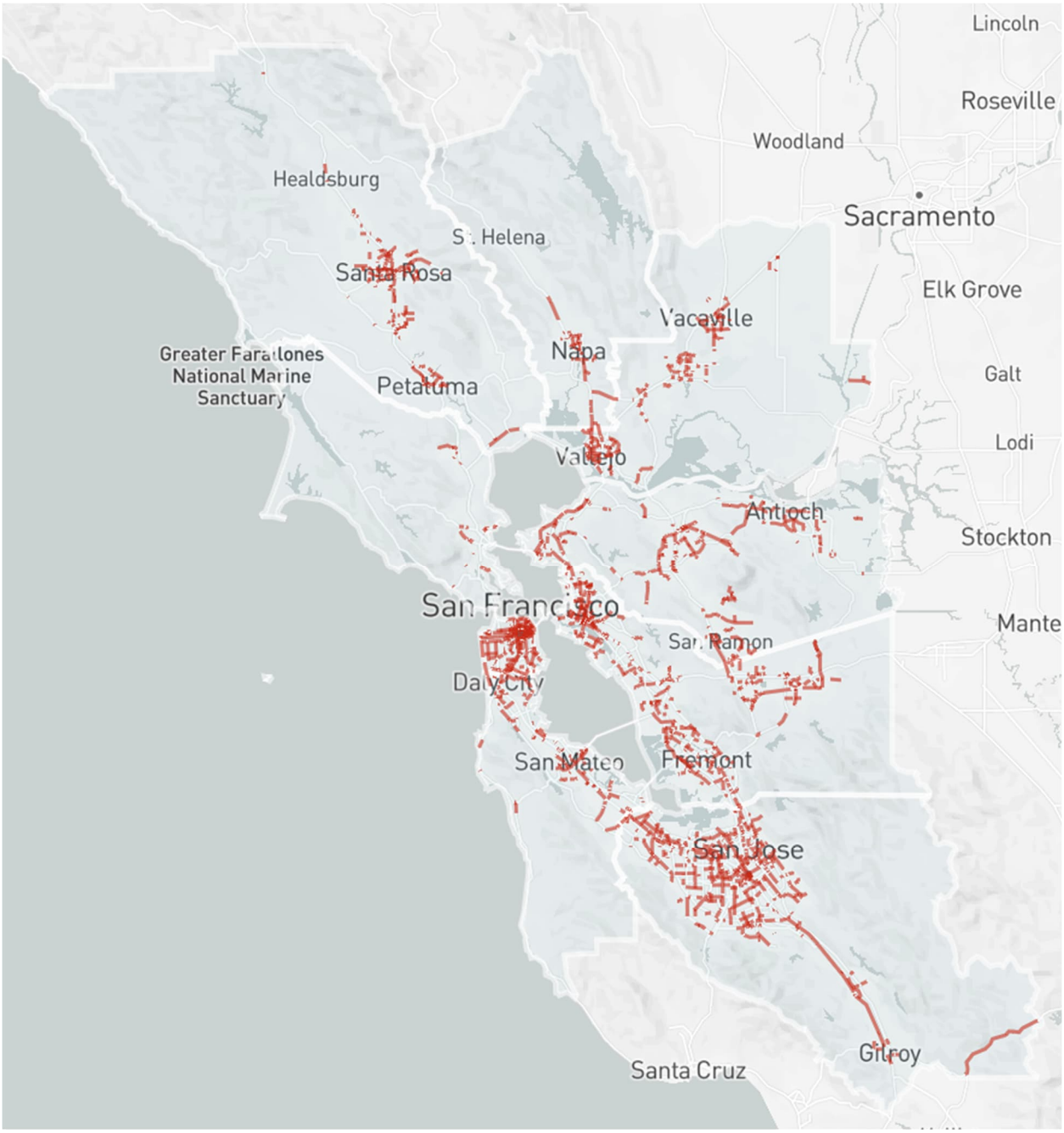


Figure 232: Vehicle-Only High-Risk Network (https://reports.mysidewalk.com/413fcf7619)

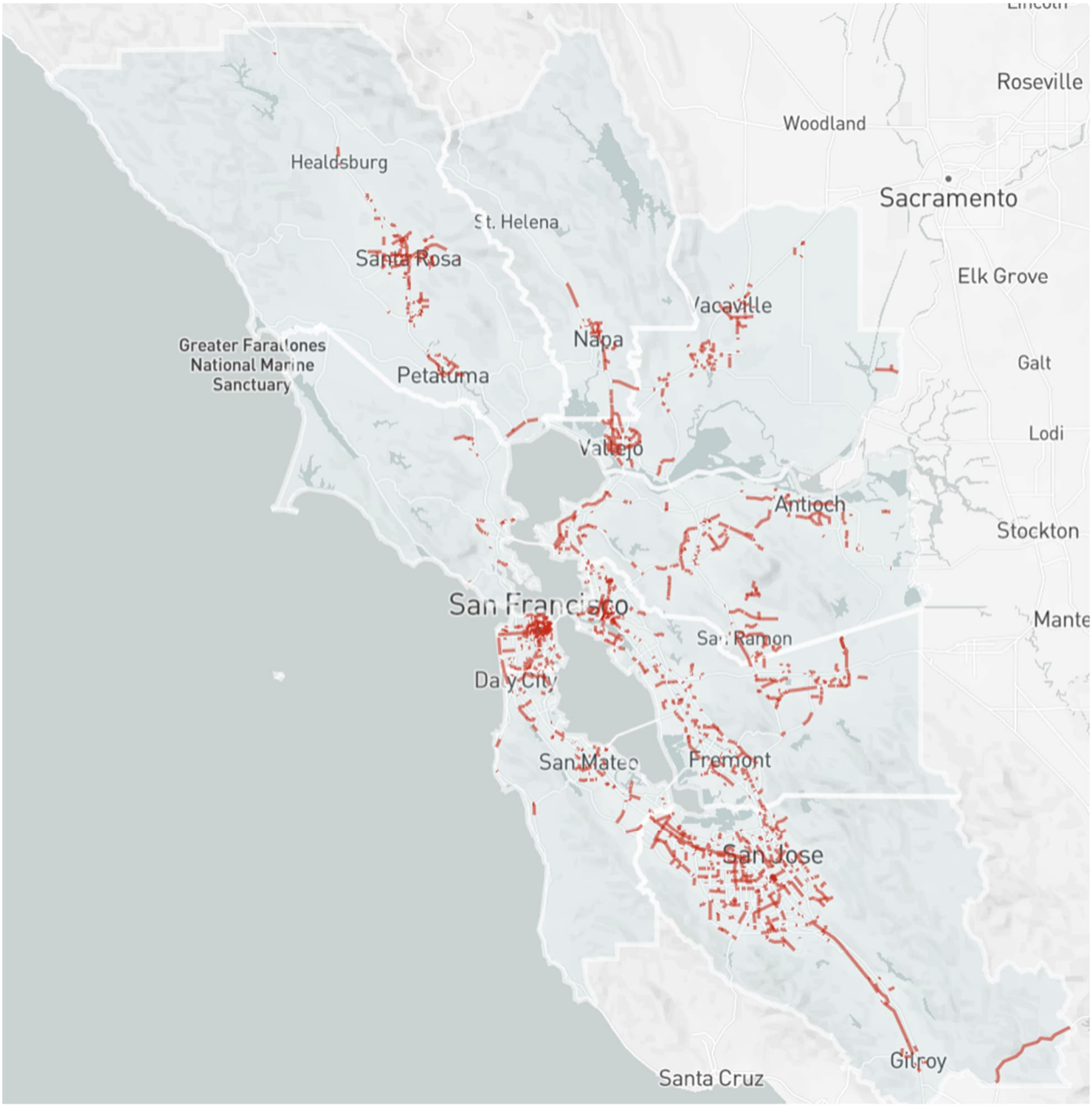


Figure 233: Bicycle and Pedestrian High Risk Network (https://reports.mysidewalk.com/413fcf7619)

Crash Locations and Mapping

In addition to mapping specific roadway corridors as High Injury Network corridors and High Risk Network corridors, it is useful to map neighborhood based crash frequency. Sometimes crashes are distributed throughout a neighborhood, and not concentrated on a specific corridor. In other cases, a concentrated set of high injury network corridors in one neighborhood, such as in the urban core areas, will lead to an entire area having an elevated concentration of crashes.

After mapping based on a variety of factors, it was found that mapping crash concentrations against total centerline mile in a census tract provided the most meaningful mapping. This approach avoids over-representing large rural census tracts when mapped based on absolute number or rate per land area. The approach also avoids over-representing areas with low residential population, as can happen when mapping against number of residents in a census tract.

The rate maps are shown in the following figures, but can also be accessed online using this link: https://reports.mysidewalk.com/16b9f54356

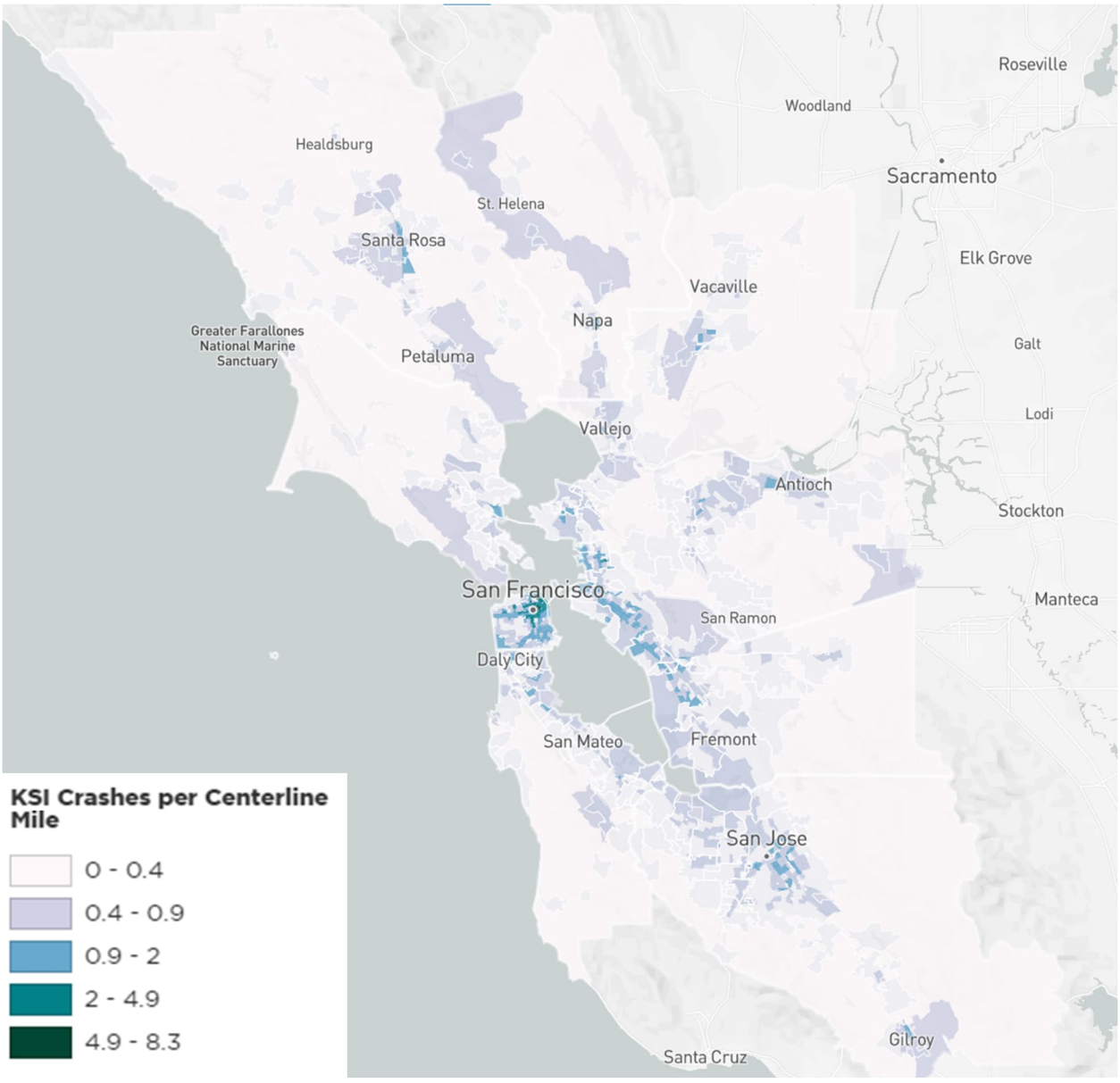


Figure 234: All KSI Crashes per Census Tract and per Centerline Mile (https://reports.mysidewalk.com/16b9f54356)

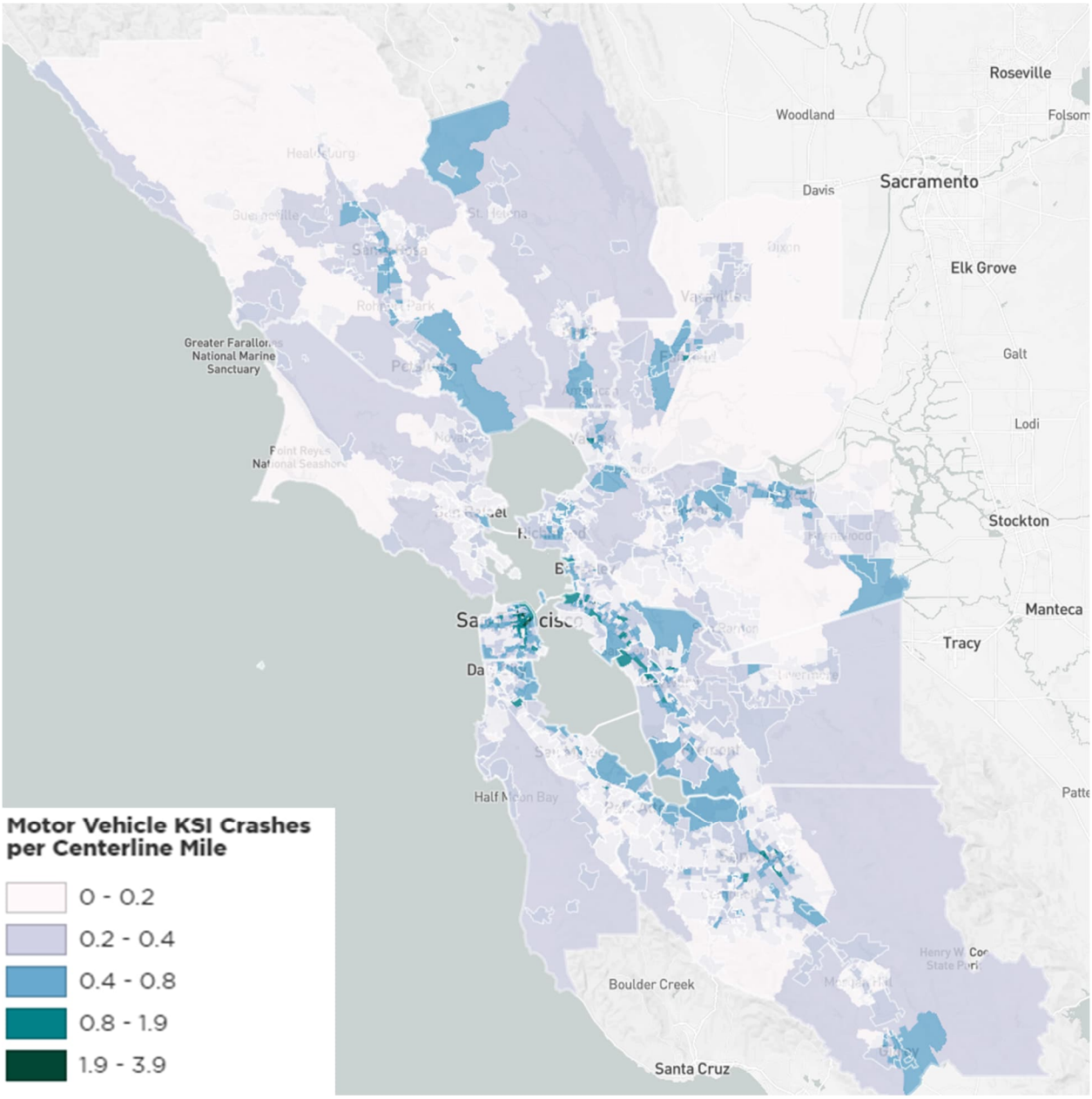


Figure 235: Vehicle KSI Crashes per Census Tract and per Centerline Mile (https://reports.mysidewalk.com/16b9f54356)

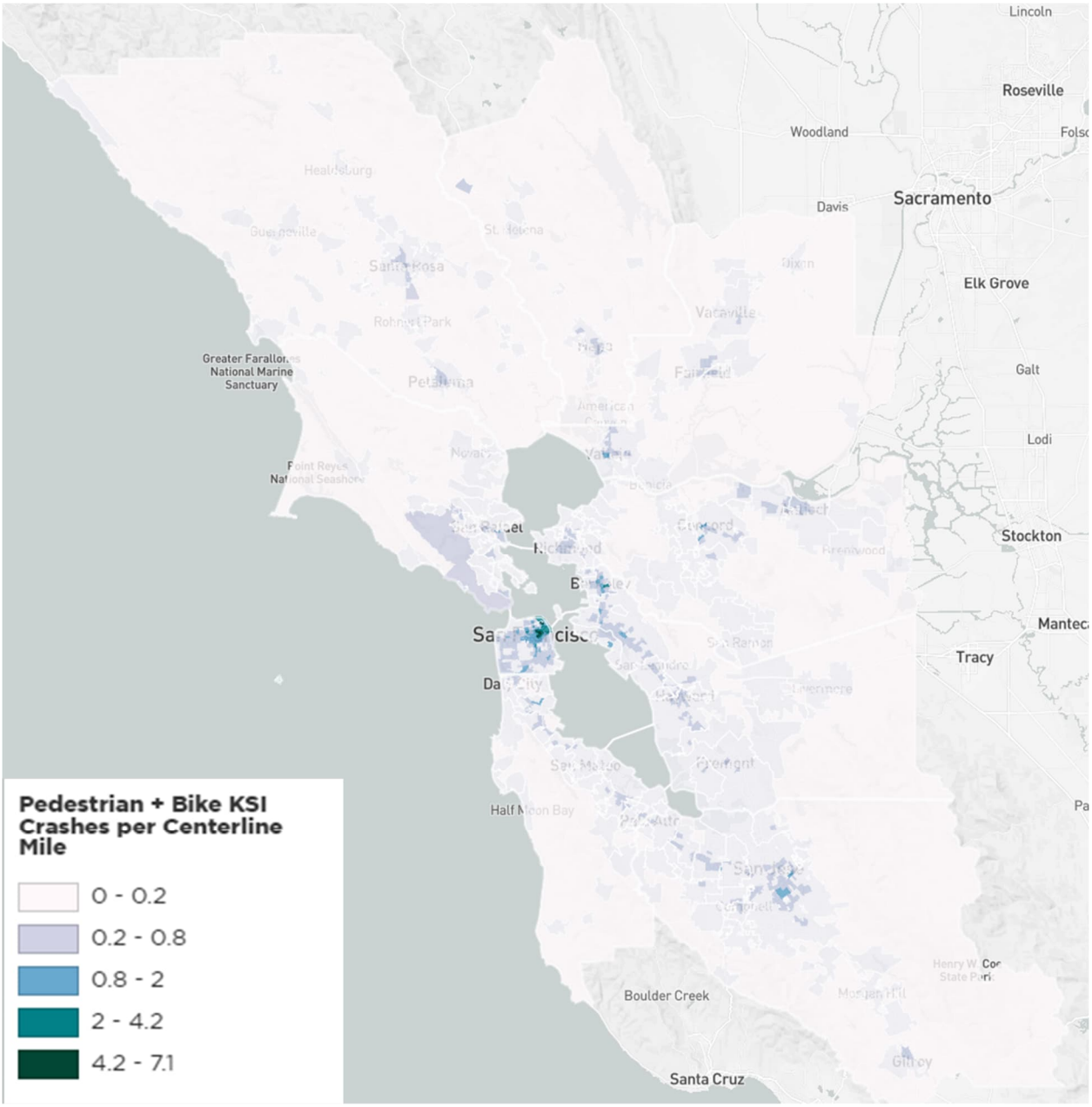


Figure 236: Bicycle and Pedestrian KSI Crashes per Census Tract and per Centerline Mile (https://reports.mysidewalk.com/16b9f54356)

Action Plan

This action plan is the vehicle that will allow us to achieve Vision Zero in the Bay Area. Achieving zero deaths and zero serious injury crashes is a major undertaking and requires focused actions. The action plan is based on three primary elements:

- Challenge Areas, which provide specific issues for the action plan to address
- Countermeasures, which provide fundamental strategies to address focus area issues
- Action Steps, which provide specific actions to be taken to implement countermeasures

Challenge Areas

Challenge Areas are the first elements of the action plan. These are the factors that have the most significant contribution to the high number of fatal and serious injury crashes as identified by MTC. By focusing on addressing the safety issues specific to these areas, we can more effectively target our countermeasures.

Fundamental Issues

Equity

To achieve Vision Zero in the Bay Area, we must identify, engage, and support traditionally underserved places and people and prioritize improvements in these communities.

Equity is among the most important issues in traffic safety and Vision Zero implementation. Issues related to race, gender, and class do not exist in a vacuum. Equity issues related to poverty and race are very apparent in traffic crashes, especially in equity priority communities of the Bay Area. These neighborhoods and users are disproportionately impacted by traffic crashes. When looking at transportation safety through an equity lens we see:

- Black and indigenous road users are 77% more likely than the average user to be killed or seriously injured in a traffic crash, as shown in Figure 237.
- Crash risk is higher in equity priority communities regardless of whether the community is in a rural, suburban, urban, or urban core area.
- A higher concentration of high injury corridors exist in equity priority communities:
    - 29% of all HIN corridors are in EPCs, but just 12% of Bay Area road-miles are in EPCs
    - 38% of pedestrian HIN corridors are in EPCs, with only 12% of Bay Area road-miles in EPCs.

- A higher concentration of high-risk corridors exist in equity priority communities: approximately 23% of the high risk network segments are in equity priority communities, but only 12% of our Bay Area road-miles are in equity priority communities.

Everyone in the Bay Area deserves access to a safe transportation system.

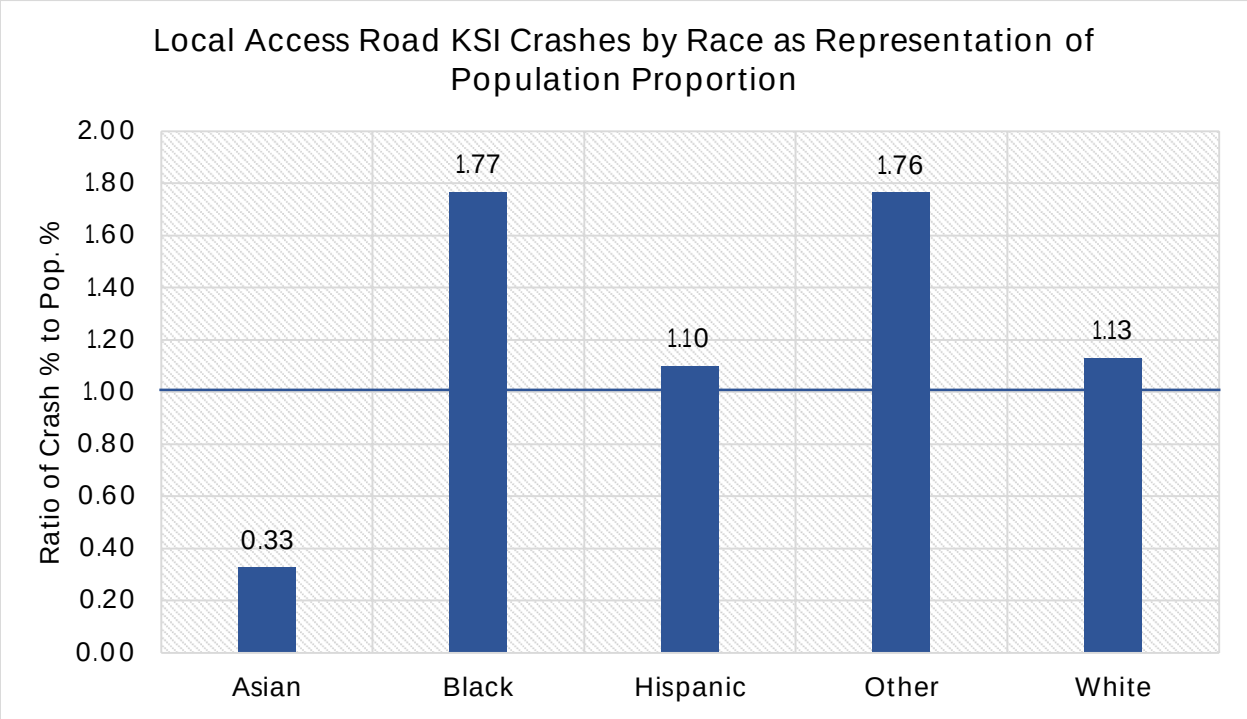


Figure 237: Local Access Roads KSI Crashes by Race as a Representation of Population (>1.0 = Over-Representation)

Speed

To achieve Vision Zero in the Bay Area, we must reduce driver speed.

As drivers' speeds increase, crashes tend to happen more often and result in more severe crashes. This is especially true for people walking and biking who do not have the protections vehicle occupants have in a crash. People walking and biking have dramatically different outcomes with small differences in vehicle speeds. A user outside a car has only a 10% chance of being killed when hit at 23 mph. That user has a 50% chance of being killed at 42 mph. At 58 mph, the user has a 90% chance of being killed.[6] Reducing speed is a fundamental aspect of the Safe System approach and achieving Vision Zero.

Unsafe speed was the top contributing circumstance noted by law enforcement officers in KSI crashes in the Bay Area. This is like an under-representation. Often law enforcement officers are hesitant to note unsafe speed in a KSI crash because it is

[6] https://www.transportation.gov/sites/dot.gov/files/2022-02/USDOT-National-Roadway-Safety-Strategy.pdf

challenging to prove in a court if criminal charges are filed against a driver. Speed was also among the most consistent factors in increasing risks on roadways for vehicle crashes. High speeds are a danger to all users of the road. In suburban & rural areas 4-Lane roads with speeds greater than 35 mph average speeds were identified as high risk regardless of configuration. In Urban and Core Areas roads with speeds greater than 40 mph speeds fell into the high-risk category as well.

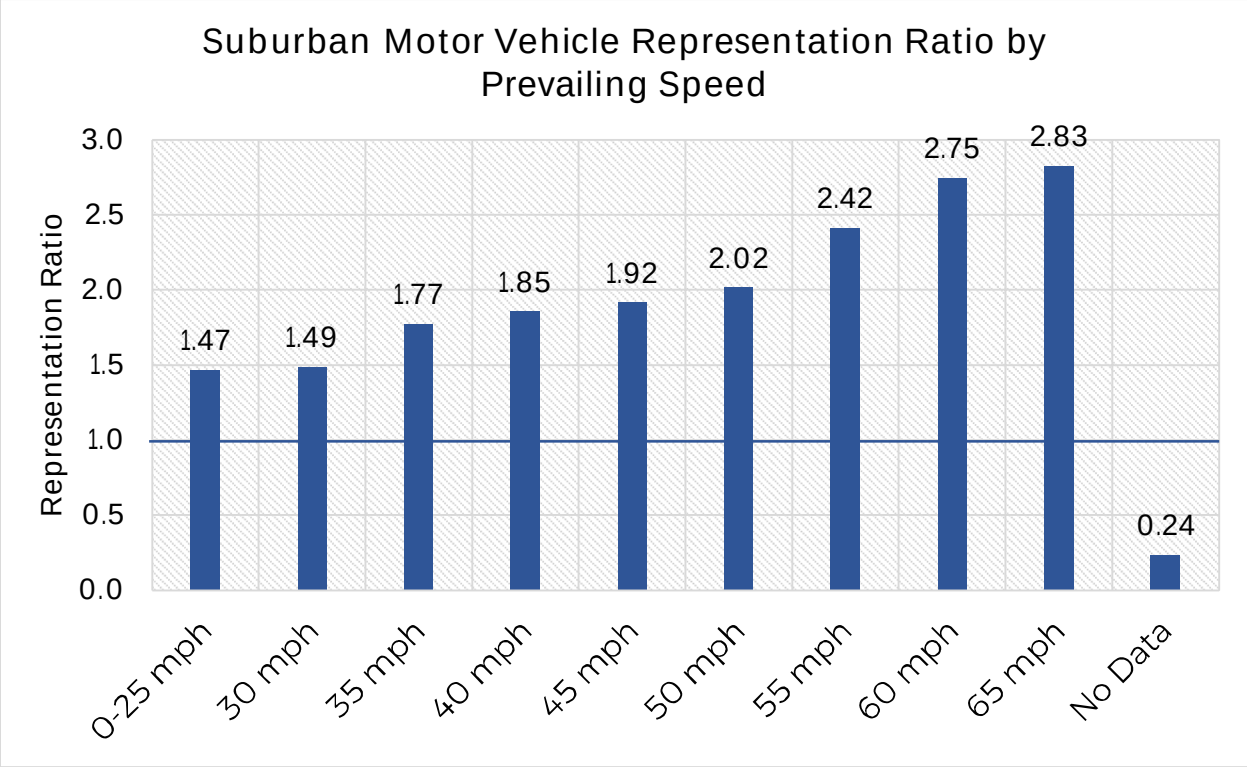


Figure 238: Segment Representation Ratio for Motor Vehicle Crashes by Prevailing Speed in Suburban Areas

High Crash Locations

High Injury Network

To achieve Vision Zero in the Bay Area, we must focus our safety efforts on areas with a high concentration of fatal and serious injury crashes on the High Injury Network.

Fatal and serious injury crashes are not evenly distributed across a roadway network. Certain road corridors and intersections have a much higher concentration of fatal and serious injury crashes than others. The Bay Area High Injury Network (HIN) illustrates this. 34% of the fatal and serious injury crashes in the city occurred on just 2% of roads. These roads have a fatal and serious injury crash rate 17 times higher than a road not on the High Injury Network. A table of some statistics can be seen in Table 10.

These high crash locations are closely tied to equity. About 12% of the roads in the Bay Area are in Equity Priority Communities. The HIN is more concentrated in these areas, with 29% of the HIN located in disadvantaged areas. This is more than double the

proportion of HIN roads in disadvantaged areas compared to average roads. This can be seen in Table 11. The full Bay Area High Injury Network can be viewed here: https://reports.mysidewalk.com/b5ef0ba311

Table 10: High Injury Network Statistics

Road Users	HIN KSI	Region KSI	HIN Miles	% of Crashes	% of Miles
All Modes					1.9%
Vehicle	1,365	5,531	623.4	24.7%	2.1%
Pedestrian	707	2,373	255.3	29.8%	0.9%
Bicyclists	533	1,227	357.6	43.4%	1.2%

Table 11: High Injury Network Statistics Related to Equity

Road Users	Miles in EPCs	HIN Miles	% HIN Miles in EPCs	% of Overall Centerline Miles in EPCs
All Modes				
Vehicle	99.2	623.4	15.9%	
Pedestrian	96.5	255.3	37.8%	
Bicyclists	81.2	357.6	22.7%	

High Risk Roads

To achieve Vision Zero in the Bay Area, we must systemically eliminate high risk infrastructure throughout the region.

While working to improve the safety in the Bay Area, it will be important to not only focus on improving the roadways where KSI crashes are occurring in high concentrations along the High Injury Network, but also the roadways with attributes that were shown to have a strong correlation with increased risk of higher severity crashes. Fatal and serious injury crashes are inherently rare when looking at an entire transportation system, and we shouldn't wait for someone to be killed or seriously injured on a road or at an intersection before we act. To be more proactive, we can change high risk streets and intersections where there is a high probability of a future KSI crash occurring to minimize that risk. Using a systemic risk analysis, the following roads were found to be the highest risk in the Bay Area:

- High risk roads for motor vehicles:
    - 2 to 4-lane one-way streets in urban core areas

    - 4-lane undivided streets in all areas
    - 4-lane divided streets with 35mph and higher average speeds in suburban and rural areas
    - 4-lane divided streets with 40 mph and lower speeds in urban and urban core areas
- High risk roads for pedestrians and cyclists:
    - 2 to 4-lane one-way streets in urban core areas
    - 4-lane undivided streets in all areas
    - 4-lane divided streets with 40 mph and lower speeds in all areas

These roads were mapped as the Bay Area High Risk Network for motor vehicles and for pedestrians/cyclists. The motor vehicle high risk network has 3.7 times higher KSI crash rate than other streets. The pedestrian/cyclist high risk network has 6.3 times more KSI crashes than other streets.

Additionally, approximately 23% of the high risk network segments are in equity priority communities, but only 12% of our Bay Area roads are in equity priority communities. This means that these communities have nearly double the amount of high risk infrastructure than the Bay Area on average.

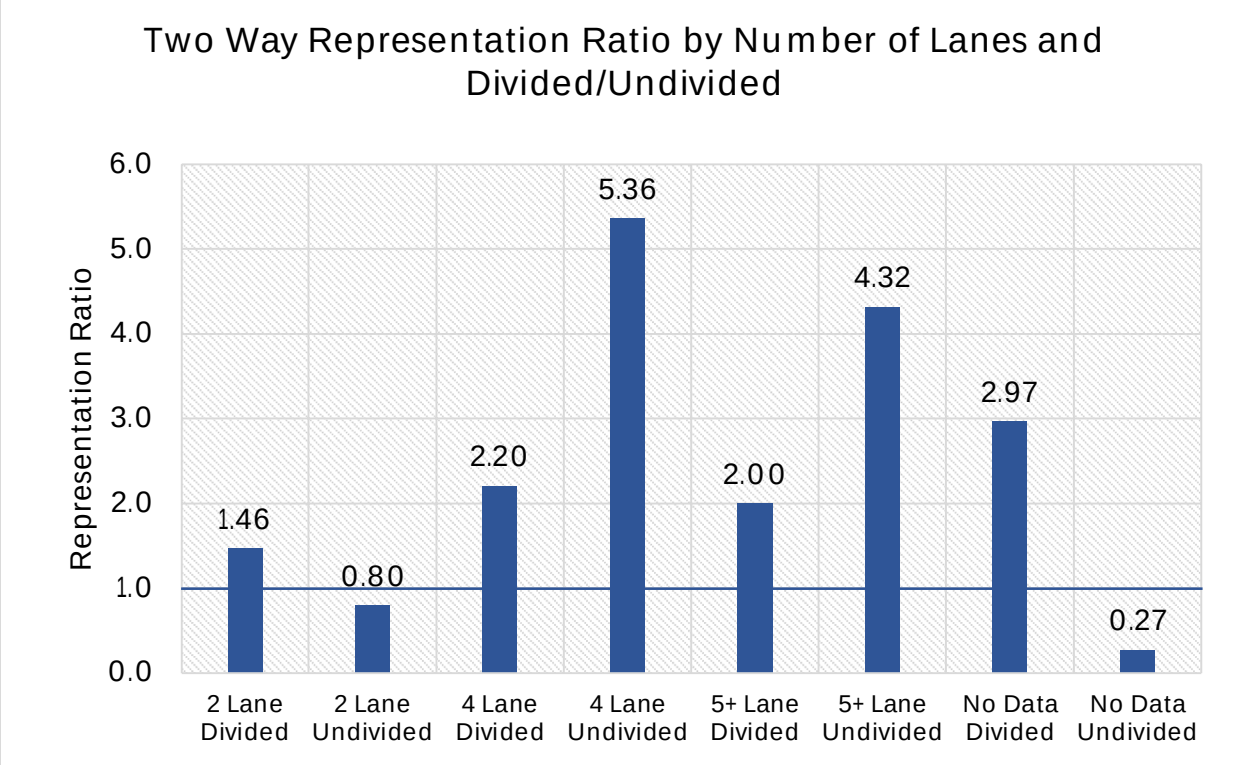


Figure 239: Two Way Representation Ratio by Number of Lanes and Divided/Undivided

Traffic Signals

To achieve Vision Zero in the Bay Area, we must address the acute safety issues at traffic signals.

Traffic signals are the highest risk type of intersection in the Bay Area. Risk of a fatal or serious injury crash is roughly 15 times higher at a signalized intersection compared to a stop controlled intersection or a roundabout. This disparity can be seen in Figure 240. Traffic signals serve a singular purpose—to create gaps in traffic flow to facilitate minor movement access. Traffic signals are not safety treatments, and they nearly always increase congestion on a street. Based on the data in the systemic risk analysis, it has become clear that the very presence of a traffic signal increases risk. The risk of KSI crashes at a traffic signal is practically independent of number of approach lanes, vehicle volumes, and whether the signal is at the intersection of one-way or two-way streets. The very presence of the traffic signal creates the crash risk.

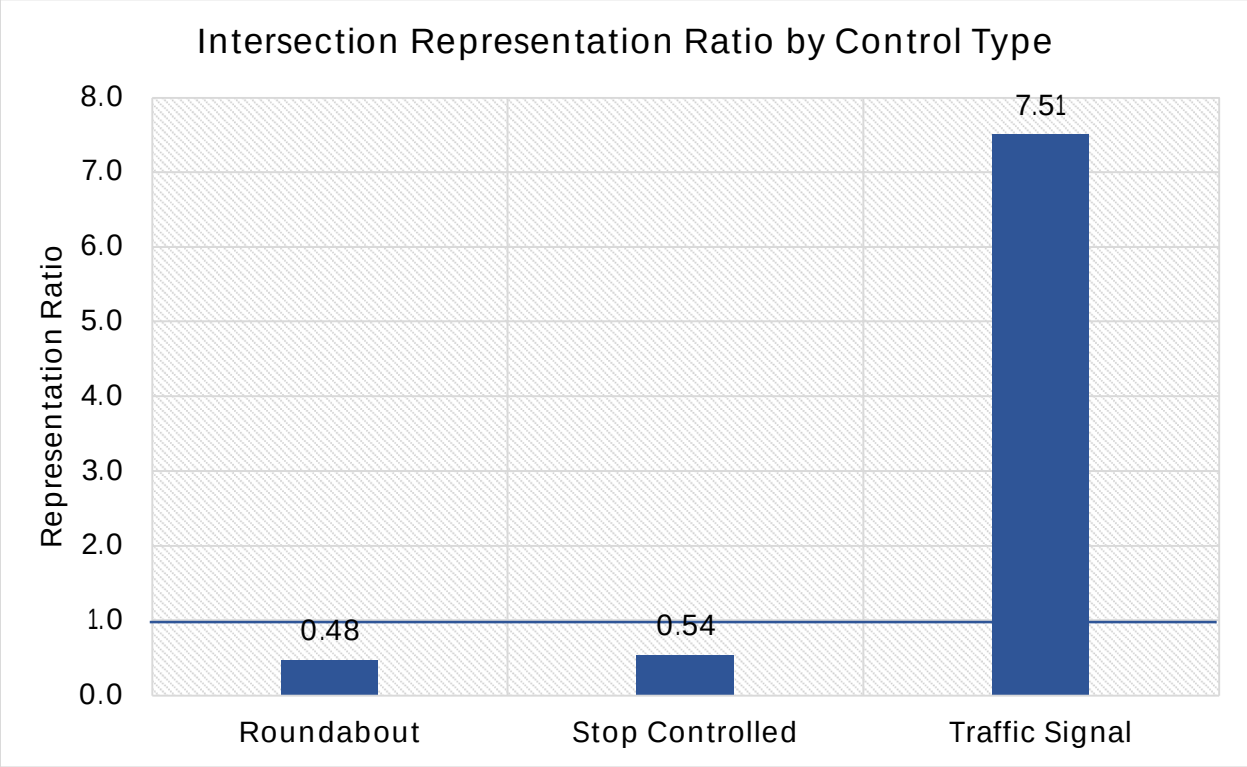


Figure 240: Intersection Representation Ratio by Type

Emphasis Crash Types

Pedestrians and Cyclists Crashes

To achieve Vision Zero in the Bay Area, we must focus on the safety of people walking and biking.

The Bay Area is a community with a high level of walking, biking, and transit usage. It contains many walkable, bikeable neighborhoods, and is home to many active residents who enjoy walking and biking for recreation and transportation. The Bay Area is also home to many people who rely on walking, biking, and transit to get around, especially in our equity priority communities.

This high rate of walking and biking in the region has led to an even higher rate of people being killed or seriously injured on our roads. In the Bay Area, 15% of KSI crashes involve cyclists, and 25% of KSI crashes involve pedestrians. Considering walking and biking mode share is approximately 2% cyclists and 15% pedestrians, these users are highly over-represented in terms of risk. When looking at areas within ½ mile of a BART station, the share of bicycle and pedestrian KSI crashes is over 50%.

Bicycle and pedestrian KSI crashes are also much more highly concentrated than motor vehicle only KSI crashes. 30% of the pedestrian KSI crashes happened on just 0.9% of Bay Area roads, and 43% of bicycle KSI crashes happened on just 1.2% of Bay Area roads. These pedestrian and cyclist High Injury Network segment are also highly concentrated in equity priority areas. 38% of pedestrian and 23% of cyclist HIN segments are in equity priority areas, compared to 12% of all streets in equity priority areas.

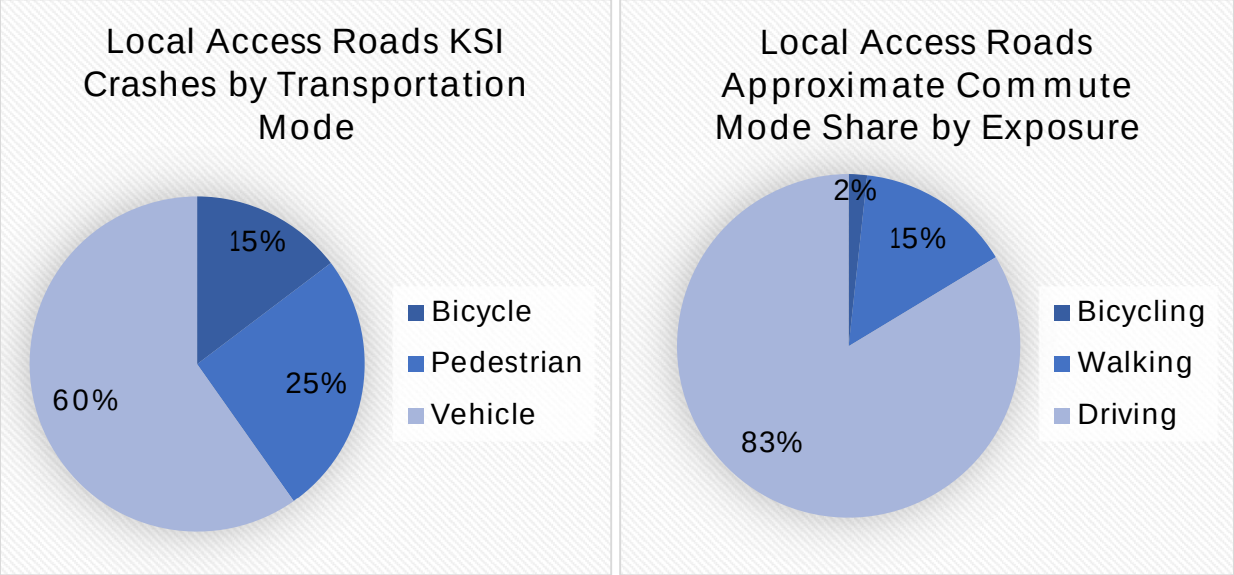


Figure 241: Local Access Roads KSI Crashes by Mode Share and by Exposure

Motorcycle Crashes

To achieve Vision Zero in the Bay Area, we must focus on the safety of motorcyclists.

Motorcyclists carry significantly increased risk of being seriously injured or killed while riding. Motorcyclists operate at the same speeds as cars and often in heavy traffic but with virtually no safety equipment to protect them in case of a crash. Many drivers also do not understand the operating characteristics of a motorcycle and can inadvertently create a dangerous situation unknowingly. All these things combine to create an extremely high proportion of motorcycle KSI crashes compared to motorcycle usage. 21% of all KSI crashes in the Bay Area involve motorcycles, and 28% of KSI crashes on controlled access highways involve motorcycles. This can be seen in Figure 242. Motorcyclists only account for 0.4% of commute mode trips in the Bay Area. This means that motorcyclists may be as much as 50 times more likely to be killed or seriously injured in a traffic crash than the average user.

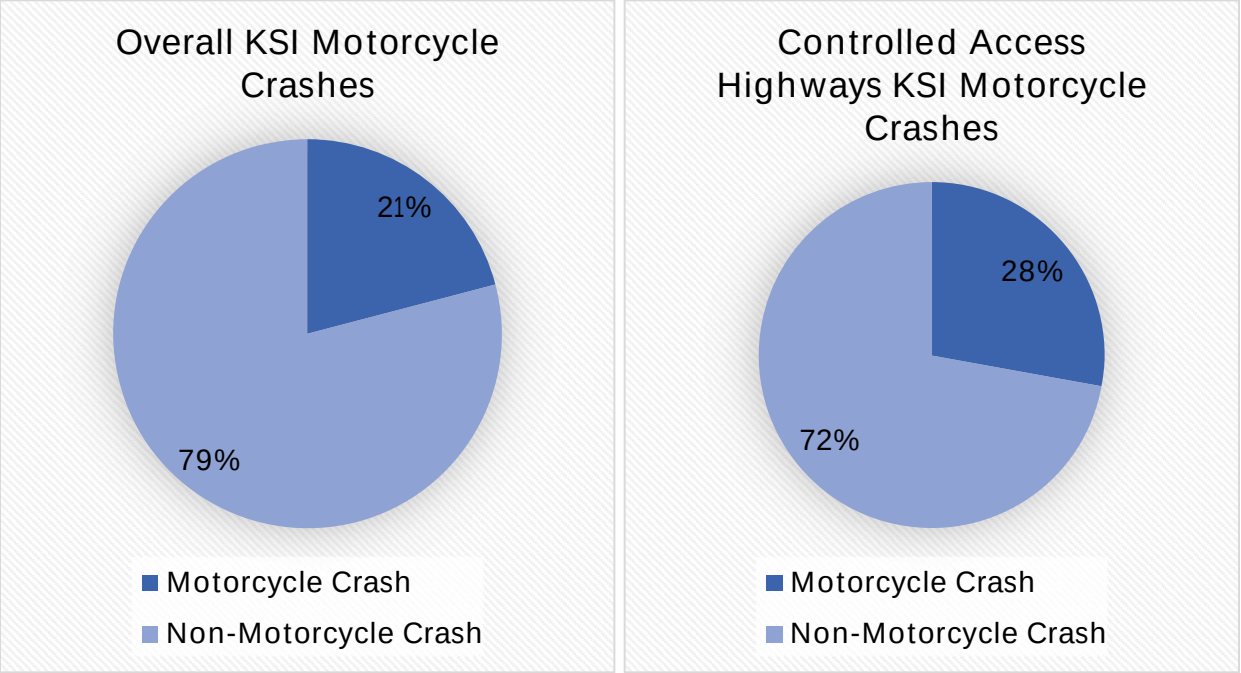


Figure 242: Overall KSI Motorcycle Crashes

Broadside Crashes

To achieve Vision Zero in the Bay Area, we must reduce the number and severity of broadside crashes.

A broadside collision is a car accident that occurs when the front of one vehicle impacts the side of another vehicle. Although all types of car crashes can result in severe injuries or deaths, broadside collisions are particularly prone to severe outcomes. Broadside crashes often result in severe injurie and fatalities due to vehicles having less impact protection on the side of the vehicle compared to the front or back. Broadside crashes are the top vehicle KSI crash type at intersections in the Bay Area, regardless of the land use context. Shown in Figure 243 below; broadside crashes accounts for over 1,000 severe injury and fatal crashes from 2015 to 2019. Most broadside crashes occur at signalized intersections, but other locations such as where minor streets meet major arterial streets are also common locations for broadside crashes.

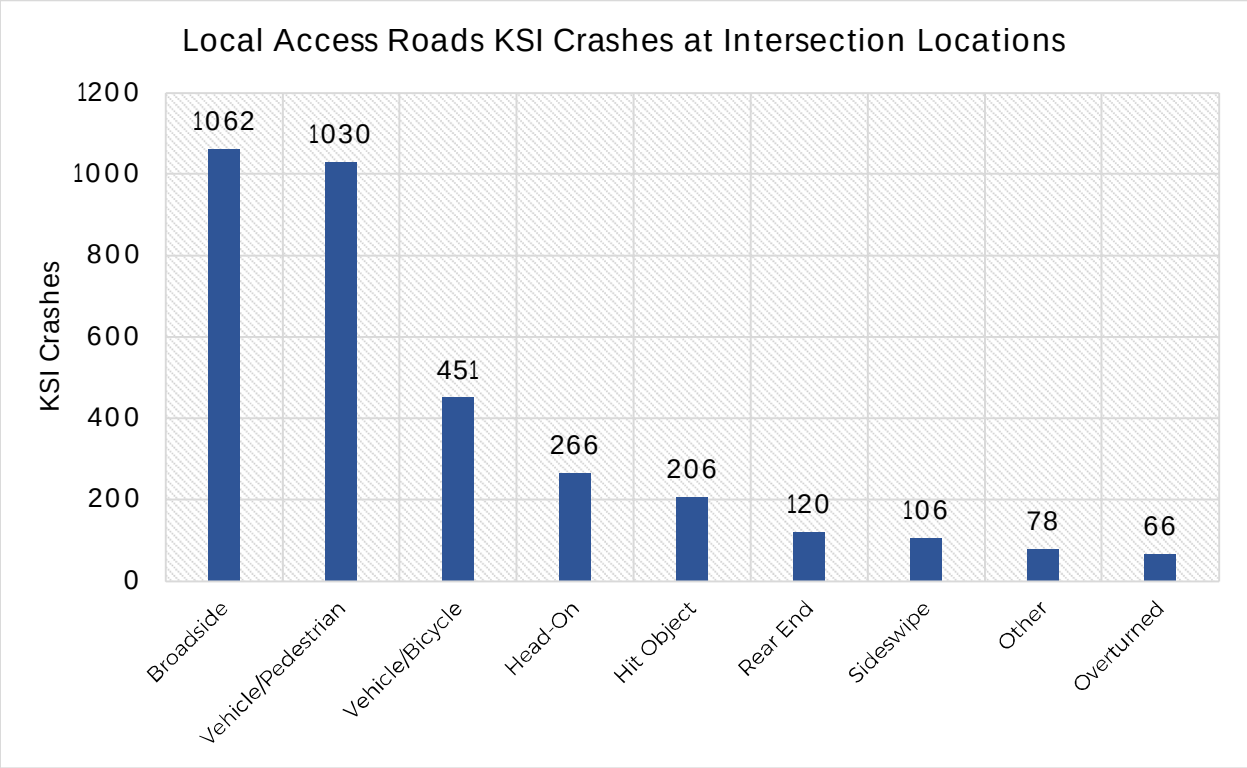


Figure 243: Local Access Road KSI Intersection Crash Types

Rural Lane Departure Crashes

To achieve Vision Zero in the Bay Area, we must reduce the number and severity of lane departure crashes in rural areas.

Rural areas make up most of the land area in the Bay Area, but only a small amount of the population. Rural areas also account for the 2nd highest amount of fatal and serious injury crashes after suburban areas. Like the more urban areas, these crashes are concentrated into a small number of roadways on the High Injury Network. Many of these roads are winding, scenic, two-lane roads in hilly areas. These roads are prone to crashes that involve a vehicle departing it's lane, either crossing an edge line or a center line of the road. Roadway departure crashes are the largest KSI crash type on rural roads by a wide margin. These include collision with fixed objects, overturned, head-on, and sideswipe crashes. Combined these crashes account for roughly 60% of all the rural KSI crashes and account for over 1,700 fatal and serious injury crashes from 2015 - 2019. These crashes are shown in Figure 244.

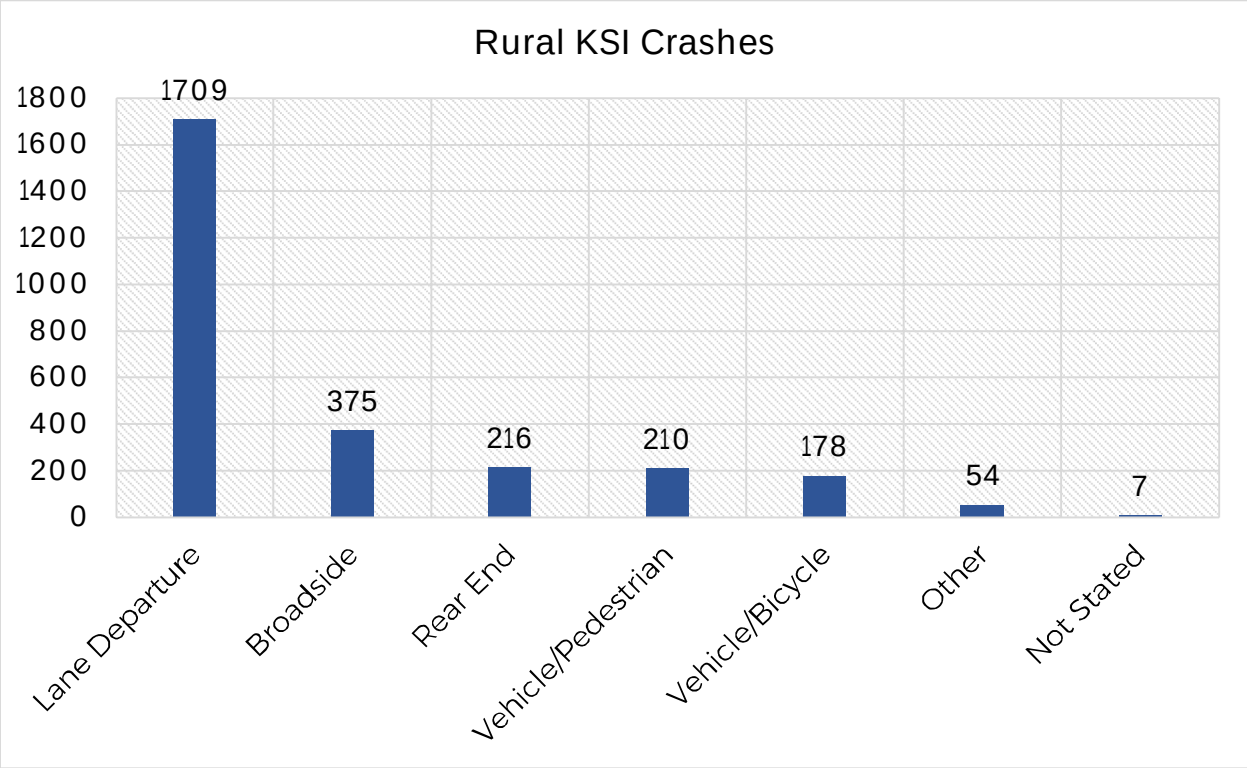


Figure 244: Rural KSI Crash Types

Users

Impaired Road Users

To achieve Vision Zero in the Bay Area, we must target educational and enforcement activities at eliminating impaired driving.

A basic tenant of the Vision Zero and Safe System approach is that humans will make mistakes and they shouldn't have to pay with their life. The goal is to create a safety system of layered countermeasures that don't result in someone killed or seriously injured on roads. However, some driving behavioral mistakes, such as impaired driving is considered reckless or even negligent. Although impairment only accounts for 13% of Bay Area KSI crashes as can be seen in Figure 245, it is still an important behavior to curb. Impaired driving must be addressed through education and enforcement. At the same time, other countermeasures should be applied so that if someone does drive impaired, there is a much lower chance that this behavior results in someone killed or seriously injured.

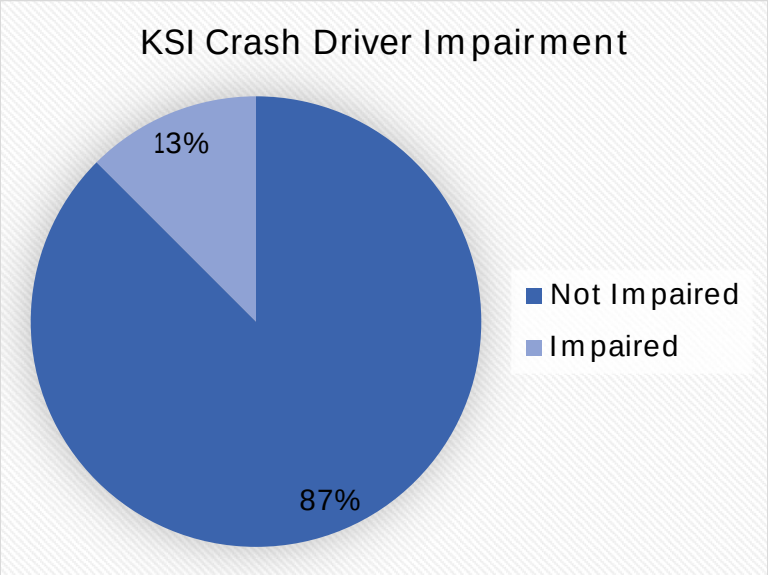


Figure 245: KSI Crashes by Impairment Status

Young Road Users

To achieve Vision Zero in the Bay Area, we must target educational and enforcement activities to young road users.

Young road users under 35 years old are involved in 45% of all KSI crashes in the Bay Area. The only age groups significantly over-represented in terms of KSI crash proportion compared to population proportion are drivers ages 15 – 30 years old. Contrary to popular belief, teen drivers are not the drivers most highly over-represented. The age group with the highest absolute number of KSI crashes and the highest over-representation by population is the 20 – 24 year old age group. This is likely due to the successes of the Graduated Driver's License (GDL) program in California, where teen drivers are significantly restricted in their operation of vehicles without adults present in the car. Drivers ages 20 – 24 have full licenses, are less likely to be driving with an adult, are more likely to engage in risky behavior than other age groups and are still relatively inexperienced drivers. Between 2015 and 2019, more than 1,800 young people ages 20 – 24 were seriously injured or killed in the Bay Area. No other older age group, including elderly road users, are over-represented in KSI crashes when normalized for population.

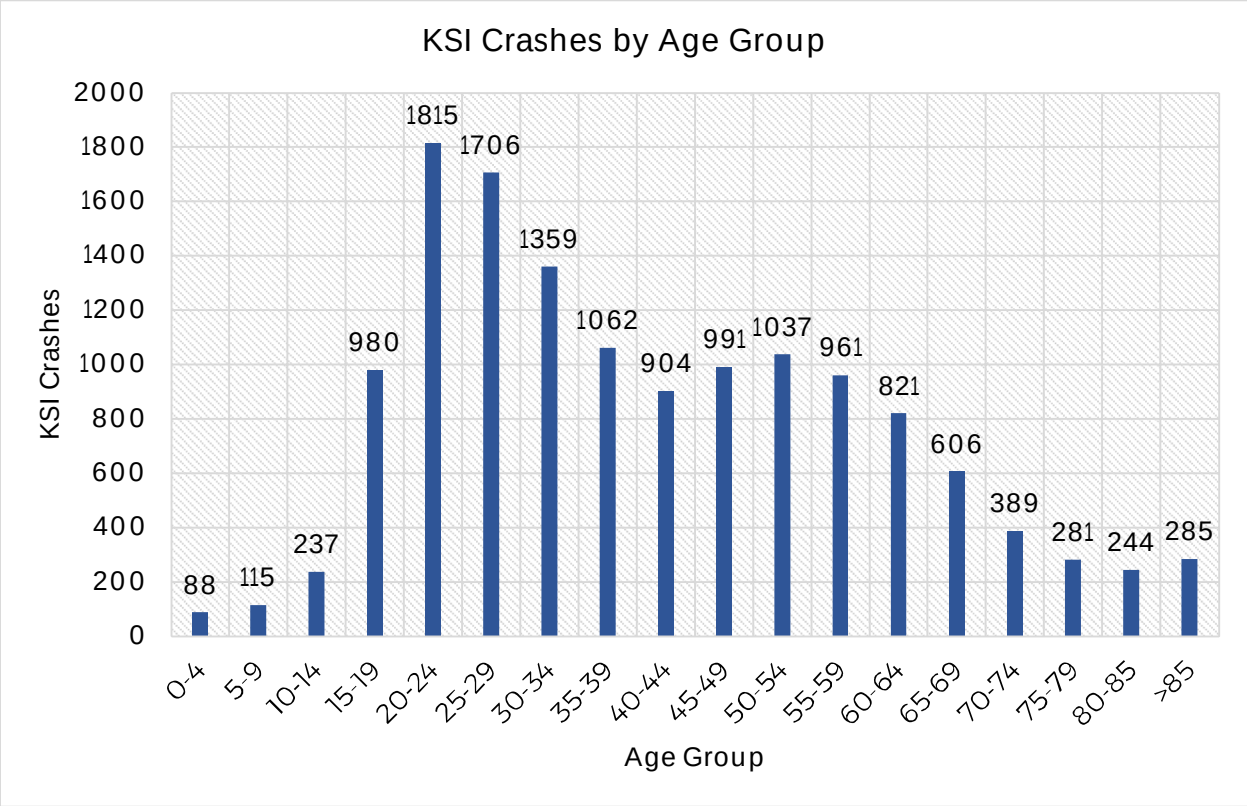


Figure 246: KSI Crashes by Age Group

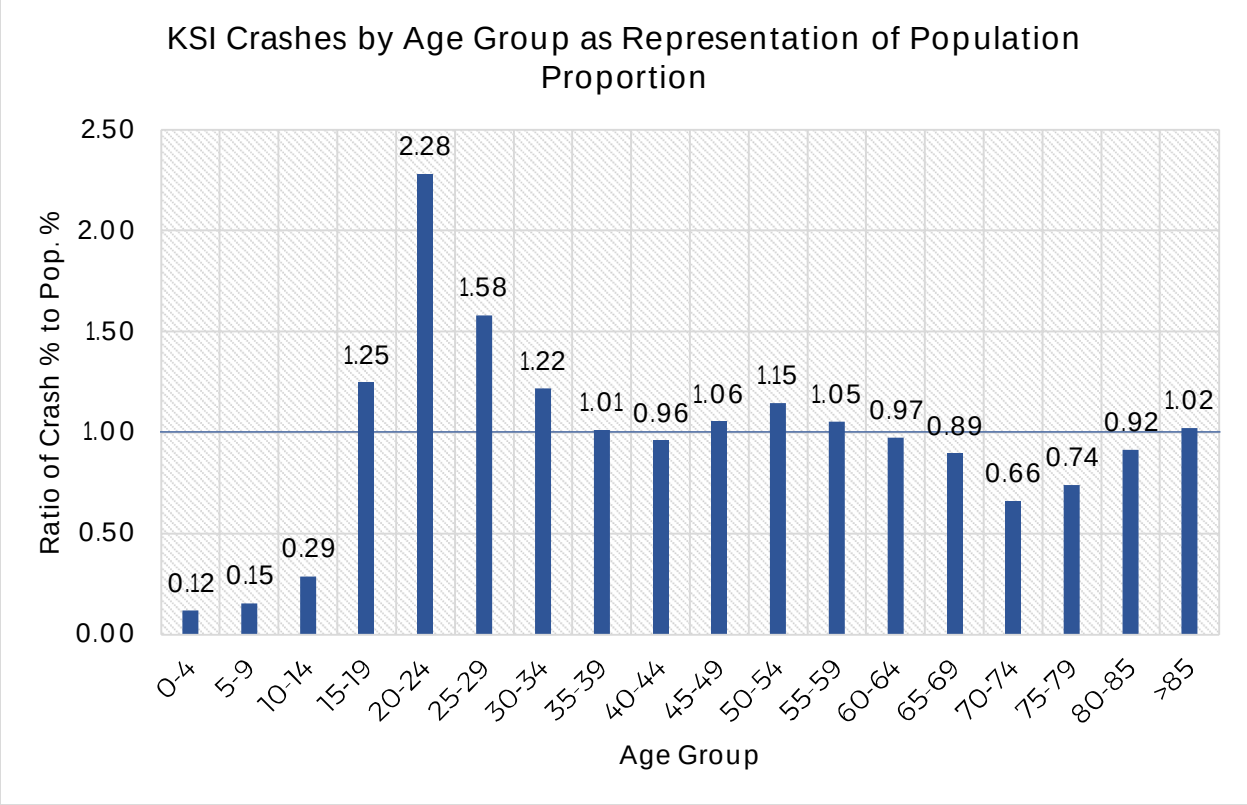


Figure 247: KSI Crashes by Age Group as Representation of Population Proportion

Male Road Users

To achieve Vision Zero in the Bay Area, we must target educational and enforcement activities to male drivers.

Male drivers make up a disproportionate number of KSI crashes compared to females. In the Bay Area, 70% of fatal and serious injury crashes involve male drivers as shown in Figure 248. Factors that may lead to this are that males are responsible for a greater proportion of miles driven and likelier to engage in dangerous behavior.

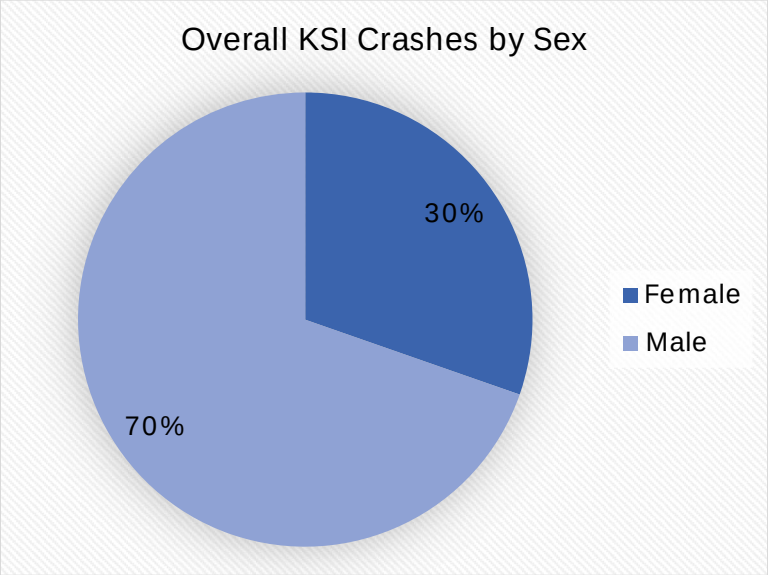


Figure 248: Overall KSI Crashes by Sex

Countermeasures

Creating effective program of countermeasures for any street or neighborhood is a multi-faceted approach which must keep equitable solutions and accurate reporting in mind. The program should focus on infrastructure that is designed to improve safety for all users of the road, but also prioritize addressing the most severe safety issues in that area. The Safe System approach of road safety looks at application of countermeasures holistically, strengthening all parts of the system. The Safe System approach includes five elements: safe road users, safe vehicles, safe speeds, safe roads, and post-crash care. At the same time, the approach incorporates the 5 Es of traffic safety: equity, engineering, education, enforcement, and emergency medical services. It goes beyond the traditional approach to enlist designers, operators, and users of the transportation system to prevent fatal crashes and reduce crash severity. Figure 250 depicts FHWA's visualization of the Safe System Approach.

In the past, much of traffic safety has focused on the users, vehicles, and post-crash care. These are important elements, but by putting a focus on these elements, the focus on designing safe streets that foster to safe speeds has been less of a focus. This plan places more focus back on the infrastructure itself, while still including elements related to users and enforcement. In addition to providing a focus on infrastructure and the configuration of road, this plan first discusses prioritizing safety. To achieve Vision Zero, all our efforts must be focused on the areas of most need.



Figure 249: The Safe System Approach Principles and Elements (Source: FHWA)

California Local Road Safety Manual

The California Department of Transportation (Caltrans)—Division of Local Assistance is responsible for administering California's Highway Safety Improvement Program (HSIP) safety funding intended for local roadway safety improvements. To make best use of these funds and to assist local agencies in their procurement Caltrans has produced a Local Road Safety Manual (LRSM) for California communities to support the distribution of the HSIP funds.[7] The manual offers an awareness on best practices in the completion of a proactive safety analysis to make sure agencies are able to put their best foot forward in the procurement of HSIP safety funding during Caltrans calls-for-projects. The principal purpose of the manual is to provide a simple and wide-ranging outline of the necessary tools needed to identify locations with roadway safety issues and the implementation of the needed countermeasures.

The Local Road Safety Manual follows a systemic approach which is founded on the use of proven countermeasures at many crash locations. This type of approach is generally based on 'system-wide' crash data with the estimates of the impacts being made in terms of benefits measured in traffic crash reduction and deployment cost. To quantify the utility of a given countermeasure in reducing crashes relative to cost, a Crash Reduction Factor is used.

[7] https://dot.ca.gov/-/media/dot-media/programs/local-assistance/documents/hsip/2020/lrsm2020.pdf

Crash reduction factors (CRFs) are an indication of the effectiveness of a particular treatment, measured by the percentage of crashes the countermeasure is expected to reduce. When used properly, CRFs can help quantify the expected safety impacts of the instalment numerous countermeasures to reduce crashes. CRFs are multiplicative factors used to estimate the expected number of crashes after implementing a given countermeasure at a specific site. The CRFs contained in the LRSM are pre-approved for use on HSIP applications. To aid local agencies in the Bay Area in obtaining HSIP funding, the Crash Modification Factors used in this report for a given countermeasure are from this manual, where available.

Additional information, including the Caltrans Countermeasure IDs can be found in Appendix A of this plan.

Prioritizing Safety

Traffic safety is a complex issue that is affected by many different people and municipal departments. To achieve Vision Zero, it is imperative that everyone who has any involvement in the transportation system take responsibility for equitably improving safety on our streets. Vision Zero must be the priority, period.

Prioritizing Vision Zero means different things for different departments through the Bay Area. For City Planning and Development, it means incorporating the fundamentals of Vision Zero in all types of plans and development application reviews. New development and plans at all levels plans should prioritize Vision Zero over other transportation considerations. For the various public works departments throughout the Bay Area, it means incorporating Vision Zero into funding decisions when planning for future infrastructure improvements and allocating funding based on the expected safety and equity improvements of the project. For the law enforcement, it means prioritizing traffic safety improvements with equitable traffic law enforcement rather than as a means for criminal enforcement. For elected officials and department heads, it means enacting and enforcing policies focused on eliminating deaths and serious injuries on our roads with equity in mind.

Fixing safety issues requires money to pay for roadway improvements, educational campaigns, and new speed safety camera equipment. Safety issues in the region are highly concentrated to certain roadway corridors and certain neighborhoods, especially in Equity Priority Communities. The funding for safety projects will not be effective if the funding is spread thinly rather than targeting the funding in the areas of greatest need.

Safe Speeds

Unsafe speeds were the most common contributing factor in both controlled access highways and local access road crashes. Aside from equity, driver speed is the most important factor in traffic safety. Speed reductions are a highly effective way to increase safety on our roads. This involves both reducing the average speed of a road and reducing the speed of the fastest drivers. When a driver is going slower, they are

better able to quickly perceive dangerous situations, they have a wider peripheral field of view to monitor streetside activity of people walking and biking, and their vehicle requires a much shorter distance to come to a stop.

To achieve Vision Zero, the speed of drivers must be lowered on our roads. This will make our roads safer, make our neighborhoods more livable, walkable, and bikeable, and reduce greenhouse gas emissions. Furthermore, lowering speeds will not significantly impact trip length—travel time is much more significantly impacted by the number of traffic signals and length of time motorists stop at them than the speed limit of the roadway.



Figure 250: Safe Speeds (Photo Credit: Mark Prado)

In the past, posted speed limits were required to be set by measuring the 85th percentile speed—the speed at which 85% of drivers were going slower. This means the speed limits were often set above the speed at which the average driver on the road is driving. By raising the posted speed limit according to the 85th percentile speed, average speeds often increase, which raises the 85th percentile speed, thus allowing another posted speed limit increase and setting up a feedback look for higher and higher speeds. There is no strong evidence that setting speed limits this way is a safe way to set speed limits.[8] With the execution of AB43, agencies in California now have greater flexibility in setting appropriate speed limits. To improve safety, lowering speed limits in the Bay Area must be considered and modern safety-target based method for setting posted speed limits must also be considered.

Posted speed limits and statutory speed limits are not always obeyed by drivers. However, studies on speed limits show **simply lowering speed limits and posting speed limit signs more frequently slow cars down with no other traffic calming interventions**. The City of Seattle performed this and has reported locations with this intervention have seen an 18% reduction in injury crashes, a 10% reduction in average speed, and a 55% reduction in people driving 40+ mph on the study corridors.[9]

In addition to considering the lowering of speed limits and posting speed limits more frequently throughout the city, these countermeasures which also address other safety concerns could be pursued to lower speeds:

[8] https://www.ntsb.gov/safety/safety-studies/documents/ss1701.pdf
[9] https://www.seattle.gov/Documents/Departments/SDOT/VisionZero/SpeedLimit_CaseStudies_Report.pdf

- **Appropriate Speed Limits for All Users** - Until 2021 it was required by California law that speed limits be set above the 85th percentile guideline set forth in the MUTCD. In October 2021, AB43 authorized the use of more flexibility for setting speed limits based on safety and other factors. Reducing speed limits can reduce the frequency and severity of crashes. FHWA has created a tool called USLIMITS2 to help local jurisdiction determine appropriate speed limits based on safety, context, users, and the 85th percentile speed. This improvement has not yet been incorporated into the Caltrans Local Road Safety Manual.
    - **Caltrans Crash Reduction Factor = 15%**
- **Speed Safety Cameras –** These automated camera systems use high-resolution digital video and still-photography cameras, equipped with radar. The radar identifies vehicles traveling within the enforcement zone at a rate of speed higher than the posted speed limit. The radar then triggers both the still and video cameras which capture the event, including the license plate of the speeding vehicle. This system, while not perfect can help prevent negative interactions with police and roadway users and reduce systemic biases currently present in speed enforcement. Speed safety cameras are not currently allowed by California state law.
    - **FHWA Crash Reduction Factor = 47%**
- **Road Diets** – Road diets, or roadway reconfigurations, can improve safety, calm traffic, provide better mobility and access for all road users, and enhance overall quality of life. A road diet typically involves converting an existing four-lane undivided roadway to a three-lane roadway consisting of two through lanes and a center two-way left-turn lane (TWLTL) but can involve any amount of vehicle drive lane reduction/repurposing. The application of this strategy usually reduces the roadway segment speeds and can address many crash types. In many cases the extra pavement width can be used for the installation of bicycle or pedestrian infrastructure.
    - **Caltrans Crash Reduction Factor = 30%**
- **Traffic Calming –** Traffic calming consists of physical design elements put in place on existing roads to reduce vehicle speeds and improve safety for pedestrians and cyclists. Vertical deflections (speed humps, speed tables, and raised intersections), horizontal shifts, and roadway narrowing are intended to reduce speed and enhance the street environment for non-motorists. Closures that obstruct traffic movements in one or more directions, such as median barriers, are intended to reduce cut-through traffic. Traffic calming measures can be implemented at an intersection, street, neighborhood, or area-wide level on both local and arterial streets.
    - **Caltrans Crash Reduction Factor = 33%**



Figure 251: Traffic Calming in San Francisco (Photo Credit: SFMTA)

- **Speed Feedback Signs –** Speed feedback signs provide drivers with dynamic feedback about their speed relative to the posted speed so that unaware drivers can immediately tell if they are speeding. The feedback can include messages as well if a given speed is over the posted speed such as SPEEDING or SLOW DOWN. When appropriately complemented with police enforcement, speed feedback signs can be an effective method for reducing speeds at a desired location.
    - **Caltrans Crash Reduction Factor = 30%**

- **Reduced School Zone Speed Limits with Flashing Beacons –** This involves lowering speeds in school zones and adding beacons scheduled to flash during school zone hours to help make drivers aware of this limit. The lowered speed limit increases the odds of a crash been survivable and the flashing beacon will help keep drivers' eyes on the road ahead, telling them exactly when they need to adjust their speed. Note that no definitive crash reduction factor has been developed for this countermeasure, but it is expected to decrease crashes.

- **Public Awareness Educational Campaigns –** These campaigns to bring awareness to the public using, flyers, mailers, pamphlets, press releases, billboards, digital media, and television and radio commercials help educate drivers on the dangers of speeding and can make drivers more mindful on the road to any potential unsafe behavior that otherwise they may not have been made aware off. Public campaigns reduce any ignorance that many drivers currently exude. Note that no definitive crash reduction factor has been developed for this countermeasure, but it is expected to decrease crashes.

Safe Streets

Creating safe streets is a fundamental aspect of Vision Zero and the Safe System approach. A street can be designed in such a way that encourages speeding, has a high number of conflict points, and forces pedestrians and cyclists into dangerous exposure to traffic. A street can also be designed in a way that encourages drivers to slow down and pay attention, reduces the total number of conflict points, and separates cyclists and pedestrians into safe spaces.



Figure 252: Safe Streets (Photo Credit: Joey Kotfica)

In the past, safety data did not exist, and analytical methods were not possible, so designers relied on street design guides like the AASHTO "Green Book" with typical parameters. The assumption was that if a street met these typical parameters, then it could be considered safe. But traffic safety isn't that simple—the roadway environment is complex, is influenced by the surrounding context, and can influence the behaviors of road users. Thankfully, now we have access to a rich set of safety data and many modern analytical techniques to identify specific safety issues on streets and proven methods to improve safety in a variety of contexts.

Within the Bay Area, all roadways with average daily traffic over 10,000 vehicles per day had a disproportionate number of crashes by a representation ratio of over 3.0 compared to the average roadway. This data relates to the way roads are built to accommodate this traffic. Wider roadways built as 4-lanes and 5-lane, especially when undivided, have a much higher proportion of crashes. 4-lane undivided roads in the Bay Area are 5.4 times more likely to experience a KSI crash than the average street.

- In urban areas, **the safest streets are those that promote low vehicle speeds and separate transportation modes into safe, dedicated spaces**. These streets have the minimum number of lanes and narrowest overall street width possible, have

traffic calming features, and are divided by medians with access management. The safest urban streets also have dedicated bicycle and pedestrian infrastructure and frequent, safe crossings of the roadway for these users.

- In rural areas, **the safest roads are those with design elements to prevent cars from leaving their lanes** such as rumble stripes, signing, pavement marking, divided medians, and median cable barriers. Those rural roads should also have a forgiving roadside design if cars do leave the roadway with wide shoulders, safety edge treatments, guardrail, and roadside clear zones.

To address these safety concerns the following countermeasures should be utilized in urbanized areas:

- **Road Safety Audits** – Road Safety Audits (RSAs) are a formal safety performance examination of an existing or future road or intersection by an independent, multidisciplinary team. RSAs seek to find what elements of the roadway present safety concerns and to find what opportunities there are to remedy the problem. It both reports on possible road safety issues and finds opportunities for enhancements in safety. It should be noted that no Caltrans crash reduction factor is provided in the LRSM because RSAs are not applicable to the HSIP program funding, although a FHWA crash reduction factor is given.
    - **FHWA Crash Reduction Factor = 60%**
- **Road Diets** – Road diets, or roadway reconfigurations, can improve safety, calm traffic, provide better mobility and access for all road users, and enhance overall quality of life. A road diet typically involves converting an existing four-lane undivided roadway to a three-lane roadway consisting of two through lanes and a center two-way left-turn lane (TWLTL) but can involve any amount of vehicle drive lane reduction/repurposing. The application of this strategy usually reduces the roadway segment speeds and can address many crash types. In many cases the extra pavement width can be used for the installation of bicycle or pedestrian infrastructure.
    - **Caltrans Crash Reduction Factor = 30%**



Figure 253: Foothill Boulevard road diet in Oakland (Photo Credit: Google)

- **Corridor Access Management -** Agencies are increasingly using access management techniques on urban and suburban arterials to manage the number of conflicts experienced at an intersection. A key element of access management is to restrict certain movements, create directional median openings, or close median openings that are deemed too close to an intersection. This can be applied for corridors and intersections noted as having turning movement crashes near the intersection as a result of insufficient access control.
    - **Caltrans Crash Reduction Factor = 50%**
- **Raised Median or Median Barrier** – are longitudinal barriers that separate opposing traffic on a divided highway and are designed to redirect vehicles striking either side of the barrier. Median barriers significantly reduce the number of cross-median crashes, which are attributed to the relatively high speeds that are typical on divided highways. Installing a raised median is a more restrictive approach in that it represents a more rigid barrier between opposing traffic. Application of raised medians on roadways with higher speeds is not advised - instead a median barrier should be considered.
    - **Caltrans Crash Reduction Factor = 25%**
- **Traffic Calming –** Traffic calming consists of physical design elements put in place on existing roads to reduce vehicle speeds and improve safety for pedestrians and cyclists. Vertical deflections (speed humps, speed tables, and raised intersections), horizontal shifts, and roadway narrowing are intended to reduce speed and enhance the street environment for non-motorists. Closures that obstruct traffic movements in one or more directions, such as median barriers, are intended to reduce cut-through traffic. Traffic calming measures

can be implemented at an intersection, street, neighborhood, or area-wide level on both local and arterial streets.

    - **Caltrans Crash Reduction Factor = 33%**

- **Segment Street Lighting** – The addition of continuous lighting on roadway segments has an established safety benefit for motorized vehicles at night. Providing adequate visibility of the roadway and its users through lighting that provides full coverage along the roadway and the strategic placement of lighting where it is needed the most. Lighting is especially important for the safety of cyclists and pedestrians who do not carry lights or wear retro reflective elements.

    - **Caltrans Crash Reduction Factor = 35% (Night Crashes)**

Rural Roads

Rural roads in the Bay Area require different treatments than roads in urbanized areas. Most rural road crashes are lane departure crashes, and the majority of those are on winding, scenic, two-lane roads in hilly areas. These types of roads are particularly prone to these kinds of crashes, and they attract motorcyclists for recreational rides. Although these roads may have low traffic volume, they are worth investing improvement funding because of their high number of fatal and serious injury crashes. Many low-cost improvements such as signing, pavement marking, rumble stripes, and guardrail can increase safety and be applied systemically across an area. Other higher cost improvements such as adding shoulders, increasing superelevation, flattening side slopes, and paving with high friction surfaces are also available and can be applied at spot locations with a known crash issue.



Figure 254: Marsh Creek Road in Contra Costa County (Photo Credit: Google)

To address the rural road safety concerns the following countermeasures should be utilized in rural areas:

- **Delineation and Friction for Horizontal Curves** – This countermeasure includes improvements like post-mounted chevrons and other warning signing are intended to warn drivers of an approaching curve and provide tracking information and guidance to the drivers. Signing improvements do not require a long development process and can typically be implemented quickly. Locations noted as having crashes on wet pavements or under dry conditions when the pavement friction available is significantly less than needed for the actual roadway approach speeds can benefit from friction improvements. Pavement friction improvements can benefit motorcycle safety in particular, as these vehicles are sensitive to low friction surfaces.
    - **Caltrans Crash Reduction Factor = 55%**



Figure 255: Example of Delineation and Friction for Horizontal Curves (Photo Credit: FHWA)

- **Roadside Design Improvements at Curves –** Improved roadside design in a rural area is an effective way to mitigate rural curve crashes. In cases where a vehicle leaves the roadway, having strategic roadside design elements, including an added or widened shoulder, flattened side slopes, or a widened clear zone can provide drivers with an opportunity to regain control and re-enter the roadway in their lane or come to a safe stop before rolling over or encountering a fixed object. These countermeasures include providing a clear zone beside the roadway, flattening side slopes, and installing barriers such as guardrail. These improvements can also be applied outside of curve locations if lane departure crashes are noted at these locations.
    - **Caltrans Crash Reduction Factor = 40%**
- **Centerline and Edgeline Rumble Strips** - Center Line rumble strips/stripes can be used on virtually any roadway in a rural area – especially those with a history

of lane departure crashes. Shoulder and edge line milled rumble strips/stripes should be used on roads with a history of roadway departure crashes. It is recommended that rumble strips/stripes be applied systematically along an entire route instead of only at spot locations. For all rumble strips/stripes, pavement condition should be sufficient to accept milled rumble strips. Care should be taken when considering installing rumble strips in locations with residential land uses or in areas with high bicycle volumes.

- **Caltrans Crash Reduction Factor = 20%**



Figure 256: Example of Rural Centerline Edgeline Rumble Strips (Photo Credit: FHWA)

Safe Intersections

Intersections are where major areas of conflict exist on a roadway network. By necessity, all modes come into conflict at these locations with people walking, biking, and driving and transit vehicles all interacting. Intersections can also act as major barriers to people walking and biking, creating environments where these users don't feel comfortable operating. Focusing on safe interactions between all modes at intersections and managing the number and type of conflict points at intersections is a key focus of the Safe System approach.

Signalized intersections are by far the most likely intersection type for a KSI crash to occur in the Bay Area. A KSI crash is 14 times more likely to happen at a signalized intersection than a stop controlled or roundabout intersection in the Bay Area. Because of this, countermeasures must be focused towards addressing signalized intersection safety issues first. This consists of evaluating whether a signal is necessary or beneficial at an intersection, whether alternate intersection types can be

constructed, and if not, what improvements can be made at the signalized intersection to make it as safe as possible.



Figure 257: Safe Intersections (Photo Credit: Noah Berger)

Intersection Control Evaluation (ICE) tools can be utilized to evaluate proper intersection traffic control based on safety and operations. FHWA provides resources for communities to implement the ICE process, such as Safety Performance for Intersection Control Evaluation (SPICE), or cities and states can implement their own policies. Committing to the ICE process could be important to ensure that the proper intersection control is built to maximize the safety of all roadway users.

Roundabouts are the safest known intersection type today. They are known intersection safety countermeasure that reduce fatalities 90% - 100% and injuries by up to 76% depending on the original intersection type.[10] Roundabouts are also by far the safest possible type of intersections for pedestrians and cyclists. Based on NHTSA data, in the past 15 years only 3 pedestrians and 1 cyclist have been killed at a roundabout *in the entire United States*. **Zero pedestrian or cyclist were killed at roundabouts in the Bay Area in the past 10 years of data.** To achieve zero roadway fatalities by 2030, a "roundabout first" policy could be implemented by local agencies in the Bay Area. A roundabout first policy is an official process by which a roundabout is considered before any other form of traffic control at an intersection. Only when a roundabout is found to be completely infeasible would a traffic signal or other type of intersection considered.

In addition to this process and to address safety concerns at intersections the following countermeasures should be utilized:

[10] https://safety.fhwa.dot.gov/intersection/roundabouts/fhwasa08006.pdf

- **Roundabouts –** Intersections that have a significant crash problem, in particular signalized intersections, can benefit dramatically from conversion to a roundabout. Roundabouts can also be very effective at intersections with complex geometry and intersections with frequent left-turn movements. Roundabouts are safer for drivers, pedestrians, and cyclists and often improve the operations of the intersection as well. They can be successfully implemented in all roadway contexts from high speed rural roundabouts to compact urban roundabouts.

    - **Caltrans Crash Reduction Factor = 67%**



Figure 258: Example of a Modern Single-lane Roundabout (Photo Credit: FHWA)

- **Reduced Left-turn Conflict Intersections –** Alternative intersection designs should be considered where a roundabout can't be implemented, operations require signalization as opposed to stop-control, and/or safety concerns at the existing signalized or stop-controlled intersection persist despite other countermeasures implemented. Reduced left-turn conflict intersections are geometric designs that alter how left-turn movements occur to simplify decisions and minimize the potential for related crashes. Two highly effective designs that rely on U-turns to complete certain left-turn movements are known as the restricted crossing U-turn (RCUT) and the median U-turn (MUT).

    - **Caltrans Crash Reduction Factor = 50%**

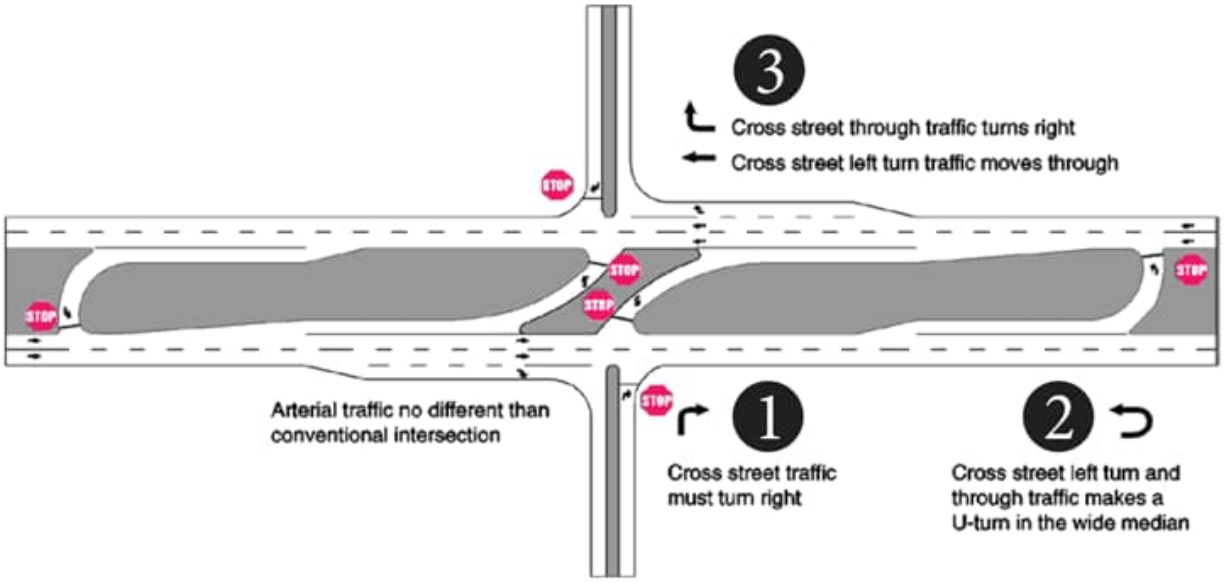


Figure 259: Example of a Restricted Crossing U-turn (Source: FHWA)

- **Add Intersection Street Lighting** – This systemic approach seeks to rectify currently unlit or poorly lit intersections. This provides benefits in terms of security for pedestrians, wheelchair and other mobility device users, bicyclists, and transit users as they travel across the intersection. Better nighttime visibility at intersections is important since various modes of travel cross paths at these locations. Agencies should consider furnishing lighting to intersections based on aspects such as a crash history at nighttime, volume of non-motorized users, the presence of crosswalks, and the presence of transit stops and boarding volumes.
    - **Caltrans Crash Reduction Factor = 40% (Night Crashes)**
- **Improved Signal Timing –** Where signalized intersections can't be converted a roundabout or stop-controlled, improving signal timings can increase safety. Certain timing, phasing, and control strategies can produce multiple safety benefits. Signalization improvements may include adding or modifying left turn phases, lengthening yellow and all-red clearance intervals, eliminating or restricting higher-risk movements, and coordinating signals at multiple locations. Understanding the corridor or roadway's crash history can provide insight into the most appropriate strategy for improving safety.
    - **Caltrans Crash Reduction Factor = 15%**
- **Signal Backplates with Retroreflective Borders –** Signalized intersections can have a high frequency of right-angle and rear-end crashes occurring because drivers are unable to see or perceive traffic signals sufficiently in advance to safely negotiate the intersection being approached. Signal intersection improvements include adding signal back plates with retro-reflective tape outlining the back plates. Signal backplates with retroflected borders increase the visibility and the awareness of drivers. This improvement is very low cost and can be applied systemically across an entire transportation system.

- Caltrans Crash Reduction Factor = 15%

- **Protected Left-turn Phasing** – Left turns are widely recognized as the highest-risk movements at signalized intersections. Providing protected left-turn phases (i.e., the provision for a specific phase for a turning movement) for signalized intersections with existing left turn pockets significantly improve the safety for left-turn maneuvers by removing the need for the drivers to navigate through gaps in oncoming/opposing through vehicles. Where left turn pockets are not protected, the pedestrian and bicyclist crossing phase often conflicts with these left turn maneuvers. Drivers focused on navigating the gaps of oncoming cars may not anticipate and/or perceive the non-motorized road users.
    - Caltrans Crash Reduction Factor = 30%

- **Dedicated Left-turn Lanes at Intersections** – To improve left-turn phasing at signalized intersections, left-turn lanes need to be present. Left-turn lanes allow separation of left-turn and through-traffic streams, thus reducing the potential for rear-end collisions. Left-turn phasing also provides a safer opportunity for drivers to make a left-turn. The combination of left-turn storage and a left turn signal has the potential to reduce many collisions between left-turning vehicles and through vehicles and/or non-motorized road users. These benefits can also be utilized at stop-controlled intersections as well. Left turn lanes can often be easily added in conjunction with a road diet.
    - Caltrans Crash Reduction Factor = 55%

- **Stop Controlled Intersection Improvements –** This systemic approach to intersection safety involves deploying a package of multiple low-cost countermeasures, including enhanced signing and pavement markings, at many stop-controlled intersections within a jurisdiction. These countermeasures increase driver awareness and recognition of the intersections and potential conflicts. The target for this strategy should be approaches to unsignalized intersections with patterns of rear-end, right-angle, or turning collisions related to lack of driver awareness of the presence of the intersection.
    - Caltrans Crash Reduction Factor = 15%

Safe Multimodal Networks

All users of the road must be considered to create a truly safe multimodal system the focus of which must be safety, ease, and accessibility. People walking and biking in the Bay Area make up 40% of the KSI crashes on local access streets. Within one-half mile of a BART station, this percentage goes up to 51% of all KSI crashes involving a pedestrian or cyclist. A Complete Street approach should be incorporated that prioritizes safety and access for people walking, biking, and using transit. The MTC toolkit already outlines many of the aspects necessary for successful Complete Street implementation throughout the Bay Area.



Figure 260: Safe Multimodal Networks (Photo Credit: Joey Kotfica)

The sheer number of users of the auto mode can dominate the ratings when project prioritization criteria focus on a small number of factors, such as vehicle miles traveled or vehicular level of service. Improving safety for people walking and biking requires different interventions from people in vehicles. Most importantly is reducing vehicle speeds, as discussed above. But more than that, the different user modes must be separated wherever possible by constructing dedicated bicycle and dedicated pedestrian facilities to minimize interactions with motor vehicles as well as fostering mode shift away from driving. Where the users can't be separated, such as at intersections, safe crossings must be constructed.

Improving transit is a key component of achieving Vision Zero in the Bay Area. Subways, buses, and streetcars are significantly less likely to be involved in high severity crashes per user-mile compared to a private motor vehicle usage. Increasing multimodal use will require land use shifts towards higher density and Transit Oriented Development (TOD) to decrease overall car trips. This is necessary for not only multimodal goals, but also to accommodate future growth while implementing safety countermeasures all while being more environmentally friendly. Increased transit reliability and utilization will allow for safety goals to be met for all users.

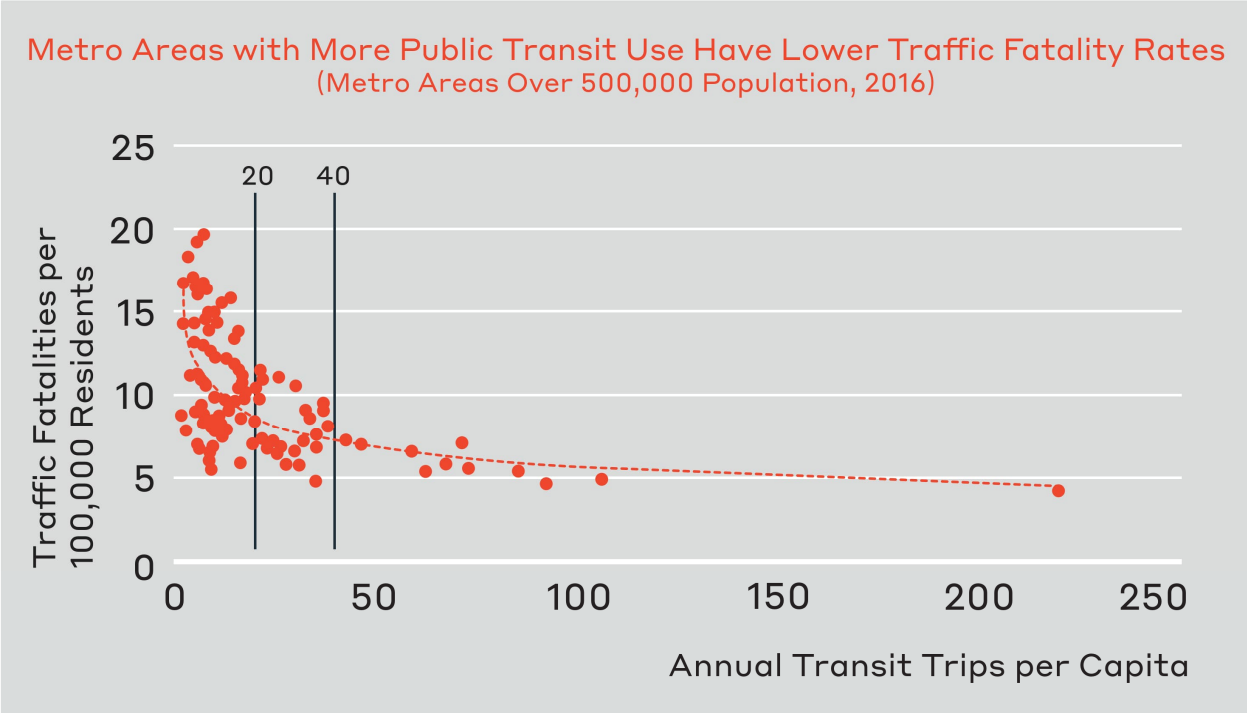


Figure 261: Metro Areas by Fatal Crashes and Annual Transit Trips (Source - American Public Transportation Association)

Additional crash countermeasures to consider that address traffic safety concerns for multimodal networks include:

- **Sidewalks and Walkways** – Sidewalks and walkways provide people with space to travel within the public right-of-way that is separated from roadway vehicles. The presence of sidewalks on both sides of the street has been found to be related to significant reductions in the "walking along roadway" pedestrian crash risk compared to locations where no sidewalks or walkways exist. For areas noted as not having adequate or no sidewalks and a history of walking along roadway pedestrian crashes. In rural areas utilizing the roadway shoulder for pedestrians may be appropriate, especially with physical barrier protection from vehicles, or separated walkways may be appropriate in these areas such as trails adjacent to roadways.
    - **Caltrans Crash Reduction Factor = 80% (Pedestrian Crashes)**
- **Dedicated Bicycle Infrastructure** - Dedicated bicycle facilities separate bicycle traffic from vehicle traffic and pedestrian traffic. Bicycle lanes provide marked areas for bicyclist to travel along the roadway and provide for more predictable movements for both bicyclist and motorist. Separated bike lanes provide increased safety and comfort for bicyclists beyond conventional bicycle lanes. By physically separating bicyclists from motor traffic, "protected" or physically separated bike lanes can offer a higher level of safety and comfort and are attractive to a wider spectrum of the public.
    - **Caltrans Crash Reduction Factor = 45% (Bicycle Crashes)**



Figure 262 Dedicated Bicycle Infrastructure in Fremont (Photo Credit: City of Fremont)

- **Leading Pedestrian Interval** - A leading pedestrian interval (LPI) gives pedestrians the opportunity to enter an intersection 3-7 seconds before vehicles are given a green indication. With this head start, pedestrians can better establish their presence in the crosswalk before vehicles have priority to turn left. LPIs provide (1) increased visibility of crossing pedestrians; (2) reduced conflicts between pedestrians and vehicles; (3) Increased likelihood of motorists yielding to pedestrians; and (4) enhanced safety for pedestrians who may be slower to start into the intersection.
    - **Caltrans Crash Reduction Factor = 60% (Pedestrian Crashes)**
- **Pedestrian Crossings at Signalized Intersections -** Adding pedestrian crossings and pedestrian countdown timers can enhance pedestrian safety at signalized locations. They are especially important at intersections with (1) multiphase traffic signals, such as left-turn arrows and split phases, (2) school crossings, and (3) double-right or double-left turns. These crossing should be provided as ADA accessible crossings with accessible push buttons.
    - **Caltrans Crash Reduction Factor = 25% (Pedestrian Crashes)**
- **Pedestrian Crossings at Uncontrolled Locations -** Adding pedestrian crossings that include enhances safety features can enhance pedestrian safety at locations noted as being especially problematic. The enhanced safety elements help delineate a portion of the roadway that is designated for pedestrian crossing. Incorporating advanced "yield" markings provide an extra safety buffer and can be effective in reducing the 'multiple-threat' danger to pedestrians. RRFBs, HAWK signals, and raised pedestrian refuge islands can further enhance

safety by increasing driver awareness of potential pedestrian conflicts and reducing crashes between vehicles and pedestrians at unsignalized intersections and mid-block pedestrian crossings.

- **Caltrans Crash Reduction Factor = 55% (Pedestrian Crashes)**



Figure 263: Example of Rapid Repeating Flashing Beacon at an Uncontrolled Location (Photo Credit: FHWA)

- **Safe Routes to School Plan** – Safe Routes to School is an approach and program that encourages active transportation such as walking and bicycling to school by way of improved infrastructure, enforcement, tools, safety education, and incentives. This creates a community involvement among parents and seek to get children used to utilizing forms of active transportation. SRTS strategies improve both safety and physical activity for students.

    - **Highway Safety Manual Crash Reduction Factor = 28% (Bike/Ped Crashes at schools with students aged 5 - 12)**

Safe Users

A fundamental principal of Vision Zero is to strengthen the system and place less reliance on driver behavior and the attempt to perfect that behavior. But road users

share responsibility for traffic safety in addition to the system designers, elected officials, and system operators. Creating safer users starts with providing a road environment and speeds in which they can safely operate. At the same time these efforts are underway, education opportunities and encouragement campaigns should also be conducted.

Certain behaviors and certain users have much more impact on and are impacted more by fatal and serious injury traffic crashes. These behaviors primarily include speeding and impaired driving. Certain users also are involved in more traffic crashes including young drivers and male drivers. **Educational campaigns should focus on these behaviors and these users and emphasize the importance of driving at a safe speed, not driving impaired, and driving cautiously around more vulnerable road users such as pedestrians, cyclists, and motorcyclists.**

Another group of people severely impacted by traffic crashes are motorcyclists. Motorcyclists are as much as 50 times more likely to be killed or seriously in a traffic crash than the average user. This is an incredible over-representation of risk for these users. Laws and educational campaigns in the past have helped reduce these crashes. Helmet usage is extremely high in the Bay Area. However, the motorcyclists crashes still happening clearly cannot be prevented by additional helmet usage—97% of the motorcyclists killed or seriously injured were wearing helmets at the time of the crash.

The California Highway Patrol (CHP) is statutorily responsible for the California Motorcyclist Safety Program (CMSP). As of 2019, over 1,200,000 motorcycle riders have received training at one of the CMSP's many training sites since the program began. While there is no official crash reduction factor given by Caltrans of FHWA, over the first 10 years of the program, the number of fatal accidents fell sharply by 70%. These efforts should be supported as possible by agencies in the Bay Area. In addition to this, educational campaigns should be undertaken encouraging drivers to drive safely around motorcycles.

Lane splitting is a legal practice in California on a motorcycle. Lane splitting is defined as operating a motorcycle on the lane lines in between rows of cars stopped in adjacent lanes. This is a highly risky way to operate a motorcycle, and likely contributes to the fact that 28% of KSI crashes on controlled access highways in the Bay Area involve cyclists. **Lane splitting is illegal in every other state in the US. To further reduce motorcyclists' deaths and serious injuries, the future use of lane splitting should be evaluated and other methods such as motorcycle hard shoulder running to keep motorcycling efficient should be explored.**

Although data is not available in the Bay Area on whether drivers were licensed at the time of a KSI crash, drivers licensing has been shown to have equity issues nationally with graduated driver's license (GDL) programs like California's. The GDL program requires new drivers to spend a certain amount of time driving with a licensed adult. This program, and programs like it, have been shown to reduce teen driving crashes, which is a major focus in traffic safety.

Although GDLs improve safety among most teens, young people living in **Equity Priority Communities with high rates of poverty and minority populations have noted impediments to obtaining a driver's license.** These teens may not have an adult in their life that can spend the time driving with them to obtain the necessary number of hours to get a full driver's license. As this issue compounds over the years, the teen may not have any adult in their life with a driver's license because of equity related GDL issues continuing over the past 25 years since California's GDL program was initiated. Other teens may have physically disabled parents or guardians, such as those with low vision, who cannot legally obtain a driver's license.

To improve drivers licensing rates, especially in Equity Priority Communities, it will be imperative to advocate for driver education classes at public schools, and partner with schools and non-profits to provide volunteers to help young drivers to meet the driving hour requirements as part of the GDL program. These efforts are expected to reduce crashes by up to 10% regionally and benefit young drivers and drivers in Equity Priority Communities the most.

Equitable Enforcement

Traffic safety is a complex issue with many variables and many affected communities and stakeholders. Vision Zero will require involvement from everyone with a stake in the transportation system safety. Law enforcement is a key component of traffic safety and the Vision Zero approach. Law enforcement officers cannot be everywhere at all times, nor is it necessarily desirable for them to be, so it is most important to change our infrastructure and educate our drivers on safe behaviors. However, enforcement remains a key tool to address the worst behaviors of drivers.

Law enforcement raises special equity issues. When enforcement is deployed, it is imperative that it is done in an equitable manner. Many of the Bay Area's most dire safety issues exist in Equity Priority Communities. These areas have historically had a strained relationship with law enforcement. Enforcement activities in these areas should be accompanied by public information and education campaigns about the enforcement activities. Data-driven and equitable policing should be utilized in the Bay Area so that officers can focus their traffic safety efforts to best achieve Vision Zero.

Traffic law enforcement should focus primarily on traffic safety enforcement, not as a means to execute criminal enforcement. This can be achieved through re-focused law enforcement department priorities and officer education into the dire consequences of fatal and serious injury traffic crashes in the Bay Area. It could also be achieved by employing a civilian traffic safety enforcement agency. Civilian traffic safety enforcement is not currently allowed in the State of California, but efforts by cities like Berkley have begun investigation into this option. The enactment of Berkley's George Floyd Act has begun discussions on the role of police in traffic safety enforcement.

Because speeding has such an important impact on traffic safety, a primary focus should be on speed enforcement. Several strategies to reduce speeds are presented in the Safe Speeds countermeasure section. Additional enforcement-related tactics are

also available. One of the most effective speed reduction enforcement countermeasures is the use of automated speed enforcement and speed safety cameras. The use of speed safety cameras has been shown to reduce crashes up to 47% by the Federal Highway Administration (FHWA). Merely advertising the use of mobile speed safety cameras has been shown to reduce KSI crashes by 10% area-wide.

Unfortunately, the use of automated speed safety cameras in California is currently not allowed by law. Much of the concern around the use of these cameras centers on the issues of ticketing cars compared to ticketing drivers. But new systems exist that allow drivers to be ticketed. **Speed safety cameras have been shown to be incredibly effective in reducing speeds and KSI crashes around the world.** Communities in the Bay Area and MTC should strongly advocate for the use of these critical safety enforcement devices.

In the absence of automated speed safety cameras, high visibility targeted speed enforcement and speed saturation patrols can be an effective tactic to reduce speeding and speed related KSI crashes. While not as impactful as automated speed safety cameras, these activities have been shown by FHWA to reduce crashes by 15% where employed.

Action Steps

Achieving Vision Zero will not happen without a coordinated, concerted effort from many different agencies and implementation projects. The action steps in this plan provide a high level framework to guide this effort.

Policy and Program Action Steps

Policies and processes should be updated in the Bay Area to bring all actions in line with the Vision Zero fundamentals. By doing this, Vision Zero will become an integral and enduring part of doing business. The below policies, processes, and educational efforts can begin immediately. Many of these action items may already be underway as official policy in some areas. Other action items have been previously identified as a priority but would benefit from formal adoption and expansion.

- Build on this Vision Zero Action Plan with a more comprehensive Vision Zero Implementation Plan highlighting a more robust list of specific projects and countermeasures for infrastructure investments and a more detailed exploration of policy, education, and enforcement actions.
- Include Vision Zero and traffic safety prioritization metrics in the next One Bay Area Grant (OBAG) program guideline update
- Develop additional technical support and educational materials to encourage local agencies and elected officials to develop local Vision Zero Action Plans, Safe System material, and manage messaging around traffic safety issues.
    - Develop Vision Zero and Safe System training program for key stakeholders.

    - Develop guides to help agency staff and elected officials better frame Vision Zero and Safe System issues.
    - Develop a media kit and media training for news outlets to better report on traffic safety issues.
- Develop a Bay Area Vision Zero performance measure online clearinghouse highlighting progress, successes, and challenges and create a best practices repository for regional Vision Zero Action Plans and implementation case studies
- Develop additional technical support resources for local agencies applying for HSIP, SSARP, or SS4A safety funding
- Develop a region wide Speed Management Program in partnership with local agencies and law enforcement agencies
- Continue to support for completion and implementation of the MTC Active Transportation Plan and other relevant MTC planning processes
- Enact a requirement that all planning processes incorporate Vision Zero into the foundation of the plan
- Conduct educational campaigns focused on speeding and impaired driving
- Create a Driver's Education Equity Task Force for Teens to address equity issues related to the Graduated Driver's License (GDL) program
- Advocate for safety reform related to motorcycle lane splitting at the California legislature
- Advocate for the use of automated speed safety cameras at the California legislature
- Create a task force in coordination with law enforcement agencies to provide more direct data exchange to support data-driven policing and to obtain higher quality crash data

Infrastructure Action Steps

MTC does not hold direct jurisdictional control over any streets in the Bay Area. However, MTC does have the ability to coordinate local agency safety actions, coordinate state and federal funding, and advocate for advancing projects, especially where multiple jurisdictions are involved. To this end, this plan contains an initial list of top priority infrastructure projects needed in the region. These projects represent the highest crash HIN corridors and high injury intersections throughout the region. Safety interventions on these corridors and at these intersections should be pursued as quickly as possible.

Intersections

Table 12 shows the topped ranked intersections based on a weighted KSI score. This is mapped in Figure 264. The map can also be accessed using this link: https://reports.mysidewalk.com/ce8aac4198

Table 12: Top Ranked KSI Weighted Intersections

Name	Fatal Crashes (2015-2019)	Serious Injury Crashes (2015-2019)	Area Type	In EPC	Traffic Control Type
Tubbs + CA-128	2	2	Rural	No	Stop
Marina + CA-12	2	2	Suburban	Yes	Signal
Beck + CA-12	2	1	Rural	Yes	Signal
Leavesely Road + Holsclaw	2	0	Rural	No	Stop
Nieman + East Capitol	2	0	Suburban	Yes	Signal
Snell + Rosenbaum	2	0	Urban	No	Signal
Pacheco + Wygal	2	0	Rural	No	Signal
Curtner + Briarwood	2	0	Suburban	No	Stop
Montery + Rancho	2	0	Suburban	Yes	Stop
7th + Howard	1	4	Core	Yes	Signal
Senter + East Capitol	1	3	Urban	Yes	Signal
1st + Howard	1	3	Core	No	Signal
Masonic + Hayes	1	2	Core	No	Signal
Marsh Creek + Vasco	1	2	Rural	No	Signal
Midway + Batavia	1	2	Rural	No	Stop
River + Trenton-Heraldsburg	1	2	Rural	No	Stop
Tully + South King	1	2	Urban	Yes	Signal
Monterey + Palm	1	2	Rural	No	Stop
Ashby + San Pablo	1	2	Urban	Yes	Signal
16th + Harrison	1	2	Core	No	Signal
3rd + Paul	1	2	Urban	Yes	Signal
Shoreline + Fairfax-Bolinas	1	2	Rural	No	Stop
Pine + Polk	1	2	Core	No	Signal

Name	Fatal Crashes (2015-2019)	Serious Injury Crashes (2015-2019)	Area Type	In EPC	Traffic Control Type
East Capitol + South Capitol	1	2	Urban	Yes	Signal
Skyline + Westmoor	1	2	Suburban	No	Stop
El Camino + Ludeman Lane	1	2	Suburban	No	Signal
Willow Pass + Fry Way	1	2	Core	Yes	Signal
Oak + Diversadero	0	6	Urban	No	Signal
Industrial + Bayshore	0	5	Urban	Yes	Signal

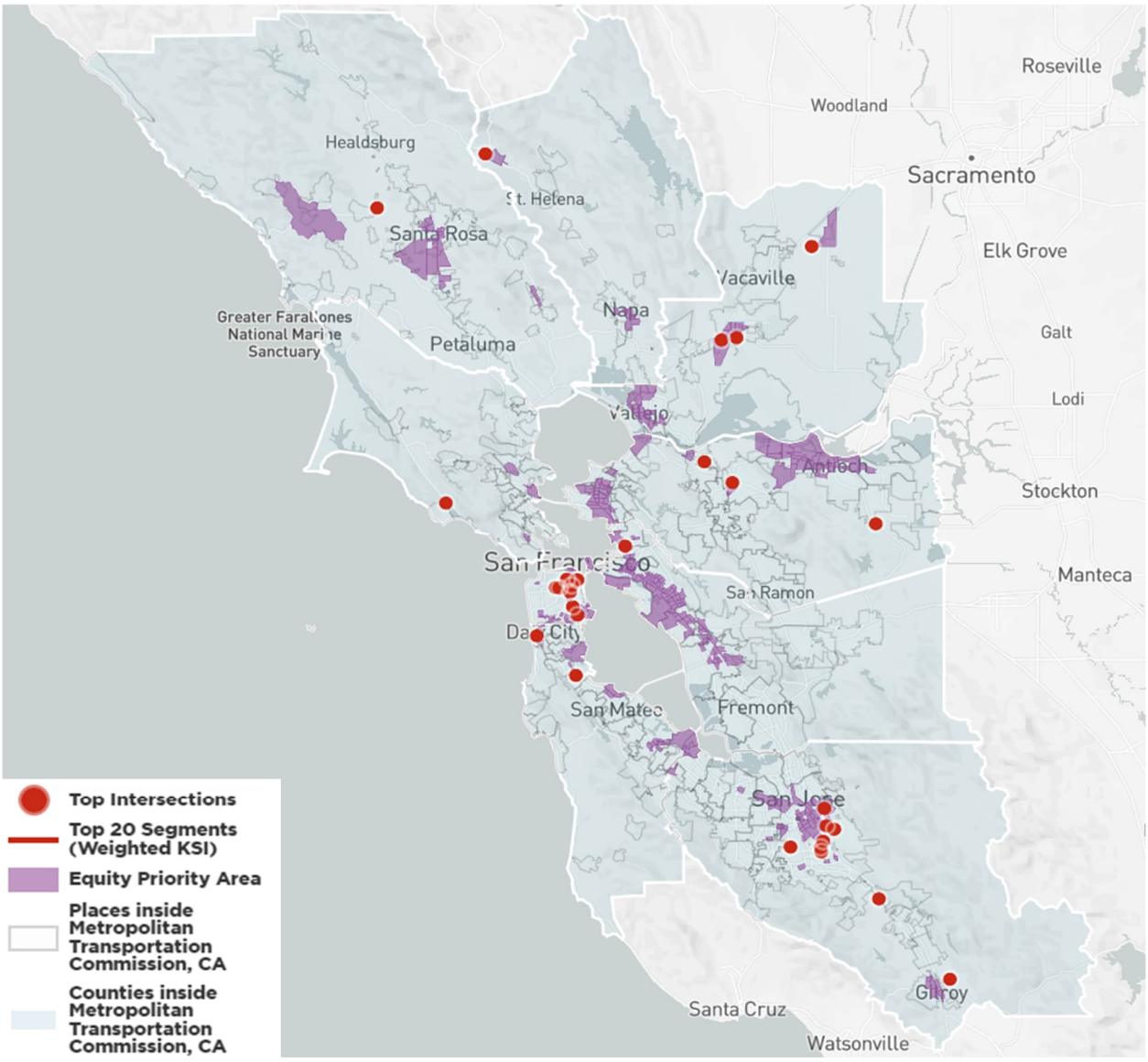


Figure 264: Top Crash Intersection Locations (https://reports.mysidewalk.com/ce8aac4198)

Corridors

A list of the top 20 highest crash corridor segments in MTC's region is identified below in Table 13 and shown in Figure 265. The map can also be accessed using this link: https://reports.mysidewalk.com/ce8aac4198.

Some of these corridors, such as International Boulevard and Ashby Street have completed, or are currently undergoing safety interventions at the time of this plan development. These corridors should be monitored for crash reduction and evaluated for the efficacy of the improvements. If improvements are highly effective, these projects should be used as case studies for achieving Vision Zero in the Bay Area.

Table 13: Top Ranked KSI Weighted Segments

Name	Length (mi)	Fatal Crashes (2015-2019)	Serious Injury Crashes (2015-2019)	In EPC	# of Lanes	Divided or Undivided	Area Type
International Boulevard	6.02	10	66	Yes	4	Undivided	Urban
Vasco Road	4.96	10	22	No	2	Undivided	Rural
La Honda Road	2.97	10	6	No	2	Undivided	Rural
Ocean Avenue	1.20	9	13	No	4	Undivided	Urban
Kirker Pass Road	3.77	9	10	Yes	6	Divided	Suburban
Railroad Avenue	2.74	8	21	Yes	4	Divided	Rural
East Capitol Expressway	3.36	8	14	Yes	8	Divided	Suburban
Pacheco Pass Highway	5.62	8	10	No	2	Undivided	Rural
El Camino Real	4.44	7	37	Yes	6	Divided	Urban
Ashby Avenue	2.45	6	30	Yes	4	Undivided	Urban
San Pablo Avenue	3.31	6	21	Yes	4	Divided	Urban
Cutting Boulevard	3.27	6	20	Yes	4	Undivided	Suburban
West El Camino Road	6.53	6	17	No	6	Divided	Urban
Willow Pass Road	2.27	6	16	No	2	Undivided	Rural
East 14th Street	4.52	5	22	Yes	4	Divided	Urban
Diversadero Street	1.36	5	21	Yes	4	Divided	Core
Foothill Boulevard	2.97	4	33	Yes	2	Undivided	Urban
3rd Street	2.15	4	25	Yes	4	Divided	Urban
16th Street	1.50	4	22	No	4	Undivided	Urban
Market Street	2.75	3	53	Yes	2	Divided	Core
Monticello Road	1.86	2	30	No	2	Undivided	Rural

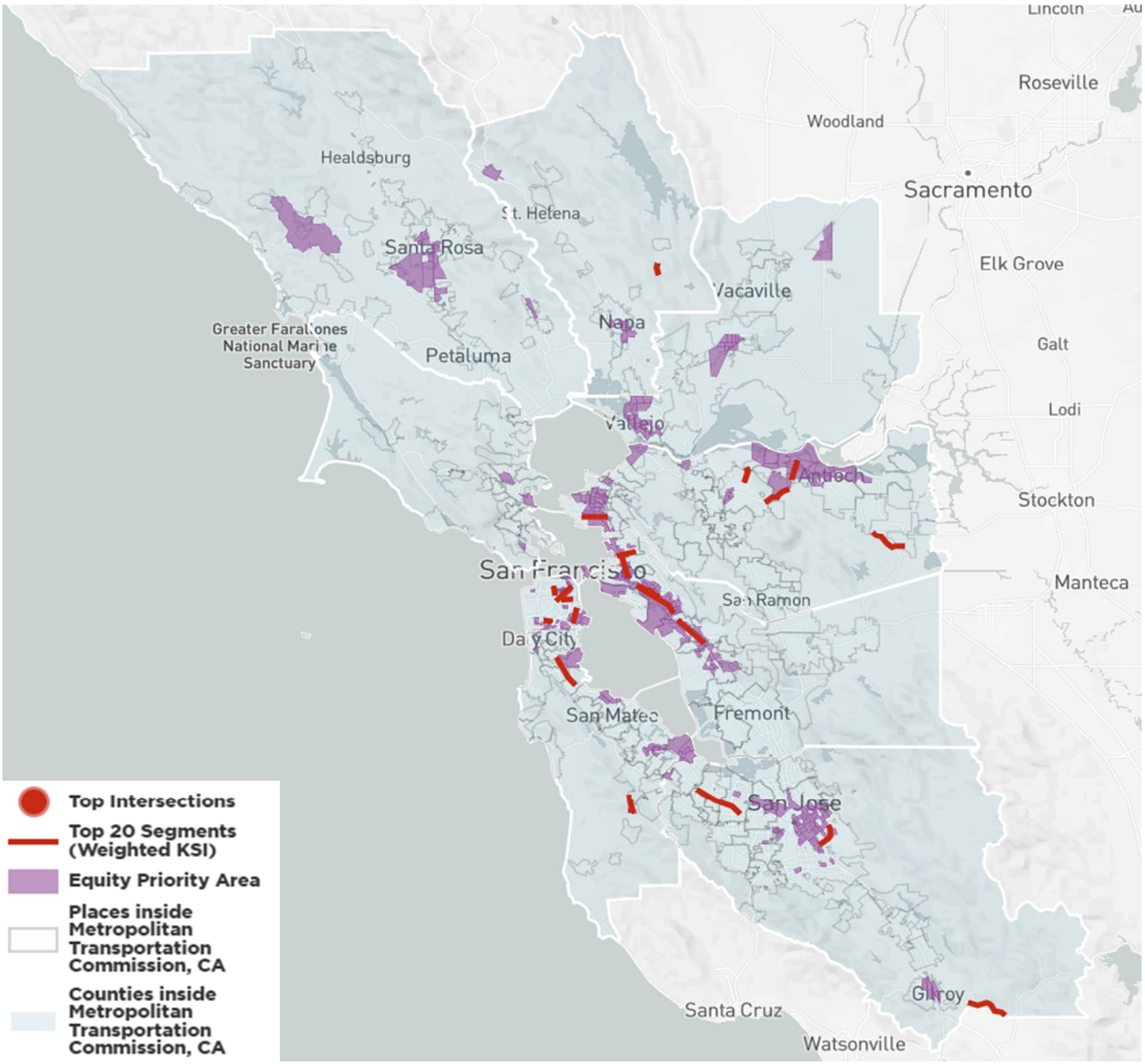


Figure 265: Top 20 Crash Corridor Map (https://reports.mysidewalk.com/ce8aac4198)

Monitoring

Monitoring performance measures over a given time as well as before and after certain projects will help determine whether progress is being made towards achieving Vision Zero in the Bay Area. As documentation of proven practice is vital for the continued implementation of Vision Zero, monitoring is especially important to its success in the region. Going forward, an annual report should be produced using the BAYVIZ system. This report should benchmark the progress of Vision Zero in the region. This report should highlight successes and continued challenge areas.

Local agencies in the Bay Area should also be encouraged to set their own aggressive benchmarks and keep track of progress while at the same time as increasing communications to learn about best practices in other Bay Area communities to help achieve the goal of Vision Zero.

Key Performance Indicators

Identifying and tracking key performance indicators will help monitor progress towards Vision Zero. The indicators should convey an evidence-based and measurable result, to demonstrate their effect on road safety. This achieved result should be viewed in relation to the targeted outcome to clearly understand how much progress has been made.

To measure progress, the most basic, and important, indicators are of course the result indicators on deaths and serious injuries, which will continue to be monitored closely. However, several factors go into a vision zero approach and as such a variety of metrics must be monitored. Over the short term, it is difficult to evaluate the success of road safety improvement projects based on crash data alone. Indicators make it possible to predict which efforts are needed to achieve the targets and to monitor progress.

Monitoring some of the following indices can provide a useful snapshot on the progress of vision zero benchmarks as well as future areas of improvement.

- Crashes
    - Number of people killed and seriously injured
    - Number of pedestrians and cyclists killed and seriously injured
- Equity
    - Crash representation ratios of EPC areas and representation by race
    - Amount of Vision Zero related infrastructure constructed in EPC's
- Infrastructure
    - Proportion of funding dedicated to safety specific projects

    - Length of safety projects funded on the High Injury Network
    - Length of sidewalks and dedicated bikeways funded
    - Number of traffic signal conversions or improvements funded
    - Length of road diets funded
    - Number of rural systemic safety improvements funded
- Policy
    - Number of local agencies in the region with Vision Zero Action Plans
    - Number of posted speed limits reduced
    - Number of educational campaigns completed related to speeding and impaired driving

Conclusion

This report is a comprehensive look into the state of safety with the Bay Area and surrounding communities. Over a decade of crash data was examined alongside economic, demographic, and geospatial data to create a fuller picture of traffic safety issues. Equity was put at the forefront of this document, the data showing the disproportional effect that traffic crashes have on certain populations. This action plan identifies a number of safety challenge areas, countermeasures, and top action steps designed to achieve Vision Zero. The plan also outlines a monitoring regime so that MTC can determine whether the Bay Area is making progress towards this goal.

A regional approach to safety will save lives. Additionally, it will help promote a safety culture and reduce costs among cities and counties so that local governments can redirect limited funds toward implementing new safety projects and policies. Vision Zero is a strategy to drastically reduce traffic fatalities and severe injuries, while promoting healthy and equitable mobility for all. The ideal goal of reducing traffic fatalities all together, must be grounded with the philosophy that everyone has the right to move safely in their communities and that traffic deaths are preventable.

Appendix

Appendix A: Countermeasure Matrix

Appendix B: Systemic Risk Analysis Crash Trees

Appendix C: Literature Review

Appendix A: Countermeasure Matrix

		Crash Type								Contexts			Information					
Counter-measure Name	Caltrans Counter-measure IDs	Broadside	Head-On	Hit Object	Overturned	Rear-End	Sideswipe	Pedestrian	Bicycle	Urban	Suburban	Rural	Cost	Crash Reduction Factor %	HSIP Funding Eligibility %	Expected Life (YRS)	Systemic Approach Opportunity	Description and Resources
Appropriate Speed Limits for All Road Users	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Low	15%	N/A	20	High	Until 2021 it was required by California law that speed limits be set according to the 85th percentile guideline set forth in the MUTCD. In October 2021, AB43 authorized the use of more flexibility for setting speed limits based on safety and other factors. Reducing speed limits can reduce the frequency and severity of crashes. FHWA has created a tool called USLIMITS2 to help local jurisdiction determine appropriate speed limits based on safety, context, users, and the 85th percentile speed. This improvement has not yet been incorporated into the Caltrans Local Road Safety Manual. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/appropriate-speed-limits.cfm https://nacto.org/publication/city-limits/
Centerline and Edgeline Rumble Stripes	R30, R31		Y	Y	Y							Y	Medium	20%	100%	10	High	Center Line rumble strips/stripes can be used on virtually any roadway – especially those with a history of head-on crashes. Shoulder and edge line milled rumble strips/stripes should be used on roads with a history of roadway departure crashes. It is recommended that rumble strips/stripes be applied systematically along an entire route instead of only at spot locations. For all rumble strips/stripes, pavement condition should be sufficient to accept milled rumble strips. Care should be taken when considering installing rumble strips in locations with residential land uses or in areas with high bicycle volumes. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/long_rumble_strip/
Corridor Access Management	S12, S14, NS14, NS15	Y					Y			Y	Y	Y	High	50%	90%	20	Medium	Agencies are increasingly using access management techniques on urban and suburban arterials to manage the number of conflicts experienced at an intersection. A key element of access management is to restrict certain movements, create directional median openings, or close median openings that are deemed too close to an intersection. This can be applied for corridors and intersections noted as having turning movement crashes near the intersection as a result of insufficient access control. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/corridor_access_mgmt/
Dedicated Bicycle Infrastructure	R32BP, R33BP							Y	Y	Y	Y		Medium	45%	90%	20	High	Dedicated bicycle facilities separate bicycle traffic from vehicle traffic and pedestrian traffic. Bicycle lanes provide marked areas for bicyclist to travel along the roadway and provide for more predictable movements for both bicyclist and motorist. Separated bike lanes provide increased safety and comfort for bicyclists beyond conventional bicycle lanes. By physically separating bicyclists from motor traffic, “protected” or physically separated bike lanes can offer a higher level of safety and comfort and are attractive to a wider spectrum of the public. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/bike-lanes.cfm https://nacto.org/publication/urban-bikeway-design-guide/ https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/ https://ruraldesignguide.com/
Dedicated Left-Turn Lanes at Intersections	S06					Y				Y	Y	Y	Medium	55%	90%	20	Low	Left-turn lanes allow separation of left-turn and through-traffic streams, thus reducing the potential for rear-end collisions. Left-turn phasing also provides a safer opportunity for drivers to make a left-turn. The combination of left-turn storage and a left turn signal has the potential to reduce many collisions between left-turning vehicles and through vehicles and/or non-motorized road users. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/left_right_turn_lanes/

		Crash Type								Contexts			Information					
Counter-measure Name	Caltrans Counter-measure IDs	Broadside	Head-On	Hit Object	Overturned	Rear-End	Sideswipe	Pedestrian	Bicycle	Urban	Suburban	Rural	Cost	Crash Reduction Factor %	HSIP Funding Eligibility %	Expected Life (YRS)	Systemic Approach Opportunity	Description and Resources
Delineation and Friction for Horizontal Curves	NS12, R21, R23, R24, R25		Y	Y	Y		Y					Y	Medium	55%	100%	10	High	Post-mounted chevrons and other warning signing are intended to warn drivers of an approaching curve and provide tracking information and guidance to the drivers. Signing improvements do not require a long development process and can typically be implemented quickly. Locations noted as having crashes on wet pavements or under dry conditions when the pavement friction available is significantly less than needed for the actual roadway approach speeds can benefit from friction improvements. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/enhanced_delineation https://safety.fhwa.dot.gov/provencountermeasures/pavement-friction.cfm
Improved Signal Timing	S03	Y				Y				Y	Y	Y	Low	15%	50%	10	High	Certain timing, phasing, and control strategies can produce multiple safety benefits. Signalization improvements may include adding phases, lengthening clearance intervals, eliminating, or restricting higher-risk movements, and coordinating signals at multiple locations. Understanding the corridor or roadway's crash history can provide insight into the most appropriate strategy for improving safety. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/yellow_xhg_intervals/ https://ops.fhwa.dot.gov/publications/fhwahop08024/chapter4.htm
Leading Pedestrian Interval	S21PB							Y	Y	Y	Y		Low	60%	100%	10	High	A leading pedestrian interval (LPI) gives pedestrians the opportunity to enter an intersection 3-7 seconds before vehicles are given a green indication. With this head start, pedestrians can better establish their presence in the crosswalk before vehicles have priority to turn left. LPIs provide (1) increased visibility of crossing pedestrians; (2) reduced conflicts between pedestrians and vehicles; (3) Increased likelihood of motorists yielding to pedestrians; and (4) enhanced safety for pedestrians who may be slower to start into the intersection. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/lead_ped_int/ https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/traffic-signals/leading-pedestrian-interval
Pedestrian Crossings at Signalized Intersections	S17BP, S18BP							Y		Y	Y	Y	Medium	25%	100%	20	High	Adding pedestrian crossings and pedestrian countdown timers can enhance pedestrian safety at signalized locations noted as being problematic. Signalized Intersections with no marked crossing and pedestrian signal heads, where pedestrians are known to be crossing intersections that involve significant turning movements. They are especially important at intersections with (1) multiphase traffic signals, such as left-turn arrows and split phases, (2) school crossings, and (3) double-right or double-left turns. Additional Resources: https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/crosswalks-and-crossings/conventional-crosswalks/

		Crash Type								Contexts			Information					
Counter-measure Name	Caltrans Counter-measure IDs	Broadside	Head-On	Hit Object	Overturned	Rear-End	Sideswipe	Pedestrian	Bicycle	Urban	Suburban	Rural	Cost	Crash Reduction Factor %	HSIP Funding Eligibility %	Expected Life (YRS)	Systemic Approach Opportunity	Description and Resources
Pedestrian Crossings at Uncontrolled Locations	NS19BP, NS20BP, NS21BP, NS22BP, NS23BP, R35BP, R36BP, R37BP							Y		Y	Y	Y	Medium	55%	100%	20	Medium	Adding pedestrian crossings that include enhances safety features can enhance pedestrian safety at locations noted as being especially problematic. The enhanced safety elements help delineate a portion of the roadway that is designated for pedestrian crossing. Incorporating advanced "yield" markings provide an extra safety buffer and can be effective in reducing the 'multiple-threat' danger to pedestrians. RRFBs, HAWK signals, and raised pedestrian refuge islands can further enhance safety by increasing driver awareness of potential pedestrian conflicts and reducing crashes between vehicles and pedestrians at unsignalized intersections and mid-block pedestrian crossings. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/crosswalk-visibility.cfm https://safety.fhwa.dot.gov/provencountermeasures/ped_medians.cfm https://safety.fhwa.dot.gov/provencountermeasures/ped_hybrid_beacon.cfm https://safety.fhwa.dot.gov/provencountermeasures/rrfb.cfm https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/crosswalks-and-crossings/midblock-crosswalks/
Protected Left Turn Phasing	S07	Y								Y	Y	Y	Low	30%	100%	20	High	Left turns are widely recognized as the highest-risk movements at signalized intersections. Providing Protected left-turn phases (i.e., the provision for a specific phase for a turning movement) for signalized intersections with existing left turn pockets significantly improve the safety for left-turn maneuvers by removing the need for the drivers to navigate through gaps in oncoming/opposing through vehicles. Where left turn pockets are not protected, the pedestrian and bicyclist crossing phase often conflicts with these left turn maneuvers. Drivers focused on navigating the gaps of oncoming cars may not anticipate and/or perceive the non-motorized road users. Additional Resources: http://www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=51 https://ops.fhwa.dot.gov/publications/fhwahop08024/chapter4.htm#4.3
Raised Median or Median Barrier	R09		Y				Y			Y	Y	Y	Medium	25%	90%	20	Medium	Median barriers are longitudinal barriers that separate opposing traffic on a divided highway and are designed to redirect vehicles striking either side of the barrier. Median barriers significantly reduce the number of cross-median crashes, which are attributed to the relatively high speeds that are typical on divided highways. Installing a raised median is a more restrictive approach in that it represents a more rigid barrier between opposing traffic. Application of raised medians on roadways with higher speeds is not advised - instead a median barrier should be considered. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/median_barrier/ https://safety.fhwa.dot.gov/provencountermeasures/ped_medians.cfm
Reduced Left-Turn Conflict Intersections	S15, NS16	Y					Y				Y	Y	High	50%	90%	20	Medium	Reduced left-turn conflict intersections are geometric designs that alter how left-turn movements occur to simplify decisions and minimize the potential for related crashes. Two highly effective designs that rely on U-turns to complete certain left-turn movements are known as the restricted crossing U-turn (RCUT) and the median U-turn (MUT). Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/reduced_left/
Road Diet	R14	Y	Y	Y		Y	Y	Y	Y	Y	Y		Medium	30%	90%	20	Medium	A Road Diet, or roadway reconfiguration, can improve safety, calm traffic, provide better mobility and access for all road users, and enhance overall quality of life. A Road Diet typically involves converting an existing four-lane undivided roadway to a three-lane roadway consisting of two through lanes and a center two-way left-turn lane (TWLTL). The application of this strategy usually reduces the roadway segment speeds and can address many crash types. In many cases the extra pavement width can be used for the installation of bicycle or pedestrian infrastructure. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/road_diets/ https://safety.fhwa.dot.gov/road_diets/guidance/info_guide/

		Crash Type								Contexts			Information					
Counter-measure Name	Caltrans Counter-measure IDs	Broadside	Head-On	Hit Object	Overturned	Rear-End	Sideswipe	Pedestrian	Bicycle	Urban	Suburban	Rural	Cost	Crash Reduction Factor %	HSIP Funding Eligibility %	Expected Life (YRS)	Systemic Approach Opportunity	Description and Resources
Roadside Design Improvements at Curves	R02, R04, R05, R06, R07		Y	Y	Y							Y	High	40%	100%	20	Medium	In cases where a vehicle leaves the roadway, having strategic roadside design elements, including an added or widened shoulder, flattened sideslopes, or a widened clear zone can provide drivers with an opportunity to regain control and re-enter the roadway in their lane or come to a safe stop before rolling over or encountering a fixed object. These countermeasures include providing a clear zone beside the roadway, flattening side slopes, and installing barriers such as guardrail. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/roadside_design/
Roundabouts	S16, NS04	Y				Y		Y			Y	Y	High	67%	100%	20	Low	Intersections that have a significant crash problem, in particular signalized intersections, can benefit dramatically from conversion to a roundabout. Roundabouts can also be very effective at intersections with complex geometry and intersections with frequent left-turn movements. Roundabouts are safer for drivers, pedestrians, and cyclists and often improve the operations of the intersection as well. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/roundabouts/ http://www.trb.org/Publications/Blurbs/164470.aspx
Sidewalks and Walkways	R34BP							Y		Y	Y	Y	Medium	80%	90%	20	Medium	Sidewalks and walkways provide people with space to travel within the public right-of-way that is separated from roadway vehicles. The presence of sidewalks on both sides of the street has been found to be related to significant reductions in the “walking along roadway” pedestrian crash risk compared to locations where no sidewalks or walkways exist. For areas noted as not having adequate or no sidewalks and a history of walking along roadway pedestrian crashes. In rural areas asphalt curbs and/or separated walkways may be appropriate. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/walkways/ https://nacto.org/publication/urban-street-design-guide/street-design-elements/sidewalks/ https://ruraldesignguide.com/
Signal Backplates with Retroreflective Borders	S02	Y				Y				Y	Y	Y	Low	15%	100%	10	High	Signalized intersections can have a high frequency of right-angle and rear-end crashes occurring because drivers are unable to see or perceive traffic signals sufficiently in advance to safely negotiate the intersection being approached. Signal intersection improvements include new LED lighting, signal back plates, retro-reflective tape outlining the back plates, or visors to increase signal visibility, larger signal heads, relocation of the signal heads, or additional signal heads. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/blackplate/
Stop-Controlled Intersection Improvements	NS06	Y				Y					Y	Y	Low	15%	100%	10	High	This systemic approach to intersection safety involves deploying a package of multiple low-cost countermeasures, including enhanced signing and pavement markings, at many stop-controlled intersections within a jurisdiction. These countermeasures increase driver awareness and recognition of the intersections and potential conflicts. The target for this strategy should be approaches to unsignalized intersections with patterns of rear-end, right-angle, or turning collisions related to lack of driver awareness of the presence of the intersection. Additional Resources: https://safety.fhwa.dot.gov/provencountermeasures/syst_stop_control/

		Crash Type								Contexts			Information					
Counter-measure Name	Caltrans Counter-measure IDs	Broadside	Head-On	Hit Object	Overturned	Rear-End	Sideswipe	Pedestrian	Bicycle	Urban	Suburban	Rural	Cost	Crash Reduction Factor %	HSIP Funding Eligibility %	Expected Life (YRS)	Systemic Approach Opportunity	Description and Resources
Traffic Calming	N/A		Y	Y		Y		Y	Y	Y	Y		Medium	33%	N/A	20	High	Traffic calming consists of physical design and other measures put in place on existing roads to reduce vehicle speeds and improve safety for pedestrians and cyclists. For example, vertical deflections (speed humps, speed tables, and raised intersections), horizontal shifts, and roadway narrowing are intended to reduce speed and enhance the street environment for non-motorists. Closures that obstruct traffic movements in one or more directions, such as median barriers, are intended to reduce cut-through traffic. Traffic calming measures can be implemented at an intersection, street, neighborhood, or area-wide level. Additional Resources: https://safety.fhwa.dot.gov/speedmgt/traffic_calm.cfm https://nacto.org/publication/urban-street-design-guide/design-controls/design-speed/speed-reduction-mechanisms/

Appendix B: Systemic Risk Analysis Crash Trees

Motor Vehicle Segment Crashes

Rural

Rep. Ratio 0.90 | KSI 4,036 41.64% | Miles 13,078 48.13%

Equity Area

Rep. Ratio 1.59 | KSI 291 3% | Miles 534 1.88%

One-Way

Rep. Ratio 0.92 | KSI 33 0.34% | Miles 105 .37%

Lanes

5+	4	3	2
Rep. Ratio 0.00	Rep. Ratio 0.86	Rep. Ratio 2.69	Rep. Ratio 0.66
KSI 0 0%	KSI 2 0.02%	KSI 1 0.01%	KSI 12 0.12%
Miles: 1 %	Miles: 7 .02%	Miles: 1 %	Miles: 53 .19%

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 10.27	Rep. Ratio 2.46	Rep. Ratio 5.05	Rep. Ratio 2.48	Rep. Ratio 0.00	Rep. Ratio 0.66	Rep. Ratio 2.04
KSI 2 0.02%	KSI 2 0.02%	KSI 8 0.08%	KSI 4 0.04%	KSI 0 0%	KSI 1 0.01%	KSI 2 0.02%
Miles: 1 %	Miles: 2 .01%	Miles: 5 .02%	Miles: 5 .02%	Miles: 6 .02%	Miles: 4 .02%	Miles: 3 .01%

Speed

70+ mph	66-70 mph	61-65 mph	56-60 mph	51-55 mph	46-50 mph	41-45 mph	36-40 mph	31-35 mph	26-30 mph	21-25 mph	0-20 mph
Rep. Ratio 3.72	Rep. Ratio 1.64	Rep. Ratio 1.35	Rep. Ratio 2.71	Rep. Ratio 1.84	Rep. Ratio 0.00	Rep. Ratio 1.38	Rep. Ratio 3.13	Rep. Ratio 2.07	Rep. Ratio 0.80	Rep. Ratio 2.00	Rep. Ratio 0.00
KSI 8 0.08%	KSI 2 0.02%	KSI 2 0.02%	KSI 3 0.03%	KSI 2 0.02%	KSI 0 0%	KSI 3 0.03%	KSI 5 0.05%	KSI 3 0.03%	KSI 1 0.01%	KSI 2 0.02%	KSI 0 0%
Miles: 6 .02%	Miles: 4 .01%	Miles: 4 .02%	Miles: 3 .01%	Miles: 3 .01%	Miles: 6 .02%	Miles: 6 .02%	Miles: 5 .02%	Miles: 4 .01%	Miles: 4 .01%	Miles: 3 .01%	Miles: 2 .01%

Two-Way

Rep. Ratio 0.90 | KSI 4,603 41.3% | Miles 12,973 45.76%

Lanes

5+	4	3	2
Rep. Ratio 3.06	Rep. Ratio 2.76	Rep. Ratio 3.86	Rep. Ratio 1.03
KSI 21 0.22%	KSI 255 2.63%	KSI 35 0.36%	KSI 2,854 29.44%
Miles: 20 .07%	Miles: 270 .95%	Miles: 26 .09%	Miles: 8,129 28.67%

Divider

5+ Divided	5+ Not Divided	4 Divided	4 Not Divided	3 Divided	3 Not Divided	2 Divided	2 Not Divided
Rep. Ratio 2.40	Rep. Ratio 6.69	Rep. Ratio 2.37	Rep. Ratio 3.56	Rep. Ratio 1.89	Rep. Ratio 4.68	Rep. Ratio 1.60	Rep. Ratio 1.01
KSI 14 0.14%	KSI 7 0.07%	KSI 147 1.52%	KSI 108 1.11%	KSI 5 0.05%	KSI 30 0.31%	KSI 135 1.32%	KSI 2,726 26.12%
Miles: 17 .06%	Miles: 3 .01%	Miles: 181 .64%	Miles: 89 .32%	Miles: 8 .03%	Miles: 19 .07%	Miles: 234 .83%	Miles: 7,895 27.85%

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 4.66	Rep. Ratio 5.02	Rep. Ratio 4.58	Rep. Ratio 4.48	Rep. Ratio 3.29	Rep. Ratio 2.47	Rep. Ratio 1.34
KSI 28 0.29%	KSI 141 1.45%	KSI 259 2.67%	KSI 370 7.94%	KSI 516 5.32%	KSI 1,134 11.7%	KSI 237 2.45%
Miles: 18 .06%	Miles: 102 .36%	Miles: 166 .58%	Miles: 503 1.78%	Miles: 471 1.66%	Miles: 1,343 4.74%	Miles: 516 1.82%

Speed

70+ mph	66-70 mph	61-65 mph	56-60 mph	51-55 mph	46-50 mph	41-45 mph	36-40 mph	31-35 mph	26-30 mph	21-25 mph	0-20 mph
Rep. Ratio 2.87	Rep. Ratio 3.23	Rep. Ratio 2.56	Rep. Ratio 2.06	Rep. Ratio 2.77	Rep. Ratio 2.05	Rep. Ratio 1.98	Rep. Ratio 1.20	Rep. Ratio 1.21	Rep. Ratio 1.10	Rep. Ratio 1.68	Rep. Ratio 1.79
KSI 1,074 11.09%	KSI 412 4.25%	KSI 316 3.26%	KSI 316 3.26%	KSI 379 3.91%	KSI 294 3.03%	KSI 245 2.57%	KSI 134 1.38%	KSI 92 0.95%	KSI 40 0.41%	KSI 25 0.26%	KSI 7 0.07%
Miles: 1,094 3.86%	Miles: 372 1.32%	Miles: 361 1.27%	Miles: 448 1.58%	Miles: 430 1.41%	Miles: 419 1.48%	Miles: 368 1.3%	Miles: 326 1.15%	Miles: 222 .78%	Miles: 107 .38%	Miles: 44 .15%	Miles: 11 .04%

Not Equity Area

Rep. Ratio 0.87 | KSI 3,745 38.64% | Miles 12,543 44.3%

One-Way

Rep. Ratio 0.92 | KSI 33 0.34% | Miles 105 .37%

Lanes

5+	4	3	2	1
Rep. Ratio 0.84	Rep. Ratio 2.24	Rep. Ratio 2.96	Rep. Ratio 0.99	Rep. Ratio 0.00
KSI 2 0.02%	KSI 10 0.1%	KSI 1 0.01%	KSI 36 0.37%	KSI 0 0%
Miles: 7 .02%	Miles: 13 .05%	Miles: 1 %	Miles: 106 .37%	Miles: 0 %

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 0.00	Rep. Ratio 1.33	Rep. Ratio 2.25	Rep. Ratio 3.26	Rep. Ratio 1.48	Rep. Ratio 2.53	Rep. Ratio 2.39
KSI 0 0%	KSI 1 0.01%	KSI 6 0.06%	KSI 16 0.17%	KSI 6 0.06%	KSI 10 0.1%	KSI 4 0.04%
Miles: 3 .01%	Miles: 2 .01%	Miles: 8 .03%	Miles: 14 .05%	Miles: 12 .04%	Miles: 12 .04%	Miles: 5 .02%

Speed

70+ mph	66-70 mph	61-65 mph	56-60 mph	51-55 mph	46-50 mph	41-45 mph	36-40 mph	31-35 mph	26-30 mph	21-25 mph	0-20 mph
Rep. Ratio 1.00	Rep. Ratio 0.00	Rep. Ratio 0.92	Rep. Ratio 0.61	Rep. Ratio 2.07	Rep. Ratio 0.28	Rep. Ratio 1.50	Rep. Ratio 1.14	Rep. Ratio 1.46	Rep. Ratio 0.81	Rep. Ratio 0.51	Rep. Ratio 4.79
KSI 1 0.01%	KSI 0 0%	KSI 1 0.01%	KSI 1 0.01%	KSI 5 0.05%	KSI 1 0.01%	KSI 8 0.08%	KSI 9 0.09%	KSI 13 0.13%	KSI 5 0.05%	KSI 2 0.02%	KSI 9 0.09%
Miles: 3 .01%	Miles: 2 .01%	Miles: 3 .01%	Miles: 5 .02%	Miles: 7 .02%	Miles: 10 .04%	Miles: 16 .06%	Miles: 23 .08%	Miles: 26 .09%	Miles: 18 .06%	Miles: 11 .04%	Miles: 5 .02%

Two-Way

Rep. Ratio 0.87 | KSI 3,275 35.78% | Miles 11,062 39.01%

Lanes

5+	4	3	2
Rep. Ratio 2.01	Rep. Ratio 2.66	Rep. Ratio 2.84	Rep. Ratio 0.82
KSI 79 0.82%	KSI 633 6.79%	KSI 21 0.22%	KSI 1,779 18.35%
Miles: 115 .4%	Miles: 603 2.13%	Miles: 22 .08%	Miles: 8,606 30.36%

Divider

5+ Divided	5+ Not Divided	4 Divided	4 Not Divided	3 Divided	3 Not Divided	2 Divided	2 Not Divided
Rep. Ratio 1.53	Rep. Ratio 5.54	Rep. Ratio 2.31	Rep. Ratio 3.98	Rep. Ratio 4.07	Rep. Ratio 2.32	Rep. Ratio 1.73	Rep. Ratio 0.56
KSI 53 0.55%	KSI 26 0.27%	KSI 252 2.71%	KSI 518 5.35%	KSI 9 0.09%	KSI 12 0.12%	KSI 213 2.2%	KSI 1,566 16.16%
Miles: 101 .36%	Miles: 14 .05%	Miles: 370 1.3%	Miles: 234 .82%	Miles: 6 .02%	Miles: 15 .05%	Miles: 360 1.27%	Miles: 8,246 29.08%

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 2.10	Rep. Ratio 3.15	Rep. Ratio 4.18	Rep. Ratio 3.09	Rep. Ratio 2.08	Rep. Ratio 1.21	Rep. Ratio 1.42
KSI 19 0.2%	KSI 68 0.7%	KSI 294 3.03%	KSI 645 6.65%	KSI 396 4.09%	KSI 320 3.3%	KSI 139 1.43%
Miles: 26 .09%	Miles: 63 .22%	Miles: 271 .96%	Miles: 611 2.15%	Miles: 558 1.97%	Miles: 775 2.73%	Miles: 286 1.01%

Speed

70+ mph	66-70 mph	61-65 mph	56-60 mph	51-55 mph	46-50 mph	41-45 mph	36-40 mph	31-35 mph	26-30 mph	21-25 mph	0-20 mph
Rep. Ratio 3.85	Rep. Ratio 2.98	Rep. Ratio 2.83	Rep. Ratio 2.75	Rep. Ratio 2.42	Rep. Ratio 2.02	Rep. Ratio 1.92	Rep. Ratio 1.85	Rep. Ratio 1.77	Rep. Ratio 1.49	Rep. Ratio 1.47	Rep. Ratio 1.44
KSI 45 0.46%	KSI 33 0.34%	KSI 51 0.53%	KSI 121 1.25%	KSI 192 1.98%	KSI 286 2.95%	KSI 436 4.5%	KSI 570 5.88%	KSI 536 5.53%	KSI 304 3.14%	KSI 121 1.25%	KSI 27 0.28%
Miles: 34 .12%	Miles: 32 .11%	Miles: 53 .19%	Miles: 129 .45%	Miles: 232 .82%	Miles: 415 1.46%	Miles: 664 2.34%	Miles: 899 3.17%	Miles: 884 3.12%	Miles: 598 2.11%	Miles: 241 .85%	Miles: 55 .19%

Suburban

Rep. Ratio 0.87 | KSI 3,335 34.41% | Miles 11,266 39.7%

Equity Area

Rep. Ratio 1.71 | KSI 1,015 10.57% | Miles 1,753 6.19%

One-Way

Rep. Ratio 0.91 | KSI 80 0.82% | Miles 193 .68%

Lanes

5+	4	3	2	1
Rep. Ratio 0.84	Rep. Ratio 2.24	Rep. Ratio 2.96	Rep. Ratio 0.99	Rep. Ratio 0.00
KSI 2 0.02%	KSI 10 0.1%	KSI 1 0.01%	KSI 36 0.37%	KSI 0 0%
Miles: 7 .02%	Miles: 13 .05%	Miles: 1 %	Miles: 106 .37%	Miles: 0 %

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 0.00	Rep. Ratio 1.33	Rep. Ratio 2.25	Rep. Ratio 3.26	Rep. Ratio 1.48	Rep. Ratio 2.53	Rep. Ratio 2.39
KSI 0 0%	KSI 1 0.01%	KSI 6 0.06%	KSI 16 0.17%	KSI 6 0.06%	KSI 10 0.1%	KSI 4 0.04%
Miles: 3 .01%	Miles: 2 .01%	Miles: 8 .03%	Miles: 14 .05%	Miles: 12 .04%	Miles: 12 .04%	Miles: 5 .02%

Speed

70+ mph	66-70 mph	61-65 mph	56-60 mph	51-55 mph	46-50 mph	41-45 mph	36-40 mph	31-35 mph	26-30 mph	21-25 mph	0-20 mph
Rep. Ratio 1.00	Rep. Ratio 0.00	Rep. Ratio 0.92	Rep. Ratio 0.61	Rep. Ratio 2.07	Rep. Ratio 0.28	Rep. Ratio 1.50	Rep. Ratio 1.14	Rep. Ratio 1.46	Rep. Ratio 0.81	Rep. Ratio 0.51	Rep. Ratio 4.79
KSI 1 0.01%	KSI 0 0%	KSI 1 0.01%	KSI 1 0.01%	KSI 5 0.05%	KSI 1 0.01%	KSI 8 0.08%	KSI 9 0.09%	KSI 13 0.13%	KSI 5 0.05%	KSI 2 0.02%	KSI 9 0.09%
Miles: 3 .01%	Miles: 2 .01%	Miles: 3 .01%	Miles: 5 .02%	Miles: 7 .02%	Miles: 10 .04%	Miles: 16 .06%	Miles: 23 .08%	Miles: 26 .09%	Miles: 18 .06%	Miles: 11 .04%	Miles: 5 .02%

Two-Way

Rep. Ratio 0.87 | KSI 3,275 35.78% | Miles 11,062 39.01%

Lanes

5+	4	3	2
Rep. Ratio 2.01	Rep. Ratio 2.66	Rep. Ratio 2.84	Rep. Ratio 0.82
KSI 79 0.82%	KSI 633 6.79%	KSI 21 0.22%	KSI 1,779 18.35%
Miles: 115 .4%	Miles: 603 2.13%	Miles: 22 .08%	Miles: 8,606 30.36%

Divider

5+ Divided	5+ Not Divided	4 Divided	4 Not Divided	3 Divided	3 Not Divided	2 Divided	2 Not Divided
Rep. Ratio 1.53	Rep. Ratio 5.54	Rep. Ratio 2.31	Rep. Ratio 3.98	Rep. Ratio 4.07	Rep. Ratio 2.32	Rep. Ratio 1.73	Rep. Ratio 0.56
KSI 53 0.55%	KSI 26 0.27%	KSI 252 2.71%	KSI 518 5.35%	KSI 9 0.09%	KSI 12 0.12%	KSI 213 2.2%	KSI 1,566 16.16%
Miles: 101 .36%	Miles: 14 .05%	Miles: 370 1.3%	Miles: 234 .82%	Miles: 6 .02%	Miles: 15 .05%	Miles: 360 1.27%	Miles: 8,246 29.08%

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 2.10	Rep. Ratio 3.15	Rep. Ratio 4.18	Rep. Ratio 3.09	Rep. Ratio 2.08	Rep. Ratio 1.21	Rep. Ratio 1.42
KSI 19 0.2%	KSI 68 0.7%	KSI 294 3.03%	KSI 645 6.65%	KSI 396 4.09%	KSI 320 3.3%	KSI 139 1.43%
Miles: 26 .09%	Miles: 63 .22%	Miles: 271 .96%	Miles: 611 2.15%	Miles: 558 1.97%	Miles: 775 2.73%	Miles: 286 1.01%

Speed

70+ mph	66-70 mph	61-65 mph	56-60 mph	51-55 mph	46-50 mph	41-45 mph	36-40 mph	31-35 mph	26-30 mph	21-25 mph	0-20 mph
Rep. Ratio 3.85	Rep. Ratio 2.98	Rep. Ratio 2.83	Rep. Ratio 2.75	Rep. Ratio 2.42	Rep. Ratio 2.02	Rep. Ratio 1.92	Rep. Ratio 1.85	Rep. Ratio 1.77	Rep. Ratio 1.49	Rep. Ratio 1.47	Rep. Ratio 1.44
KSI 45 0.46%	KSI 33 0.34%	KSI 51 0.53%	KSI 121 1.25%	KSI 192 1.98%	KSI 286 2.95%	KSI 436 4.5%	KSI 570 5.88%	KSI 536 5.53%	KSI 304 3.14%	KSI 121 1.25%	KSI 27 0.28%
Miles: 34 .12%	Miles: 32 .11%	Miles: 53 .19%	Miles: 129 .45%	Miles: 232 .82%	Miles: 415 1.46%	Miles: 664 2.34%	Miles: 899 3.17%	Miles: 884 3.12%	Miles: 598 2.11%	Miles: 241 .85%	Miles: 55 .19%

Urban

Rep. Ratio 1.43 | KSI 1,407 14.52% | Miles 2,678 10.14%

Equity Area

Rep. Ratio 2.12 | KSI 655 6.76% | Miles 603 3.18%

One-Way

Rep. Ratio 1.15 | KSI 46 0.5% | Miles 122 .43%

Lanes

5+	4	3	2
Rep. Ratio 0.91	Rep. Ratio 2.61	Rep. Ratio 0.00	Rep. Ratio 1.30
KSI 1 0.01%	KSI 7 0.07%	KSI 0 0%	KSI 35 0.36%
Miles: 3 .01%	Miles: 8 .03%	Miles: 1 %	Miles: 79 .28%

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 14.59	Rep. Ratio 1.67	Rep. Ratio 1.71	Rep. Ratio 3.29	Rep. Ratio 2.34	Rep. Ratio 1.99	Rep. Ratio 0.00
KSI 2 0.02%	KSI 2 0.02%	KSI 2 0.02%	KSI 13 0.13%	KSI 9 0.09%	KSI 6 0.06%	KSI 0 0%
Miles: 0 %	Miles: 4 .01%	Miles: 3 .01%	Miles: 12 .04%	Miles: 11 .04%	Miles: 9 .03%	Miles: 4 .01%

Speed

70+ mph	66-70 mph	61-65 mph	56-60 mph	51-55 mph	46-50 mph	41-45 mph	36-40 mph	31-35 mph	26-30 mph	21-25 mph	0-20 mph
Rep. Ratio 5.24	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 1.28	Rep. Ratio 0.77	Rep. Ratio 0.45	Rep. Ratio 1.16	Rep. Ratio 1.91	Rep. Ratio 0.92	Rep. Ratio 1.81	Rep. Ratio 1.64
KSI 1 0.01%	KSI 0 0%	KSI 0 0%	KSI 0 0%	KSI 2 0.02%	KSI 1 0.01%	KSI 1 0.01%	KSI 4 0.04%	KSI 12 0.12%	KSI 6 0.06%	KSI 11 0.11%	KSI 7 0.07%
Miles: 1 %	Miles: 2 .01%	Miles: 1 %	Miles: 3 .01%	Miles: 5 .02%	Miles: 4 .01%	Miles: 6 .02%	Miles: 10 .04%	Miles: 18 .06%	Miles: 19 .07%	Miles: 18 .06%	Miles: 13 .04%

Two-Way

Rep. Ratio 1.44 | KSI 1,359 14.02% | Miles 2,754 9.71%

Lanes

5+	4	3	2
Rep. Ratio 2.40	Rep. Ratio 2.95	Rep. Ratio 3.70	Rep. Ratio 0.98
KSI 59 0.61%	KSI 245 2.53%	KSI 28 0.29%	KSI 667 6.78%
Miles: 72 .25%	Miles: 243 .86%	Miles: 14 .05%	Miles: 1,957 6.9%

Divider

5+ Divided	5+ Not Divided	4 Divided	4 Not Divided	3 Divided	3 Not Divided	2 Divided	2 Not Divided
Rep. Ratio 2.43	Rep. Ratio 2.10	Rep. Ratio 1.98	Rep. Ratio 4.38	Rep. Ratio 9.06	Rep. Ratio 4.73	Rep. Ratio 1.09	Rep. Ratio 0.98
KSI 54 0.55%	KSI 5 0.05%	KSI 98 1.01%	KSI 147 1.52%	KSI 10 0.1%	KSI 18 0.19%	KSI 43 0.44%	KSI 614 6.33%
Miles: 65 .23%	Miles: 7 .02%	Miles: 145 .51%	Miles: 98 .35%	Miles: 3 .01%	Miles: 11 .04%	Miles: 115 .41%	Miles: 1,842 6.5%

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 4.02	Rep. Ratio 2.99	Rep. Ratio 2.94	Rep. Ratio 3.27	Rep. Ratio 2.71	Rep. Ratio 1.38	Rep. Ratio 2.12
KSI 21 0.22%	KSI 51 0.53%	KSI 95 1.01%	KSI 251 2.59%	KSI 144 1.49%	KSI 85 0.88%	KSI 63 0.65%
Miles: 15 .05%	Miles: 52 .18%	Miles: 99 .35%	Miles: 225 .79%	Miles: 156 .55%	Miles: 181 .64%	Miles: 87 .31%

Speed

70+ mph	66-70 mph	61-65 mph	56-60 mph	51-55 mph	46-50 mph	41-45 mph	36-40 mph	31-35 mph	26-30 mph	21-25 mph	0-20 mph
Rep. Ratio 3.14	Rep. Ratio 2.21	Rep. Ratio 4.87	Rep. Ratio 2.62	Rep. Ratio 3.65	Rep. Ratio 2.05	Rep. Ratio 2.11	Rep. Ratio 2.26	Rep. Ratio 2.08	Rep. Ratio 2.54	Rep. Ratio 2.06	Rep. Ratio 1.84
KSI 11 0.11%	KSI 3 0.03%	KSI 13 0.13%	KSI 16 0.17%	KSI 30 0.31%	KSI 33 0.34%	KSI 80 0.82%	KSI 196 2.02%	KSI 263 2.71%	KSI 317 3.27%	KSI 192 1.98%	KSI 59 0.61%
Miles: 10 .04%	Miles: 4 .01%	Miles: 8 .03%	Miles: 18 .06%	Miles: 24 .08%	Miles: 47 .17%	Miles: 123 .44%	Miles: 254 .9%	Miles: 370 1.31%	Miles: 365 1.29%	Miles: 273 .96%	Miles: 94 .33%

Not Equity Area

Rep. Ratio 1.11 | KSI 752 7.76% | Miles 1,973 6.96%

One-Way

Rep. Ratio 1.29 | KSI 167 1.72% | Miles 380 1.34%

Lanes

5+	4	3	2	1
Rep. Ratio 1.38	Rep. Ratio 2.65	Rep. Ratio 8.47	Rep. Ratio 1.01	Rep. Ratio 4.31
KSI 4 0.04%	KSI 25 0.26%	KSI 34 0.35%	KSI 71 0.73%	KSI 2 0.02%
Miles: 8 .03%	Miles: 28 .1%	Miles: 12 .04%	Miles: 205 .72%	Miles: 1 %

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 3.68	Rep. Ratio 1.36	Rep. Ratio 4.74	Rep. Ratio 3.65	Rep. Ratio 1.39	Rep. Ratio 2.19	Rep. Ratio 3.85
KSI 3 0.03%	KSI 3 0.03%	KSI 20 0.21%	KSI 40 0.41%	KSI 11 0.11%	KSI 16 0.17%	KSI 20 0.21%
Miles: 2 .01%	Miles: 8 .02%	Miles: 12 .04%	Miles: 32 .11%	Miles: 23 .08%	Miles: 21 .08%	Miles: 15 .05%

Speed

70+ mph	66-70 mph	61-65 mph	56-60 mph	51-55 mph	46-50 mph	41-45 mph	36-40 mph	31-35 mph	26-30 mph	21-25 mph	0-20 mph
Rep. Ratio 1.00	Rep. Ratio 0.00	Rep. Ratio 0.92	Rep. Ratio 0.61	Rep. Ratio 2.07	Rep. Ratio 0.28	Rep. Ratio 1.50	Rep. Ratio 1.14	Rep. Ratio 1.46	Rep. Ratio 0.81	Rep. Ratio 0.51	Rep. Ratio 4.79
KSI 1 0.01%	KSI 0 0%	KSI 1 0.01%	KSI 1 0.01%	KSI 5 0.05%	KSI 1 0.01%	KSI 8 0.08%	KSI 9 0.09%	KSI 13 0.13%	KSI 5 0.05%	KSI 2 0.02%	KSI 9 0.09%
Miles: 3 .01%	Miles: 2 .01%	Miles: 3 .01%	Miles: 5 .02%	Miles: 7 .02%	Miles: 10 .04%	Miles: 16 .06%	Miles: 23 .08%	Miles: 26 .09%	Miles: 18 .06%	Miles: 11 .04%	Miles: 5 .02%

Two-Way

Rep. Ratio 0.86 | KSI 7,203 74.31% | Miles 24,596 86.08%

Lanes

5+	4	3	2
Rep. Ratio 2.03	Rep. Ratio 2.61	Rep. Ratio 4.15	Rep. Ratio 0.77
KSI 131 1.35%	KSI 891 9.19%	KSI 87 0.9%	KSI 4,410 45.5%
Miles: 188 .66%	Miles: 999 3.49%	Miles: 61 .22%	Miles: 16,803 58.28%

Divider

5+ Divided	5+ Not Divided	4 Divided	4 Not Divided	3 Divided	3 Not Divided	2 Divided	2 Not Divided
Rep. Ratio 1.71	Rep. Ratio 4.42	Rep. Ratio 1.90	Rep. Ratio 3.81	Rep. Ratio 3.35	Rep. Ratio 4.47	Rep. Ratio 1.54	Rep. Ratio 0.74
KSI 97 1%	KSI 34 0.35%	KSI 431 4.45%	KSI 460 4.75%	KSI 20 0.21%	KSI 82 0.99%	KSI 332 3.43%	KSI 4,078 42.07%
Miles: 166 .59%	Miles: 23 .08%	Miles: 636 2.24%	Miles: 853 3.24%	Miles: 17 .06%	Miles: 44 .16%	Miles: 629 2.22%	Miles: 16,173 57.04%

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 7.53	Rep. Ratio 3.74	Rep. Ratio 4.33	Rep. Ratio 2.25	Rep. Ratio 1.92	Rep. Ratio 1.30	Rep. Ratio 1.54
KSI 7 0.07%	KSI 5 0.05%	KSI 17 0.18%	KSI 13 0.13%	KSI 9 0.09%	KSI 6 0.06%	KSI 447 4.61%
Miles: 3 .01%	Miles: 4 .01%	Miles: 11 .04%	Miles: 12 .04%	Miles: 11 .04%	Miles: 9 .03%	Miles: 851 3%

Speed

70+ mph	66-70 mph	61-65 mph	56-60 mph	51-55 mph	46-50 mph	41-45 mph	36-40 mph	31-35 mph	26-30 mph	21-25 mph	0-20 mph
Rep. Ratio 1.25	Rep. Ratio 0.00	Rep. Ratio 3.23	Rep. Ratio 2.86	Rep. Ratio 1.95	Rep. Ratio 2.98	Rep. Ratio 1.98	Rep. Ratio 1.16	Rep. Ratio 2.80	Rep. Ratio 2.27	Rep. Ratio 2.73	Rep. Ratio 3.43
KSI 1 0.01%	KSI 0 0%	KSI 3 0.03%	KSI 5 0.05%	KSI 3 0.03%	KSI 12 0.12%	KSI 20 0.21%	KSI 22 0.23%	KSI 73 0.75%	KSI 90 0.93%	KSI 204 2.1%	KSI 197 2.03%
Miles: 2 .01%	Miles: 1 %	Miles: 3 .01%	Miles: 5 .02%	Miles: 3 .01%	Miles: 12 .04%	Miles: 30 .1%	Miles: 56 .2%	Miles: 76 .27%	Miles: 118 .41%	Miles: 219 .77%	Miles: 168 .59%

Core

Rep. Ratio 2.30 | KSI 858 8.85% | Miles 1,089 3.84%

Equity Area

Rep. Ratio 2.65 | KSI 339 3.5% | Miles 375 1.32%

One-Way

Rep. Ratio 4.10 | KSI 191 1.97% | Miles 135 .48%

Lanes

5+	4	3	2	1
Rep. Ratio 3.86	Rep. Ratio 6.82	Rep. Ratio 7.68	Rep. Ratio 3.07	Rep. Ratio 3.85
KSI 3 0.03%	KSI 34 0.35%	KSI 61 0.63%	KSI 80 0.83%	KSI 2 0.02%
Miles: 2 .01%	Miles: 15 .05%	Miles: 24 .08%	Miles: 76 .27%	Miles: 2 .01%

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 11.95	Rep. Ratio 3.86	Rep. Ratio 7.70	Rep. Ratio 6.32	Rep. Ratio 5.22	Rep. Ratio 3.51	Rep. Ratio 5.96
KSI 6 0.06%	KSI 3 0.03%	KSI 21 0.22%	KSI 56 0.58%	KSI 26 0.27%	KSI 14 0.14%	KSI 38 0.39%
Miles: 1 .01%	Miles: 2 .01%	Miles: 8 .03%	Miles: 26 .09%	Miles: 15 .05%	Miles: 12 .04%	Miles: 19 .07%

Speed

70+ mph	66-70 mph	61-65 mph	56-60 mph	51-55 mph	46-50 mph	41-45 mph	36-40 mph	31-35 mph	26-30 mph	21-25 mph	0-20 mph
Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 1.91	Rep. Ratio 3.15	Rep. Ratio 3.38	Rep. Ratio 4.44	Rep. Ratio 4.95	Rep. Ratio 4.88
KSI 0 0%	KSI 0 0%	KSI 0 0%	KSI 0 0%	KSI 0 0%	KSI 0 0%	KSI 3 0.02%	KSI 5 0.05%	KSI 6 0.06%	KSI 17 0.18%	KSI 50 0.52%	KSI 104 1.07%
Miles: 0 %	Miles: 0 %	Miles: 0 %	Miles: 1 %	Miles: 1 %	Miles: 1 %	Miles: 3 .01%	Miles: 5 .02%	Miles: 5 .02%	Miles: 11 .04%	Miles: 30 .1%	Miles: 62 .22%

Two-Way

Rep. Ratio 2.04 | KSI 667 6.88% | Miles 955 3.37%

Lanes

5+	4	3	2
Rep. Ratio 3.20	Rep. Ratio 4.50	Rep. Ratio 5.61	Rep. Ratio 1.39
KSI 23 0.24%	KSI 177 1.83%	KSI 30 0.31%	KSI 316 3.26%
Miles: 21 .07%	Miles: 115 .41%	Miles: 16 .06%	Miles: 663 2.34%

Divider

5+ Divided	5+ Not Divided	4 Divided	4 Not Divided	3 Divided	3 Not Divided	2 Divided	2 Not Divided
Rep. Ratio 3.29	Rep. Ratio 2.73	Rep. Ratio 1.92	Rep. Ratio 7.23	Rep. Ratio 2.37	Rep. Ratio 6.63	Rep. Ratio 1.09	Rep. Ratio 1.41
KSI 20 0.21%	KSI 3 0.03%	KSI 41 0.42%	KSI 130 1.34%	KSI 3 0.03%	KSI 27 0.28%	KSI 16 0.17%	KSI 300 3.1%
Miles: 16 .06%	Miles: 3 .01%	Miles: 62 .22%	Miles: 71 .26%	Miles: 4 .01%	Miles: 12 .04%	Miles: 43 .15%	Miles: 620 2.19%

AADT

40,001+	30,001-40,000	20,001-30,000	10,001-20,000	5,001-10,000	1,001-5,000	0-1,000
Rep. Ratio 1.79	Rep. Ratio 5.36	Rep. Ratio 4.12	Rep. Ratio 3.39	Rep. Ratio 2.40	Rep. Ratio 1.70	Rep. Ratio 4.99
KSI 4 0.04%	KSI 34 0.35%	KSI 55

Pedestrian and Bicycle Segment Crashes

Motor Vehicle Intersection Crashes

Equity Area — Rep. Ratio 2.26 — KSI: 1,172 31.25% — Locations: 29,772 13.83%

Roundabout — Rep. Ratio 0.31 — KSI: 2 0.05% — Locations: 374 .17%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 0.00 — KSI: 0 0% — Locations: 54 .03%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 114 .05%	Rep. Ratio 0.56 — KSI: 2 0.05% — Locations: 206 .1%

1	2	3	4
Rep. Ratio 0.00 — KSI: 0 0% — Locations: 21 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 23 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 7 %	Rep. Ratio 0.43 — KSI: 2 0.05% — Locations: 266 .12%

AADT

(0,1000]	(1000,5000]	(5000,10000]	(10000,20000]	(20000,30000]	(30000,40000]
Rep. Ratio 0.00 — KSI: 0 0% — Locations: 11 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 17 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 11 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 2 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 3 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 1 %

Stop Controlled — Rep. Ratio 1.30 — KSI: 587 15.65% — Locations: 25,932 12.05%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 0.48 — KSI: 2 0.05% — Locations: 238 .11%	Rep. Ratio 1.30 — KSI: 61 1.63% — Locations: 23,662 11%	Rep. Ratio 1.33 — KSI: 47 1.25% — Locations: 2,032 .94%

1	2	3	4	5+
Rep. Ratio 2.74 — KSI: 34 0.91% — Locations: 712 .33%	Rep. Ratio 0.72 — KSI: 61 1.63% — Locations: 4,840 2.25%	Rep. Ratio 1.13 — KSI: 23 0.61% — Locations: 1,164 .54%	Rep. Ratio 1.35 — KSI: 329 8.77% — Locations: 13,978 6.5%	Rep. Ratio 3.15 — KSI: 128 3.41% — Locations: 2,329 1.08%

AADT

(0,1000]	(1000,5000]	(5000,10000]	(10000,20000]	(20000,30000]	(30000,40000]	(40000,Inf]
Rep. Ratio 2.31 — KSI: 36 0.96% — Locations: 896 .42%	Rep. Ratio 1.67 — KSI: 57 1.52% — Locations: 1,955 .91%	Rep. Ratio 2.64 — KSI: 85 2.27% — Locations: 1,846 .86%	Rep. Ratio 2.92 — KSI: 114 3.04% — Locations: 2,240 1.04%	Rep. Ratio 4.42 — KSI: 88 2.35% — Locations: 1,141 .53%	Rep. Ratio 4.11 — KSI: 32 0.85% — Locations: 447 .21%	Rep. Ratio 1.98 — KSI: 12 0.32% — Locations: 348 .16%

Traffic Signal — Rep. Ratio 9.65 — KSI: 583 15.54% — Locations: 3,466 1.61%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 11.26 — KSI: 31 0.83% — Locations: 158 .07%	Rep. Ratio 9.68 — KSI: 454 12.1% — Locations: 2,692 1.25%	Rep. Ratio 9.13 — KSI: 98 2.61% — Locations: 616 .29%

1	2	3	4	5+
Rep. Ratio 7.34 — KSI: 22 0.59% — Locations: 172 .08%	Rep. Ratio 12.78 — KSI: 98 2.61% — Locations: 440 .2%	Rep. Ratio 9.65 — KSI: 38 1.01% — Locations: 226 .11%	Rep. Ratio 9.73 — KSI: 167 4.45% — Locations: 985 .46%	Rep. Ratio 8.73 — KSI: 232 6.19% — Locations: 1,525 .71%

AADT

(0,1000]	(1000,5000]	(5000,10000]	(10000,20000]	(20000,30000]	(30000,40000]	(40000,Inf]
Rep. Ratio 6.79 — KSI: 20 0.53% — Locations: 169 .08%	Rep. Ratio 6.16 — KSI: 25 0.67% — Locations: 233 .11%	Rep. Ratio 8.33 — KSI: 71 1.89% — Locations: 489 .23%	Rep. Ratio 10.85 — KSI: 185 4.93% — Locations: 978 .45%	Rep. Ratio 9.32 — KSI: 108 2.88% — Locations: 665 .31%	Rep. Ratio 8.44 — KSI: 49 1.31% — Locations: 333 .15%	

Not Equity Area — Rep. Ratio 0.80 — KSI: 2,579 68.75% — Locations: 185,431 86.17%

Roundabout — Rep. Ratio 0.55 — KSI: 14 0.37% — Locations: 1,456 .68%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 0.00 — KSI: 0 0% — Locations: 152 .07%	Rep. Ratio 0.75 — KSI: 7 0.19% — Locations: 538 .25%	Rep. Ratio 0.52 — KSI: 7 0.19% — Locations: 766 .36%

1	2	3	4	5+
Rep. Ratio 0.00 — KSI: 0 0% — Locations: 132 .06%	Rep. Ratio 0.68 — KSI: 1 0.03% — Locations: 84 .04%	Rep. Ratio 0.97 — KSI: 1 0.03% — Locations: 59 .03%	Rep. Ratio 0.48 — KSI: 7 0.19% — Locations: 845 .39%	Rep. Ratio 20.49 — KSI: 5 0.13% — Locations: 14 .01%

AADT

(0,1000]	(1000,5000]	(5000,10000]	(10000,20000]	(20000,30000]	(30000,40000]	(40000,Inf]
Rep. Ratio 0.00 — KSI: 0 0% — Locations: 153 .07%	Rep. Ratio 1.33 — KSI: 3 0.08% — Locations: 129 .06%	Rep. Ratio 3.22 — KSI: 5 0.13% — Locations: 89 .04%	Rep. Ratio 2.55 — KSI: 2 0.05% — Locations: 45 .02%	Rep. Ratio 14.34 — KSI: 2 0.05% — Locations: 8 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 6 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 2 %

Stop Controlled — Rep. Ratio 0.45 — KSI: 1,360 36.26% — Locations: 173,265 80.51%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 0.27 — KSI: 3 0.08% — Locations: 645 .3%	Rep. Ratio 0.45 — KSI: 1,280 34.12% — Locations: 164,465 76.42%	Rep. Ratio 0.54 — KSI: 77 2.05% — Locations: 8,155 3.79%

1	2	3	4	5+
Rep. Ratio 1.17 — KSI: 81 2.16% — Locations: 3,964 1.84%	Rep. Ratio 0.26 — KSI: 170 4.53% — Locations: 37,202 17.29%	Rep. Ratio 0.56 — KSI: 115 3.07% — Locations: 11,795 5.48%	Rep. Ratio 0.49 — KSI: 658 17.54% — Locations: 77,823 36.18%	Rep. Ratio 1.95 — KSI: 296 7.89% — Locations: 8,695 4.04%

AADT

(0,1000]	(1000,5000]	(5000,10000]	(10000,20000]	(20000,30000]	(30000,40000]	(40000,Inf]
Rep. Ratio 0.95 — KSI: 79 2.11% — Locations: 4,776 2.22%	Rep. Ratio 0.80 — KSI: 164 4.37% — Locations: 11,793 5.48%	Rep. Ratio 1.40 — KSI: 218 5.81% — Locations: 8,928 4.15%	Rep. Ratio 1.99 — KSI: 301 8.02% — Locations: 8,692 4.04%	Rep. Ratio 2.04 — KSI: 153 4.08% — Locations: 4,300 2%	Rep. Ratio 2.05 — KSI: 77 2.05% — Locations: 2,153 1%	Rep. Ratio 1.59 — KSI: 48 1.28% — Locations: 1,734 .81%

Traffic Signal — Rep. Ratio 6.46 — KSI: 1,205 32.12% — Locations: 10,710 4.98%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 12.68 — KSI: 21 0.56% — Locations: 95 .04%	Rep. Ratio 6.16 — KSI: 1,022 27.25% — Locations: 9,514 4.42%	Rep. Ratio 8.44 — KSI: 162 4.32% — Locations: 1,101 .51%

1	2	3	4	5+
Rep. Ratio 4.16 — KSI: 45 1.2% — Locations: 620 .29%	Rep. Ratio 6.91 — KSI: 226 6.03% — Locations: 1,876 .87%	Rep. Ratio 5.63 — KSI: 76 2.03% — Locations: 775 .36%	Rep. Ratio 5.96 — KSI: 268 7.14% — Locations: 2,581 1.2%	Rep. Ratio 6.65 — KSI: 503 13.41% — Locations: 4,341 2.02%

AADT

(0,1000]	(1000,5000]	(5000,10000]	(10000,20000]	(20000,30000]	(30000,40000]	(40000,Inf]
Rep. Ratio 5.97 — KSI: 72 1.92% — Locations: 692 .32%	Rep. Ratio 0.00 — KSI: 100 2.67% — Locations: 863 .4%	Rep. Ratio 8.32 — KSI: 139 3.71% — Locations: 1,261 .59%	Rep. Ratio 8.37 — KSI: 289 7.7% — Locations: 2,602 1.21%	Rep. Ratio 7.53 — KSI: 237 6.32% — Locations: 1,806 .84%	Rep. Ratio 8.41 — KSI: 109 2.91% — Locations: 976 .45%	[illegible] — KSI: 97 2.59% — Locations: 899 .42%

Rural — Rep. Ratio 0.61 — KSI: 729 19.43% — Locations: 68,801 31.97%

Roundabout — Rep. Ratio 0.88 — KSI: 7 0.19% — Locations: 454 .21%

Avg Approach Lanes

Blended	4
Rep. Ratio 1.05 — KSI: 40.11% — Locations: 219 .1%	Rep. Ratio 0.26 — KSI: 10.03% — Locations: 223 .1%

AADT

Blended	Two-Way	One-Way
Rep. Ratio 0.70 — KSI: 220.59% — Locations: 1,807 .84%	Rep. Ratio 0.42 — KSI: 479 14.44% — Locations: 64,755 30.09%	Rep. Ratio 0.30 — KSI: 10.03% — Locations: 194 .09%

5+	4	3	2	1
Rep. Ratio 2.69 — KSI: 651.73% — Locations: 1,385 .64%	Rep. Ratio 0.66 — KSI: 2787.41% — Locations: 24,269 11.28%	Rep. Ratio 0.53 — KSI: 551.47% — Locations: 5,962 2.77%	Rep. Ratio 0.24 — KSI: 611.63% — Locations: 14,738 6.85%	Rep. Ratio 1.12 — KSI: 290.77% — Locations: 1,492 .69%

AADT

0-1,000
Rep. Ratio 0.81 — KSI: 240.64% — Locations: 1,699 .79%

Lanes

Rep. Ratio 2.50 — KSI: 140.37% — Locations: 321 .15%	Rep. Ratio 3.43 — KSI: 270.72% — Locations: 451 .21%	Rep. Ratio 3.22 — KSI: 541.44% — Locations: 962 .45%	Rep. Ratio 2.73 — KSI: 1062.83% — Locations: 2,225 1.03%	Rep. Ratio 1.77 — KSI: 882.35% — Locations: 2,858 1.33%	Rep. Ratio 1.36 — KSI: 1082.88% — Locations: 4,562 2.12%

Traffic Signal — Rep. Ratio 7.95 — KSI: 220 5.87% — Locations: 1,587 .74%

Avg Approach Lanes

Blended	Two-Way	One-Way
Rep. Ratio 4.04 — KSI: 100.27% — Locations: 142 .07%	Rep. Ratio 8.35 — KSI: 210 5.6% — Locations: 1,443 .67%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 2 %

5+	4	3	2	1
Rep. Ratio 6.57 — KSI: 631.68% — Locations: 550 .26%	Rep. Ratio 9.05 — KSI: 591.57% — Locations: 374 .17%	Rep. Ratio 8.09 — KSI: 220.59% — Locations: 156 .07%	Rep. Ratio 11.75 — KSI: 591.57% — Locations: 288 .13%	Rep. Ratio 2.84 — KSI: 60.16% — Locations: 121 .06%

AADT

Rep. Ratio 9.49 — KSI: 210.56% — Locations: 127 .06%	Rep. Ratio 10.72 — KSI: 200.53% — Locations: 107 .05%	Rep. Ratio 10.25 — KSI: 45 1.2% — Locations: 252 1.2%	Rep. Ratio 8.52 — KSI: 531.41% — Locations: 357 .17%	Rep. Ratio 8.43 — KSI: 360.96% — Locations: 245 .11%	Rep. Ratio 7.09 — KSI: 220.59% — Locations: 178 .08%	Rep. Ratio 4.15 — KSI: 60.16% — Locations: 83 .04%

Suburban — Rep. Ratio 0.79 — KSI: 1,496 39.88% — Locations: 108,262 50.31%

Roundabout — Rep. Ratio 0.61 — KSI: 8 0.21% — Locations: 757 .35%

Avg Approach Lanes

Blended	Two-Way	One-Way
Rep. Ratio 0.58 — KSI: 40.11% — Locations: 396 .18%	Rep. Ratio 0.81 — KSI: 40.11% — Locations: 282 .13%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 79 .04%

5+	4	3	2	1
Rep. Ratio 5.22 — KSI: 10.03% — Locations: 11 .01%	Rep. Ratio 0.89 — KSI: 70.19% — Locations: 453 .21%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 30 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 42 .02%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 54 .03%

AADT

Rep. Ratio 0.00 — KSI: 0 0% — Locations: 3 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 3 %	Rep. Ratio 8.20 — KSI: 20.05% — Locations: 14 .01%	Rep. Ratio 1.08 — KSI: 10.03% — Locations: 53 .02%	Rep. Ratio 1.32 — KSI: 20.05% — Locations: 87 .04%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 86 .04%

Stop Controlled — Rep. Ratio 0.43 — KSI: 502 13.38% — Locations: 66,761 31.02%

Avg Approach Lanes

Blended	Two-Way	One-Way
Rep. Ratio 0.49 — KSI: 391.04% — Locations: 4,551 2.11%	Rep. Ratio 0.49 — KSI: 834 25.22% — Locations: 96,965 45.06%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 295 .14%

5+	4	3	2	1
Rep. Ratio 1.95 — KSI: 1985.28% — Locations: 5,840 2.71%	Rep. Ratio 0.48 — KSI: 438 11.48% — Locations: 51,969 24.15%	Rep. Ratio 0.57 — KSI: 541.44% — Locations: 5,388 2.5%	Rep. Ratio 0.27 — KSI: 1062.83% — Locations: 22,510 10.46%	Rep. Ratio 1.47 — KSI: 561.49% — Locations: 2,181 1.01%

AADT

Rep. Ratio 1.74 — KSI: 30 0.8% — Locations: 990 .46%	Rep. Ratio 2.01 — KSI: 461.23% — Locations: 1,310 .61%	Rep. Ratio 2.25 — KSI: 1133.01% — Locations: 2,886 1.34%	Rep. Ratio 1.78 — KSI: 1834.88% — Locations: 5,892 2.74%	Rep. Ratio 1.37 — KSI: 1393.71% — Locations: 5,833 2.71%	Rep. Ratio 0.55 — KSI: 671.79% — Locations: 6,974 3.24%	Rep. Ratio 1.06 — KSI: 471.25% — Locations: 2,535 1.18%

Traffic Signal — Rep. Ratio 6.20 — KSI: 615 16.4% — Locations: 5,693 2.65%

Avg Approach Lanes

Blended	Two-Way	One-Way
Rep. Ratio 8.20 — KSI: 531.41% — Locations: 371 .17%	Rep. Ratio 6.05 — KSI: 560 14.93% — Locations: 5,314 2.47%	Rep. Ratio 14.34 — KSI: 20.05% — Locations: 8 %

5+	4	3	2	1
Rep. Ratio 5.94 — KSI: 2286.08% — Locations: 2,011 .02%	Rep. Ratio 6.08 — KSI: 1564.16% — Locations: 1,473 .68%	Rep. Ratio 5.74 — KSI: 411.09% — Locations: 410 .19%	Rep. Ratio 6.39 — KSI: 1072.85% — Locations: 961 .45%	Rep. Ratio 5.20 — KSI: 310.83% — Locations: 342 .16%

AADT

Rep. Ratio 4.45 — KSI: 290.77% — Locations: 374 .17%	Rep. Ratio 6.21 — KSI: 551.47% — Locations: 508 .24%	Rep. Ratio 6.49 — KSI: 1163.09% — Locations: 1,026 .48%	Rep. Ratio 7.28 — KSI: 1895.04% — Locations: 1,490 .69%	Rep. Ratio 5.51 — KSI: 691.84% — Locations: 718 .33%	Rep. Ratio 4.08 — KSI: 30 0.8% — Locations: 422 .2%	Rep. Ratio 4.36 — KSI: 200.53% — Locations: 263 .12%

Urban — Rep. Ratio 1.75 — KSI: 808 21.54% — Locations: 26,525 12.33%

Roundabout — Rep. Ratio 0.14 — KSI: 1 0.03% — Locations: 419 .19%

Avg Approach Lanes

Blended	Two-Way	One-Way
Rep. Ratio 0.23 — KSI: 10.03% — Locations: 248 .12%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 125 .06%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 46 .02%

5+	4	3	2	1
Rep. Ratio 0.00 — KSI: 0 0% — Locations: 1 %	Rep. Ratio 0.18 — KSI: 10.03% — Locations: 319 .15%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 13 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 19 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 14 .01%

AADT

Rep. Ratio 0 0% — KSI: 0 0% — Locations: 2 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 3 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 5 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 19 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 25 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 16 .01%

Stop Controlled — Rep. Ratio 0.97 — KSI: 381 10.16% — Locations: 22,608 10.51%

Avg Approach Lanes

Blended	Two-Way	One-Way
Rep. Ratio 0.90 — KSI: 391.04% — Locations: 2,491 1.16%	Rep. Ratio 0.98 — KSI: 3419.09% — Locations: 19,941 9.27%	Rep. Ratio 1.55 — KSI: 200.53% — Locations: 740 .34%

5+	4	3	2	1
Rep. Ratio 2.45 — KSI: 1042.77% — Locations: 2,440 1.13%	Rep. Ratio 0.90 — KSI: 1794.77% — Locations: 11,393 5.29%	Rep. Ratio 1.03 — KSI: 220.59% — Locations: 1,222 .57%	Rep. Ratio 0.68 — KSI: 451.2% — Locations: 3,818 1.77%	Rep. Ratio 2.56 — KSI: 300.88% — Locations: 740 .34%

AADT

Rep. Ratio 1.16 — KSI: 100.27% — Locations: 494 .23%	Rep. Ratio 2.27 — KSI: 220.59% — Locations: 555 .26%	Rep. Ratio 2.54 — KSI: 491.31% — Locations: 1,106 .51%	Rep. Ratio 2.67 — KSI: 882.35% — Locations: 1,892 .88%	Rep. Ratio 2.07 — KSI: 511.36% — Locations: 1,412 .66%	Rep. Ratio 1.30 — KSI: 350.93% — Locations: 1,539 .72%	Rep. Ratio 1.13 — KSI: 160.43% — Locations: 811 .38%

Traffic Signal — Rep. Ratio 8.99 — KSI: 426 11.3% — Locations: 3,498 1.63%

Avg Approach Lanes

Blended	Two-Way	One-Way
Rep. Ratio 8.02 — KSI: 521.39% — Locations: 372 .17%	Rep. Ratio 6.83 — KSI: 3699.84% — Locations: 3,099 1.44%	Rep. Ratio 5.09 — KSI: 180.48% — Locations: 203 .09%

5+	4	3	2	1
Rep. Ratio 5.60 — KSI: 1473.92% — Locations: 1,505 .7%	Rep. Ratio 8.34 — KSI: 1213.23% — Locations: 832 .39%	Rep. Ratio 7.11 — KSI: 30 0.8% — Locations: 242 .11%	Rep. Ratio 7.26 — KSI: 721.92% — Locations: 569 .26%	Rep. Ratio 4.97 — KSI: 160.47% — Locations: 203 .09%

AADT

Rep. Ratio 6.97 — KSI: 391.04% — Locations: 321 .15%	Rep. Ratio 4.92 — KSI: 330.88% — Locations: 385 .18%	Rep. Ratio 6.44 — KSI: 721.92% — Locations: 641 .3%	Rep. Ratio 7.16 — KSI: 1092.91% — Locations: 873 .41%	Rep. Ratio 6.78 — KSI: 431.15% — Locations: 364 .17%	Rep. Ratio 7.33 — KSI: 340.91% — Locations: 266 .12%	Rep. Ratio 5.96 — KSI: 160.43% — Locations: 154 .07%

Core — Rep. Ratio 3.38 — KSI: 605 16.13% — Locations:

Not Equity Area — Rep. Ratio 3.24 — KSI: 396 10.56% — Locations: 7,011 3.26%

Equity Area — Rep. Ratio 3.67 — KSI: 209 5.57% — Locations: 3,265 1.52%

Roundabout — Rep. Ratio 0.00 — KSI: 0 0% — Locations: 186 .09%

Avg Approach Lanes

Blended	Two-Way	One-Way
Rep. Ratio 0.00 — KSI: 0 0% — Locations: 99 .05%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 66 .03%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 21 .01%

4	3	2	1
Rep. Ratio 0.00 — KSI: 0 0% — Locations: 107 .05%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 9 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 16 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 22 .01%

AADT

Rep. Ratio 0.00 — KSI: 0 0% — Locations: 1 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 1 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 10 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 5 %	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 17 .01%	Rep. Ratio 0.00 — KSI: 0 0% — Locations: 16 .01%

Stop Controlled — Rep. Ratio 1.21 — KSI: 149 3.97% — Locations: 7,055 3.28%

Avg Approach Lanes

Blended	Two-Way	One-Way
Rep. Ratio 1.05 — KSI: 220.59% — Locations: 1,203 .56%	Rep. Ratio 1.26 — KSI: 1243.31% — Locations: 5,641 2.62%	Rep. Ratio 0.82 — KSI: 30.08% — Locations: 211 .1%

5+	4	3	2	1
Rep. Ratio 2.06 — KSI: 391.04% — Locations: 1,087 .51%	Rep. Ratio 1.19 — KSI: 792.11% — Locations: 3,801 1.77%	Rep. Ratio 1.07 — KSI: 60.16% — Locations: 321 .15%	Rep. Ratio 1.03 — KSI: 160.43% — Locations: 892 .41%	Rep. Ratio 1.70 — KSI: 60.16% — Locations: 203 .09%

AADT

Rep. Ratio 1.10 — KSI: 40.11% — Locations: 208 .1%	Rep. Ratio 2.48 — KSI: 90.24% — Locations: 208 .1%	Rep. Ratio 2.80 — KSI: 180.48% — Locations: 369 .17%	Rep. Ratio 2.09 — KSI: 270.72% — Locations: 741 .34%	Rep. Ratio 1.98 — KSI: 190.51% — Locations: 550 .26%	Rep. Ratio 0.99 — KSI: 100.27% — Locations: 582 .27%	Rep. Ratio 2.57 — KSI: 260.69% — Locations: 580 .27%

Traffic Signal — Rep. Ratio 8.62 — KSI: 456 12.1% — Locations: 3,039 1.41%

Avg Approach Lanes

Blended	Two-Way	One-Way
Rep. Ratio 9.83 — KSI: 1363.63% — Locations: 794 .37%	Rep. Ratio 7.81 — KSI: 2767.36% — Locations: 2,028 .94%	Rep. Ratio 11.85 — KSI: 441.17% — Locations: 213 .1%

5+	4	3	2	1
Rep. Ratio 10.58 — KSI: 2727.25% — Locations: 1,475 .69%	Rep. Ratio 6.02 — KSI: 852.27% — Locations: 810 .38%	Rep. Ratio 6.62 — KSI: 180.48% — Locations: 156 .07%	Rep. Ratio 9.12 — KSI: 681.81% — Locations: 428 .2%	Rep. Ratio 4.73 — KSI: 80.21% — Locations: 97 .05%

AADT

Rep. Ratio 9.84 — KSI: 411.09% — Locations: 239 .11%	Rep. Ratio 9.53 — KSI: 441.17% — Locations: 265 .12%	Rep. Ratio 11.38 — KSI: 962.56% — Locations: 484 .22%	Rep. Ratio 8.04 — KSI: 1092.91% — Locations: 778 .36%	Rep. Ratio 7.67 — KSI: 521.39% — Locations: 389 .18%	Rep. Ratio 9.21 — KSI: 350.93% — Locations: 218 .1%	Rep. Ratio 7.75 — KSI: 471.25% — Locations: 348 .16%

Pedestrian or Bike Intersection Crashes

Rural

Roundabout

Rep. Ratio 0.00 | KSI: 0 0% | Locations: 219 .1%

Avg Approach Lanes

5+	4	3	2	1
Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00
KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%
Locations: 2 %	Locations: 223 .1%	Locations: 9 %	Locations: 30 .01%	Locations: 63 .03%

AADT

30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00
KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%
Locations: 1 %	Locations: 4 %	Locations: 18 .01%	Locations: 21 .01%	Locations: 17 .01%	Locations: 35 .02%

Stop Controlled

Rep. Ratio 0.18 | KSI: 185 5.45% | Locations: 66,760 31.02%

Avg Approach Lanes

5+	4	3	2	1
Rep. Ratio 0.59	Rep. Ratio 0.32	Rep. Ratio 0.23	Rep. Ratio 0.08	Rep. Ratio 0.25
KSI: 130 38%	KSI: 123 3.61%	KSI: 220 6.5%	KSI: 180 5.3%	KSI: 60 1.8%
Locations: 1,385 .64%	Locations: 24,269 11.28%	Locations: 5,962 2.77%	Locations: 14,738 6.85%	Locations: 1,492 .69%

AADT

40k +	30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 0.39	Rep. Ratio 0.98	Rep. Ratio 1.05	Rep. Ratio 1.11	Rep. Ratio 0.86	Rep. Ratio 0.32	Rep. Ratio 0.63
KSI: 20 0.6%	KSI: 70 2.1%	KSI: 160 4.7%	KSI: 391 14%	KSI: 391 14%	KSI: 230 6.7%	KSI: 17 0.5%
Locations: 321 .15%	Locations: 451 .21%	Locations: 962 .45%	Locations: 2,225 1.03%	Locations: 2,858 1.33%	Locations: 4,556 2.12%	Locations: 1,699 .79%

Traffic Signal

Rep. Ratio 3.38 | KSI: 85 2.49% | Locations: 1,587 .74%

Avg Approach Lanes

5+	4	3	2	1
Rep. Ratio 3.79	Rep. Ratio 3.21	Rep. Ratio 3.64	Rep. Ratio 4.16	Rep. Ratio 2.61
KSI: 330 97%	KSI: 190 56%	KSI: 90 26%	KSI: 190 56%	KSI: 50 15%
Locations: 550 .26%	Locations: 374 .17%	Locations: 156 .07%	Locations: 288 .13%	Locations: 121 .06%

AADT

40k +	30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 5.96	Rep. Ratio 5.90	Rep. Ratio 4.26	Rep. Ratio 2.47	Rep. Ratio 4.64	Rep. Ratio 1.06	Rep. Ratio 0.76
KSI: 120 35%	KSI: 100 29%	KSI: 17 0.5%	KSI: 140 41%	KSI: 180 53%	KSI: 30 9%	KSI: 10 3%
Locations: 127 .06%	Locations: 107 .05%	Locations: 252 .12%	Locations: 357 .17%	Locations: 245 .11%	Locations: 178 .08%	Locations: 83 .04%

Suburban

Roundabout

Rep. Ratio 0.58 | KSI: 7 0.21% | Locations: 757 .35%

Avg Approach Lanes

5+	4	3	2	1
Rep. Ratio 5.74	Rep. Ratio 0.42	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00
KSI: 10 3%	KSI: 30 0.9%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%
Locations: 11 .01%	Locations: 453 .21%	Locations: 30 .01%	Locations: 42 .02%	Locations: 54 .03%

AADT

40k +	30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 0.00	Rep. Ratio 21.04	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 1.19	Rep. Ratio 0.00	Rep. Ratio 0.00
KSI: 0 0%	KSI: 10 3%	KSI: 0 0%	KSI: 0 0%	KSI: 10 3%	KSI: 0 0%	KSI: 0 0%
Locations: 2 %	Locations: 3 %	Locations: 3 %	Locations: 14 .01%	Locations: 53 .02%	Locations: 87 .04%	Locations: 86 .04%

Stop Controlled

Rep. Ratio 0.46 | KSI: 705 21.8% | Locations: 107,681 47.31%

Avg Approach Lanes

5+	4	3	2	1
Rep. Ratio 1.95	Rep. Ratio 0.46	Rep. Ratio 0.48	Rep. Ratio 0.26	Rep. Ratio 1.01
KSI: 180 5.2%	KSI: 38 11.2%	KSI: 41 1.2%	KSI: 91 2.67%	KSI: 35 1.03%
Locations: 5,840 2.71%	Locations: 51,969 4.15%	Locations: 5,388 2.5%	Locations: 22,512 10.46%	Locations: 2,181 1.01%

AADT

40k +	30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 1.27	Rep. Ratio 1.64	Rep. Ratio 2.45	Rep. Ratio 1.82	Rep. Ratio 1.27	Rep. Ratio 0.77	Rep. Ratio 0.77
KSI: 20 0.59%	KSI: 34 1%	KSI: 112 3.28%	KSI: 170 4.99%	KSI: 117 3.43%	KSI: 85 2.49%	KSI: 31 0.91%
Locations: 990 .46%	Locations: 1,310 .61%	Locations: 2,886 1.34%	Locations: 5,892 2.74%	Locations: 5,833 2.71%	Locations: 6,974 3.24%	Locations: 2,535 1.18%

Traffic Signal

Rep. Ratio 5.78 | KSI: 521 15.2% | Locations: 5,603 2.65%

Avg Approach Lanes

5+	4	3	2	1
Rep. Ratio 5.82	Rep. Ratio 5.61	Rep. Ratio 6.16	Rep. Ratio 5.65	Rep. Ratio 3.88
KSI: 203 5.95%	KSI: 131 3.84%	KSI: 401 17%	KSI: 862 52%	KSI: 210 62%
Locations: 2,201 1.02%	Locations: 1,473 .68%	Locations: 410 .19%	Locations: 961 .45%	Locations: 342 .16%

AADT

40k +	30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 6.41	Rep. Ratio 5.34	Rep. Ratio 7.93	Rep. Ratio 5.17	Rep. Ratio 5.19	Rep. Ratio 3.44	Rep. Ratio 4.80
KSI: 38 1.11%	KSI: 43 1.26%	KSI: 129 3.78%	KSI: 122 3.58%	KSI: 59 1.73%	KSI: 23 0.67%	KSI: 20 0.59%
Locations: 374 .17%	Locations: 508 .24%	Locations: 1,026 .48%	Locations: 1,490 .69%	Locations: 718 .33%	Locations: 422 .2%	Locations: 263 .12%

Urban

Roundabout

Rep. Ratio 0.76 | KSI: 30 0.9% | Locations: 248 .12%

Avg Approach Lanes

5+	4	3	2	1
Rep. Ratio 0.00	Rep. Ratio 0.59	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00
KSI: 0 0%	KSI: 30 0.9%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%
Locations: 1 %	Locations: 319 .15%	Locations: 13 .01%	Locations: 19 .01%	Locations: 14 .01%

AADT

30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 3.94
KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 10 3%
Locations: 2 %	Locations: 3 %	Locations: 5 %	Locations: 19 .01%	Locations: 25 .01%	Locations: 16 .01%

Stop Controlled

Rep. Ratio 1.17 | KSI: 420 12.3% | Locations: 22,603 10.51%

Avg Approach Lanes

5+	4	3	2	1
Rep. Ratio 2.48	Rep. Ratio 1.16	Rep. Ratio 0.62	Rep. Ratio 0.89	Rep. Ratio 2.56
KSI: 96 2.82%	KSI: 210 6.16%	KSI: 120 3.5%	KSI: 541 58%	KSI: 300 88%
Locations: 2,440 1.13%	Locations: 11,393 5.29%	Locations: 1,222 .57%	Locations: 3,818 1.77%	Locations: 740 .34%

AADT

40k +	30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 2.04	Rep. Ratio 2.62	Rep. Ratio 2.68	Rep. Ratio 2.77	Rep. Ratio 2.86	Rep. Ratio 1.72	Rep. Ratio 1.48
KSI: 16 0.47%	KSI: 23 0.67%	KSI: 47 1.38%	KSI: 83 2.43%	KSI: 64 1.88%	KSI: 42 1.23%	KSI: 190 56%
Locations: 494 .23%	Locations: 555 .26%	Locations: 1,106 .51%	Locations: 1,892 .88%	Locations: 1,412 .66%	Locations: 1,539 .72%	Locations: 811 .38%

Traffic Signal

Rep. Ratio 7.27 | KSI: 403 11.8% | Locations: 3,498 1.63%

Avg Approach Lanes

5+	4	3	2	1
Rep. Ratio 6.29	Rep. Ratio 7.36	Rep. Ratio 4.69	Rep. Ratio 10.76	Rep. Ratio 4.97
KSI: 150 4.4%	KSI: 97 2.84%	KSI: 180 53%	KSI: 97 2.84%	KSI: 160 47%
Locations: 1,505 .7%	Locations: 832 .39%	Locations: 242 .11%	Locations: 569 .26%	Locations: 203 .09%

AADT

40k +	30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 7.08	Rep. Ratio 7.54	Rep. Ratio 7.78	Rep. Ratio 7.52	Rep. Ratio 4.85	Rep. Ratio 5.69	Rep. Ratio 7.79
KSI: 36 1.06%	KSI: 46 1.35%	KSI: 79 2.32%	KSI: 104 3.05%	KSI: 28 0.82%	KSI: 24 0.7%	KSI: 190 56%
Locations: 321 .15%	Locations: 385 .18%	Locations: 641 .3%	Locations: 873 .41%	Locations: 364 .17%	Locations: 266 .12%	Locations: 154 .07%

Core

Rep. Ratio 5.69 | KSI: 926 27.16% | Locations: 10,276 4.78%

Roundabout

Rep. Ratio 0.00 | KSI: 0 0% | Locations: 186 .09%

Avg Approach Lanes

4	3	2	1
Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00
KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%
Locations: 107 .05%	Locations: 9 %	Locations: 16 .01%	Locations: 22 .01%

AADT

30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00
KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%
Locations: 1 %	Locations: 1 %	Locations: 10 %	Locations: 5 %	Locations: 17 .01%	Locations: 16 .01%

Stop Controlled

Rep. Ratio 2.09 | KSI: 234 6.86% | Locations: 7,055 3.26%

Avg Approach Lanes

5+	4	3	2	1
Rep. Ratio 3.89	Rep. Ratio 2.19	Rep. Ratio 1.57	Rep. Ratio 1.20	Rep. Ratio 2.49
KSI: 67 1.96%	KSI: 132 3.87%	KSI: 80 2.3%	KSI: 17 0.5%	KSI: 80 2.3%
Locations: 1,087 .51%	Locations: 3,801 1.77%	Locations: 321 .15%	Locations: 892 .41%	Locations: 203 .09%

AADT

40k +	30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 3.03	Rep. Ratio 2.73	Rep. Ratio 3.42	Rep. Ratio 4.34	Rep. Ratio 1.95	Rep. Ratio 2.39	Rep. Ratio 4.90
KSI: 10 0.29%	KSI: 9 0.26%	KSI: 20 0.59%	KSI: 51 1.5%	KSI: 17 0.5%	KSI: 22 0.65%	KSI: 45 1.32%
Locations: 208 .1%	Locations: 208 .1%	Locations: 369 .17%	Locations: 741 .34%	Locations: 550 .26%	Locations: 582 .27%	Locations: 580 .27%

Traffic Signal

Rep. Ratio 14.39 | KSI: 692 20.5% | Locations: 3,039 1.41%

Avg Approach Lanes

5+	4	3	2	1
Rep. Ratio 16.30	Rep. Ratio 10.91	Rep. Ratio 15.78	Rep. Ratio 14.01	Rep. Ratio 12.36
KSI: 381 11.3%	KSI: 140 4.11%	KSI: 39 1.14%	KSI: 95 2.79%	KSI: 190 56%
Locations: 1,475 .69%	Locations: 810 .38%	Locations: 156 .07%	Locations: 428 .2%	Locations: 97 .05%

AADT

40k +	30k-40k	20k-30k	10k-20k	5k-10k	1k-5k	0-1k
Rep. Ratio 11.35	Rep. Ratio 16.43	Rep. Ratio 17.08	Rep. Ratio 13.55	Rep. Ratio 15.41	Rep. Ratio 9.26	Rep. Ratio 15.60
KSI: 43 1.26%	KSI: 69 2.02%	KSI: 13 3.84%	KSI: 16 7 4.9%	KSI: 95 2.79%	KSI: 32 0.94%	KSI: 86 2.52%
Locations: 239 .11%	Locations: 265 .12%	Locations: 484 .22%	Locations: 778 .36%	Locations: 389 .18%	Locations: 218 .1%	Locations: 348 .16%

Equity Area

Rep. Ratio 2.46 | KSI: 1,161 34.05% | Locations: 29,772 13.83%

Roundabout

Rep. Ratio 0.17 | KSI: 1 0.03% | Locations: 374 .17%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.31
KSI: 0 0%	KSI: 0 0%	KSI: 1 0.03%
Locations: 54 .03%	Locations: 114 .05%	Locations: 206 .1%

AADT

1	2	3	4
Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.24
KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 1 0.03%
Locations: 21 .01%	Locations: 23 .01%	Locations: 7 %	Locations: 266 .12%

0-1k	1k-5k	5k-10k	10k-20k	20k-30k	30k-40k
Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00
KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 0 0%
Locations: 11 .01%	Locations: 17 .01%	Locations: 11 .01%	Locations: 2 %	Locations: 3 %	Locations: 1 %

Stop Controlled

Rep. Ratio 1.16 | KSI: 478 14.02% | Locations: 25,932 12.05%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 1.33	Rep. Ratio 1.12	Rep. Ratio 1.62
KSI: 5 0.15%	KSI: 421 12.35%	KSI: 52 1.52%
Locations: 238 .11%	Locations: 23,662 11%	Locations: 2,032 .94%

AADT

1	2	3	4	5+
Rep. Ratio 2.66	Rep. Ratio 0.59	Rep. Ratio 1.03	Rep. Ratio 1.13	Rep. Ratio 3.52
KSI: 30 0.88%	KSI: 45 1.32%	KSI: 19 0.56%	KSI: 251 7.36%	KSI: 130 3.81%
Locations: 712 .33%	Locations: 4,840 2.25%	Locations: 1,164 .54%	Locations: 13,978 6.5%	Locations: 2,329 1.08%

0-1k	1k-5k	5k-10k	10k-20k	20k-30k	30k-40k	40k +
Rep. Ratio 2.04	Rep. Ratio 1.48	Rep. Ratio 2.60	Rep. Ratio 3.24	Rep. Ratio 3.54	Rep. Ratio 4.09	Rep. Ratio 1.63
KSI: 29 0.85%	KSI: 46 1.35%	KSI: 76 2.23%	KSI: 115 3.37%	KSI: 64 1.88%	KSI: 29 0.85%	KSI: 9 0.26%
Locations: 896 .42%	Locations: 1,955 .91%	Locations: 1,846 .86%	Locations: 2,240 1.04%	Locations: 1,141 .53%	Locations: 447 .21%	Locations: 348 .16%

Traffic Signal

Rep. Ratio 12.42 | KSI: 682 20% | Locations: 3,466 1.61%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 28.76	Rep. Ratio 10.55	Rep. Ratio 16.35
KSI: 72 2.11%	KSI: 450 13.2%	KSI: 150 4.68%
Locations: 158 .07%	Locations: 2,692 1.25%	Locations: 616 .29%

AADT

1	2	3	4	5+
Rep. Ratio 11.01	Rep. Ratio 14.34	Rep. Ratio 8.38	Rep. Ratio 9.93	Rep. Ratio 13.74
KSI: 30 0.88%	KSI: 100 2.93%	KSI: 30 0.88%	KSI: 155 4.55%	KSI: 332 9.74%
Locations: 172 .08%	Locations: 440 .2%	Locations: 226 .11%	Locations: 985 .46%	Locations: 1,525 .71%

0-1k	1k-5k	5k-10k	10k-20k	20k-30k	30k-40k	40k +
Rep. Ratio 21.29	Rep. Ratio 7.58	Rep. Ratio 7.74	Rep. Ratio 12.00	Rep. Ratio 12.34	Rep. Ratio 12.22	Rep. Ratio 15.78
KSI: 57 1.67%	KSI: 28 0.82%	KSI: 60 1.76%	KSI: 186 5.45%	KSI: 130 3.81%	KSI: 65 1.91%	KSI: 50 1.47%
Locations: 169 .08%	Locations: 233 .11%	Locations: 489 .23%	Locations: 978 .46%	Locations: 665 .31%	Locations: 333 .15%	Locations: 200 .09%

Not Equity Area

Rep. Ratio 0.77 | KSI: 2,249 65.95% | Locations: 185,431 86.17%

Roundabout

Rep. Ratio 0.52 | KSI: 12 0.35% | Locations: 1,456 .68%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 1.25	Rep. Ratio 0.12	Rep. Ratio 0.66
KSI: 3 0.09%	KSI: 1 0.03%	KSI: 8 0.23%
Locations: 152 .07%	Locations: 539 .25%	Locations: 766 .36%

AADT

1	2	3	4	5+
Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 0.60	Rep. Ratio 4.51
KSI: 0 0%	KSI: 0 0%	KSI: 0 0%	KSI: 8 0.23%	KSI: 1 0.03%
Locations: 132 .06%	Locations: 84 .04%	Locations: 59 .03%	Locations: 845 .39%	Locations: 14 .01%

0-1k	1k-5k	5k-10k	10k-20k	20k-30k	30k-40k	40k +
Rep. Ratio 1.65	Rep. Ratio 0.00	Rep. Ratio 0.71	Rep. Ratio 0.00	Rep. Ratio 0.00	Rep. Ratio 10.52	Rep. Ratio 0.00
KSI: 4 0.12%	KSI: 0 0%	KSI: 1 0.03%	KSI: 0 0%	KSI: 0 0%	KSI: 1 0.03%	KSI: 0 0%
Locations: 153 .07%	Locations: 129 .06%	Locations: 89 .04%	Locations: 45 .02%	Locations: 8 %	Locations: 6 %	Locations: 2 %

Stop Controlled

Rep. Ratio 0.47 | KSI: 1,164 34.13% | Locations: 173,265 80.51%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 0.29	Rep. Ratio 0.41	Rep. Ratio 0.77
KSI: 3 0.09%	KSI: 1,062 31.14%	KSI: 99 2.9%
Locations: 645 .3%	Locations: 164,465 76.42%	Locations: 8,155 3.79%

AADT

1	2	3	4	5+
Rep. Ratio 0.84	Rep. Ratio 0.24	Rep. Ratio 0.38	Rep. Ratio 0.40	Rep. Ratio 1.84
KSI: 53 1.55%	KSI: 140 4.11%	KSI: 67 1.96%	KSI: 606 17.77%	KSI: 253 7.42%
Locations: 3,964 1.84%	Locations: 37,202 17.29%	Locations: 11,795 5.48%	Locations: 77,823 36.16%	Locations: 8,695 4.04%

0-1k	1k-5k	5k-10k	10k-20k	20k-30k	30k-40k	40k +
Rep. Ratio 1.12	Rep. Ratio 0.68	Rep. Ratio 1.16	Rep. Ratio 1.76	Rep. Ratio 2.04	Rep. Ratio 1.58	Rep. Ratio 1.49
KSI: 85 2.49%	KSI: 127 3.72%	KSI: 164 4.81%	KSI: 243 7.13%	KSI: 139 4.08%	KSI: 54 1.58%	KSI: 41 1.2%
Locations: 4,776 2.22%	Locations: 11,793 5.48%	Locations: 8,928 4.15%	Locations: 8,692 4.04%	Locations: 4,300 2%	Locations: 2,153 1%	Locations: 1,734 .81%

Traffic Signal

Rep. Ratio 6.32 | KSI: 1,073 31.47% | Locations: 10,710 4.98%

Avg Approach Lanes

One-Way	Two-Way	Blended
Rep. Ratio 21.92	Rep. Ratio 5.61	Rep. Ratio 11.12
KSI: 33 0.97%	KSI: 846 24.81%	KSI: 194 5.69%
Locations: 95 .04%	Locations: 9,514 4.42%	Locations: 1,101 .51%

AADT

1	2	3	4	5+
Rep. Ratio 3.56	Rep. Ratio 6.96	Rep. Ratio 6.76	Rep. Ratio 5.87	Rep. Ratio 6.67
KSI: 35 1.03%	KSI: 207 6.07%	KSI: 83 2.43%	KSI: 240 7.04%	KSI: 459 13.46%
Locations: 620 .29%	Locations: 1,876 .87%	Locations: 775 .36%	Locations: 2,581 1.2%	Locations: 4,341 2.02%

0-1k	1k-5k	5k-10k	10k-20k	20k-30k	30k-40k	40k +
Rep. Ratio 6.57	Rep. Ratio 3.95	Rep. Ratio 7.21	Rep. Ratio 5.89	Rep. Ratio 8.11	Rep. Ratio 7.18	Rep. Ratio 5.83
KSI: 72 2.11%	KSI: 54 1.58%	KSI: 144 4.22%	KSI: 243 7.13%	KSI: 232 6.8%	KSI: 111 3.26%	KSI: 83 2.43%
Locations: 692 .32%	Locations: 863 .4%	Locations: 1,261 .59%	Locations: 2,602 1.21%	Locations: 1,806 .84%	Locations: 976 .45%	Locations: 699 .32%

Not Equity Area

Rep. Ratio 4.76 | KSI: 529 15.51% | Locations: 7,011 3.26%

Equity Area

Rep. Ratio 7.67 | KSI: 397 11.64% | Locations: 3,265 1.52%

Appendix C: Literature Review

MTC Regional Safety Data System Literature and Best Practices Review



FINAL

July 2021

METROPOLITAN TRANSPORTATION COMMISSION

WSP

MTC Regional Safety Data System

Literature and Best Practices Review

July 2021

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Introduction

The Metropolitan Transportation Commission (MTC) has retained the mySidewalk + WSP team to develop a Regional Safety Data System and State of Safety in the Region Report. This robust safety data source will provide an important resource for local jurisdictions to analyze, identify, and correct safety problems when developing safety plans. The system will integrate information about crashes, infrastructure, equity, and demographics, as well as additional data that become available over time (Metropolitan Transportation Commission, 2021).

MTC recognizes an increasing focus on traffic safety at the federal and state levels and is taking initial steps to encourage more jurisdictions to prioritize safety by leading Vision Zero efforts in the San Francisco Bay Area. The key objectives of this project are to:

1. Integrate key data sources into a comprehensive system that allows for easy access, synthesis, and analysis of safety data;
2. Produce a "State of the Safety in the Region Report," including a Regional High Injury Network; and,
3. Proofing of the system, such that it may continue to be used well into the future as new and better data becomes available.

As part of this effort, the mySidewalk + WSP team has been tasked with conducting a literature review to understand the state of practice of analytical approaches to traffic safety and Vision Zero and ensure adherence to best practice. The mySidewalk + WSP team conducted a search for the most recent and relevant literature (including journal articles and reports) through the Transport Research International Documentation (TRID) and the University of California, Berkeley (UC Berkeley) Safe Transportation Research and Education Center (SafeTrec) databases. This document includes findings from the team's literature review and a bibliography of all reference materials.

In addition to the literature review, an analysis has been made of the current best practices with a sampling of example Vision Zero action plans from California, nationally, and internationally. An outline of the steps to move towards implementation of Vision Zero are covered in addition to identifying the key elements of a comprehensive Vision Zero action plan.

Vision Zero Overview

MTC recognizes that as the population increases and the total vehicle miles traveled increases, policy changes are needed to mitigate an increased number of fatalities and serious vehicular injuries. A regional approach to safety will help promote safety and reduce costs among cities and counties so that local governments can redirect limited funds toward implementing new safety projects and policies (Metropolitan Transportation Commission, 2021).

Vision Zero is a strategy to eliminate all traffic fatalities and severe injuries, while increasing safe, healthy, equitable mobility for all. Vision Zero is rooted in the belief that everyone has the right to move safely in their communities, and that traffic deaths are preventable. Vision Zero takes a systems approach—to ensure that system designers and policymakers can improve the roadway environment—and a multidisciplinary approach—to acknowledge that may factors contribute to safety mobility, including roadway design, speeds, behaviors, technology, and policies. These two approaches set clear objectives to achieve the shared goal of zero fatalities and severe injuries (Vision Zero Network, 2021).

The first Vision Zero program was adopted by the Swedish Parliament in 1997, as one of several "Safe System" approaches developing throughout the world, with the overall goal of ensuring that no one is seriously injured or killed due to traffic crashes. The Swedish Vision Zero program is known internationally for its success, which boasts a 60% decrease in deaths among car users from 2000 to 2010. Roads in Sweden are among the world's safest, with approximately 3 deaths per 100,000 people on the roads each year, compared to approximately 10 deaths per 100,000 people annually in the United States. Its success has also inspired Vision Zero philosophies to expand to other fields, such as health care and the automotive industry and related technology (Kristianssen, et al., 2018).

The main innovation of the policy was using scientific principles from deaths and injuries as the basis for requirements to improve road safety. Traditional road traffic safety policies typically view traffic crashes as the problem to be solved. In contrast, Vision Zero centralizes death and injury as the problem. Additionally, the Vision Zero approach transfers some of the attributable cause from user error to related conditions in the road traffic environment and vehicle system. Therefore, in addition to the responsibility borne by the user, system designers are responsible for taking further measures to combat the occurrence of serious injuries and death when there are insufficiencies in user behavior (Kristianssen, et al., 2018).

Key Takeaways

This section summarizes the key takeaways from the Literature Review and Best Practices findings. These key takeaways were identified as most relevant to the Safety Data System and State of Safety in the Region Report development.

Overall Key Takeaways

- Road safety should focus on eliminating fatalities and serious injuries.
- A data-driven analysis approach will narrow the focus to areas with the greatest need or impact.
- Quality data is vital to understanding safety issues and should be obtained from multiple sources.
- Current analysis methods and data are not as robust for vulnerable road users.
- Visualization tools may help practitioners make more informed decisions using data.
- Data helps decision-makers identify both emphasis areas as well as effective countermeasures.
- A comprehensive analysis approach allows for both spot and systemic improvements based on data availability or potential changes.
- A High Injury Network (HIN) should be developed to help prioritize and target countermeasures
- Setting and monitoring performance targets helps track and communicate progress towards safety goals.
- Vision Zero requires a long-term commitment from a range of stakeholders
- Development of a Vision Zero action plan is recommended to serve as an overarching guide.

Data Collection Key Takeaways

- Quality data is vital to understanding safety issues.
- Effective data collection will lead to high-quality, timely, and accessible data.
- Safety data should come from multiple sources.
- Understand that police crash data is often incomplete, especially for bicycle and pedestrian crashes and in equity priority areas.
- Integrating public health/hospital/trauma data can help fill gaps.

Data Analysis Key Takeaways

- Analysis should focus on KSI crashes (crashes with people killed or seriously injured).
- Analysis should study contributing factors to KSI crashes such as:
    - Speed

    - Vulnerable Users
    - Equity
- Analysis should be done with multiple approaches:
    - Hot spot analysis
    - Systemic/predictive analysis
- Data requirements should vary based on the level of analysis; broader screenings should require fewer inputs than a narrow analysis at a specific location.
- Practitioners must understand the possibility of bias when attempting to estimate risks using available crash data. Methods to understand and counteract this bias include:
    - Utilizing anecdotal data through public engagement to understand issues beyond what is seen in the data
    - Understanding implications of small sample sizes in areas with low population/low crash frequencies
    - Prioritizing vulnerable users by either introducing weights into a formula-based approach or limiting the data analysis to emphasize a priority user

Data Outputs Key Takeaways

- Leverage safety data analysis outputs to create visualizations to identify patterns, develop countermeasures, develop policies, and evaluate performance
- Develop internal and public facing visualization outputs
- Summarize analysis results in a meaningful using tools such as
    - High-injury or crash network maps
    - Data reports that describe crash frequency, crash averages, crash trends, and crash rates
- Use analysis to identify countermeasures using various approaches:
    - Spot Location
    - Systemic approach
    - Comprehensive approach combining spot and systemic

Vision Zero Best Practices Key Takeaways

- Integrating a Vision Zero mindset into road safety activities requires a long-term commitment from a range of stakeholders
- Development of a Vision Zero action plan is recommended to serve as an overarching guide
- Vision Zero Action Plan must have the following characteristics elements to be successful
    - Data Driven
    - Actionable
    - Accountable

- A complete Vision Zero Action Plan is an involved document that requires a substantial amount of work by practitioners and outreach to community members, public agency staff, and other stakeholders
- A High Injury Network (HIN) should be developed to help prioritize and target countermeasures. HIN should consider:
    - Years of data
    - Intersection or corridor focused analysis
    - Roadway facility types included
    - Consideration of transportation modes
    - Weight assignment, such as assigning more weight to collisions involving certain populations or types of injury severity
    - Normalization
    - Overall threshold, which determines a potential cut-off for including a portion of a roadway on the high injury network

Literature Review Findings

This summary reflects key findings, best practices, and lessons learned from over two dozen highly cited reports and journal articles published in recent years related to safety data analytics and developing effective and impactful safety programs. The summary is organized into three sections:

- **Data Collection** – How data are collected, common data sources, cross-jurisdictional data sharing, common approaches for storing collected data, and challenges with data collection (e.g., improving data quality and availability)
- **Data Analysis** – How different data types used in analysis, methods to characterize crashes, modeling, data points that are predictive of fatality or injury, and bias are considered to identify key patterns and areas of concern
- **Data Outputs** – How the outputs of data analysis are applied and used to crowdsource information, inform the public, develop countermeasures, inform decision-making, and to evaluate performance of safety projects, plans, programs, and policies

The sections below describe each of these topics in more detail to identify the data needs, analysis methods, outcomes, and challenges that must be incorporated into a successful safety data system.

Data Collection

The comprehensiveness of a safety data analysis is largely dependent on the depth and breadth of data that is available. Developing a robust repository of data is the first step to not only identify where and why crashes are currently happening, but to attempt to predict conditions that may lead to higher crash incidence or severity through modeling. Effective data collection will lead to high-quality, timely, and accessible data and enable municipalities to develop and communicate a zero-fatalities message and philosophy (Tobias, et al., 2016).

Data Collection Methods

Since metropolitan planning organizations (MPOs) may face competing ideas and needs on how to invest limited transportation safety dollars, using a data-driven approach will narrow the focus to tackle those areas with the greatest need and/or those areas where investment will result in the greatest impact. Considerations for data collection include (Tang, et al., 2018):

- What do we want to know?
- What information is valuable for identifying needed actions?
- What level of analysis do we need?
- What data do we need? What data are available? How do we fill existing gaps?
- How could anecdotal information supplement traditional data?

The provision of safety data should be a coordinated effort across multiple stakeholders—rather than relying solely on a single source. In addition, data should be supplemented with local knowledge about areas or behaviors in which collisions are under-reported (Shahum & Vanderkooy, 2017). Common types of safety data include crash data, roadway conditions/characteristics, traffic volume, driver and passenger information, vehicles, injury control (e.g., Emergency Medical Service [EMS] response time), citation, and adjudication (e.g., driver arrest record) (Waldheim, et al., 2014).

> Agencies should ensure redundancy for their capability to conduct safety planning and analysis—the responsibility often falls to a single staff member or small group of staff. Assigning dedicated staff to this effort and ensuring safety data collection and management are integrated into agency processes are important to ensuring continuity of the program in the event of staff turnover (Waldheim, Wemple, & Fish, 2014).

Table 1 illustrates an example of the types and sources of data that agencies can leverage to identify the trends and factors that affect regional traffic safety.

Table 1: Sources of Federal, State, and Local Data Sets

Data Type	Federal	State	Local
Crashes	NHSTA or FHWA	State Police and/or Department of Transportation	Police Department/Emergency Medical Services
Roadway Conditions	FHWA	Department of Transportation	Department of Transportation
Traffic Violations	FHWA	Department of Transportation	Department of Transportation

Source: Transportation Safety Planning and the Zero Deaths Vision: A Guide for Metropolitan Planning Organizations and Local Communities

In addition to data collected by the state Department of Transportation (DOT) (roadway and volume data) or local law enforcement (for crash data), other data sources may include Departments of Motor Vehicles (driver and vehicle records), Departments of Health (injury surveillance), and court systems (citation prosecution, and adjudication data). Integrating the various data sources into a single database will facilitate ease of analysis and reporting (Tang, et al., 2018).

Table 2 summarizes data used for Vision Zero analysis for various cities nationally and internationally.

Table 2: Data Sources by City

City	Primary Metric Data Sources	Additional Data Collected	Common Data Not Used
Boston	• EMS data (three years) • BPD traffic-related homicide data (three years)	• Crowdsourced problem location data (collected after action plan was developed) • Equity/demographic data (e.g., an environmental justice index)	• Trauma center and hospital data (only EMS data was used) • Cross-section or functional class data • Traffic volume data
Los Angeles	• SWITRS crash data (2009–2013) • Community Health and Equity Index (an environmental justice index) • Demographic data	• Community input on problem locations	• Trauma center and hospital data • Cross-section or functional class data • Traffic volume data
New York City	• NYSDOT KSI crash data (2009–2013) • NYPD fatality data (2011–2013)	• Crowdsourced problem location data (collected after action plan developed • Traffic volume data • Cross-section and functional class data	• Trauma center and hospital data • Equity/demographic data (e.g., an environmental justice index)
Portland	• Oregon Department of Transportation (ODOT) crash data (2004–2013) • Traffic volume data	• Communities of Concern (an environmental justice index) • Trauma center and hospital data (collected but not used)	• Crowdsourced problem location data • Cross-section or functional class data

City	Primary Metric Data Sources	Additional Data Collected	Common Data Not Used
San Francisco	• SFPD crash data • Hospital data • Zuckerberg San Francisco General Hospital (ZSFG) Level I Trauma center data • ZSFG Emergency Department data • Office of the Medical Examiner data • EMS data (various ambulance providers)	• MTC's Communities of Concern index (an environmental justice index) • Crowdsourced problem location data	• SWITRS (statewide) crash data (used in initial analysis, but no longer)
Seattle	• Seattle Police crash data (2012–2016) • Cross-section or functional class data (general road characteristics) • Traffic volume data	• Race and Social Justice Initiative data (an environmental justice index) • Crowdsourced problem location data • Ongoing analysis incorporates data on land use, lighting, topography, transit, and more	• Trauma center and hospital data
Washington, D.C.	• MPD crash data (2010–2014) • Crowdsourced problem location data	• Trauma center and hospital data (recent initiative) • Cross-section or functional class data	• Equity/demographic data (e.g., an environmental justice index) • Traffic volume data

City	Primary Metric Data Sources	Additional Data Collected	Common Data Not Used
London	• STATS19 crash data (2008–2011) • London Travel Demand Survey (LTDS)	• Equity/demographic data (TfL reports on indices of multiple deprivation) • Hospital Episode Statistics (HES) • Department of Transport traffic volume data	• Crowdsourced problem location data • Cross-section or functional class data
Sweden	• Cross-section data	• Police crash data • Hospital data • Traffic volume data	• Crowdsourced problem location data • Equity/demographic data

Source: Philadelphia Crash Analysis Standards and Recommendations (Commission, 2018)

Collecting bicycle and pedestrian infrastructure data can be challenging since the networks do not align entirely with motor vehicle networks. Agencies that have developed bicycle and pedestrian infrastructure inventories include Washington DOT, New Jersey DOT, Maryland State Highway Administration, City of Rancho Cucamonga, City of Berkeley, and City of Alexandria. Washington DOT developed its inventory of 7,000 miles by reviewing video footage and then recording sidewalks, marked crosswalks, and other pedestrian and bicycle facilities. The New Jersey DOT developed its 13,200-mile inventory using a vehicle equipped with GPS and four digital cameras to collect data on the presence of pedestrian and bicycle facilities. Agencies that have developed bicycle and pedestrian count data include City of Los Angeles, Arlington County, Delaware Valley Region, City of Portland, and City of Seattle. (Proulx, et al., 2014).

Both TransBase (developed in San Francisco) and the Swedish Traffic Accident Data Acquisition (STRADA) database leverage data from hospitals and police.

Data Platforms for Storing Data Collected

The City of Philadelphia engaged the Delaware Valley Regional Planning Commission (DVPRC) to identify best practices in data management and analysis, establish a consistent source of crash data, and formalize standard procedures for analyzing crashes and tracking performance. As part of this study, DVPRC surveyed peer agencies to understand their data analysis process for Vision Zero. The study found that Vision Zero cities leveraged several databases and software for the analysis of crash data (**Table 3**)—most cities maintained an internal platform for data analysis and investment prioritization and an external data viewer accessible to the public (Commission, 2018).

Table 3: Vision Zero Data Platforms

City	Internal Data Platform	External Data Platform
Boston	GIS	Esri GIS Online Map
Los Angeles	RoadSafeEGIS	GeoHub
New York	Safety Data Viewer	Vision Zero View
Philadelphia	GeoDB2/PTDMS	Open Data Philly
Portland	GIS	Esri GIS Online Map
San Francisco	TransBASESF.org	TransBASESF.org
Seattle	Hansen/Collision Cube	Vision Zero Dashboard & Webmap
Washington, D.C.	TARAS	Open Data Portal
Sweden	STRADA	N/A

Source: DVPRC (2017)

Improving Data Quality & Availability

Data Quality

The successful application of safety data to the transportation process is contingent, in part, on the quality of the data inputs. The following six characteristics should be considered when evaluating data quality (Waldheim, et al., 2014):

- **Timeliness** refers to how quickly crash reports are entered into a database and become available for analysis. The sooner data are available, the sooner the agency can analyze the data and develop appropriate countermeasures—a difference of several months could result in several crashes being prevented. Electronic crash reporting and better integration of crash data systems have allowed some states to provide access to crashes within a few days.
- **Accuracy** can affect the conclusions that can be drawn from the data. While some level of error is expected, accuracy can be improved by using business rules to ensure data reports submitted to the database are logical and consistent.
- **Completeness** refers to the degree to which each crash is represented in the database, as well as whether all relevant information has been provided for each crash. Missing crashes could make roads appear safer than they really are, and incomplete crash records could prevent accurate conclusions from being drawn.
- **Consistency/Uniformity** limit likelihood that differences in reporting practices influence safety funding decisions, and that information can be appropriately compared between regions or states.
- **Integration** of safety data applies to all data sources—not only to crash, roadway, and traffic volume data, but also to citation, EMS, and injury data—and integration of both state and local data. Relating these datasets to crashes and to each other provides a more comprehensive assessment of driver risk factors (e.g., previous driving under the influence [DUI] offenses), emergency response times, and injury outcomes, with respect to the other information provided in the crash data. However, integration of safety datasets may raise legal and privacy concerns, institutional challenges, and technical hurdles.

WSDOT is a recognized leader in data analytics—the agency developed a crash data system as a collaborative effort between the agency, Washington State Patrol, and the Departments of Labor and Industries and Health. The group meets on a regular basis to discuss data definitions, data analysis methods, data presentations, and priority and goal setting. Data are made available to agencies such as law enforcement and public works for their own analyses (Tobias, et al., 2016).

- **Accessibility** refers to the ease with which safety stakeholders can access and use safety datasets to conduct their own analyses and develop their own safety-related programs.

It is important to also consider the source of the data and whether it provides an accurate reflection of the total number of crashes. Bicyclist and pedestrian collisions are often underreported, and therefore underrepresented in state or national databases. The number of pedestrian collisions tends to be higher than the number of bicycle collisions reported. In 2005, a study was conducted to compare police-reported incidents and data from the San Francisco General Hospital (SFGH) to estimate the level of underreported injuries, to estimate underreporting by ethnicity, and to estimate pedestrian injury rates by ethnicity. The study found that 1,909 pedestrian-motor injury collisions were reported during 2000 and 2001 (using SWITRS [Statewide Integrated Traffic Records System]), while an additional 531 pedestrian injuries were reported at SFGH. This translates into at least 21.8% additional pedestrian-motor injury collisions in the city during those two years that were not included in the police data. In addition, the study found that in a review of more than 2,000 collisions, African Americans were less likely than Caucasians to file a police report, and women were more likely than men to file a police report; severe and fatal injuries were less likely to be underreported. Since the current reporting system tends to favor motor vehicle crashes, reporting of pedestrian and bicycle collisions can be improved by bringing in other data sources and conducting a comparison of the collisions (Arnold, et al., 2010).

> The City of Oakland developed its Pedestrian Master Plan based on extensive data analysis—data collected from the Statewide Integrated Traffic Records System (SWITRS) provided information on high collisions, but it **also relied on community outreach to identify areas pedestrians were avoiding** (Arnold, et al., 2010).

Data Availability

State DOTs have leveraged a range of initiatives to promote the improvement of data quantity, quality linkage, and accessibility at the state level include electronic crash reporting (e.g., Idaho and Maine), stronger Traffic Records Coordinating Committees (TRCC), increased data collection and support for emphasis area teams, a data liaison (e.g., in Louisiana and Maryland) to work with law enforcement on data quality improvements, and others (Tobias, et al., 2016).

Many states use the Model Minimum Uniform Crash Criteria (MMUCC) guideline to improve the amount of data available for analysis. The MMUCC guideline identifies a "minimum set of motor vehicles crash data elements and their attributes that states should consider collecting and including in their state crash data system."[11] Maine has implemented MMUCC in collaboration with the state police and members of the TRCC, the Bureau of Highway Safety, Maine DOT, the local police, the Federal Motor

[11] https://www.nhtsa.gov/mmucc-1

Carrier Safety Administration, and the Bureau of Motor Vehicles. The system captures data that users did not previously have access to, such as distracted driving, and driving while impaired by drugs, alcohol, or medication (Tobias, et al., 2016).

Time Lag

Cities often faced a delay for crash data to become available from the state DOT (often a one year or more lag time between the time of the crash until the crash data are available to analyze), resulting in cities shifting to receiving data directly from local police (where the lag time is roughly one month) and/or trauma centers. Trauma center data have been challenging to obtain for many cities; San Francisco was able to obtain the data because it has only a single Level One Trauma Center. While Portland gained access to trauma center data, it faced challenges with linking the trauma center and crash data, which limited its use for Vision Zero-related analysis (Commission, 2018).

The District of Columbia Department of Transportation (DDOT) has a robust data management process in place for its Vision Zero program. DDOT receives crash data every 24 hours directly from the Metropolitan Police Department (MPD), via TARAS, a proprietary software interface that produces standardized reports from this raw data. DDOT geocodes the data and makes the data available through the DC Open Data Portal. Internally, DDOT uses a version of the open data portal to share data and analyses throughout the department. The agency has recently started publishing moving and non-moving violations data on the portal as well (Commission, 2018).

The Swedish STRADA system is an accident database used to support and enhance road safety by making it easier to identify which actions are needed within the road system to decrease the number of fatalities and injuries. The Swedish Transport Agency, who is responsible for maintaining the system, strives to increase data availability by incorporating accident data from multiple sources (Swedish Transport Agency, 2021).

STRADA has three main differences to other road accident databases:
1. Only crashes with personal injuries are registered
2. Both police and hospitals report road injuries
3. Pedestrian-only injuries are registered

The Seattle Department of Transportation (SDOT) uses a similar process to DDOT; police record incidents in Hansen, the city's asset and incident management system database. Collision Cube, a proprietary data system interface, was developed for SDOT to access this police data, which becomes available within approximately two weeks of the incident. A related data system interface called Sector allows SDOT employees to access police citation data. This was made possible with the transition to electronic crash reporting (Commission, 2018).

Data Analysis

Once all relevant data have been collected, agencies are then able to conduct analyses on the data to inform priority areas and the types of interventions and

countermeasures that will be most effective. Key data points that are typically analyzed include traffic conditions, such as individual or average vehicle speeds that have predictable effects on crashes and which can be leveraged to meet specific crash reduction goals; and vulnerable road user and environmental data, that can help ensure these goals are applied equitably. Organizing the interaction of these components in a crash through industry standard systems allow for the easy application of analytic methods to identify hot spots and identify inputs into predictive models. These analytic methods then directly translate into practical policy applications, mitigations, and interventions.

Data Types

Vehicle Speed

Vehicle speed is a key contributor to crashes, influencing crashes primarily in two ways: incidence and severity. Speed is important to consider for the incidence, or likelihood, of crash involvement, but incidence is also affected by the complex interactions of roadway type and characteristics including curvature, grade, width, and adjacent land use, as well as other factors such as driver age and alcohol impairment. In contrast, the relationship between speed and injury severity is stronger, both in consistency and direction (National Transportation Safety Board, 2017). While the severity of injuries resulting from a vehicle crash are also dependent upon these other factors, speed has perhaps been the most widely studied. This is especially true for the relationship between speed and injury severity of the crash, particularly when crashes involve unprotected parties such as pedestrians and bicyclists (Grembeck, et al., 2020).

Average Vehicle Speed and Likelihood of Crashes

Increased average vehicle speed is correlated with how likely a crash is to occur on a given segment. With increasing vehicle speed, drivers must process increasing amounts of visual information, which has negative behavioral and cognitive effects on drivers. Faster speeds also require longer stop periods and increase driver fatigue and stress (Grembeck, et al., 2020).

Although most studies find a relationship between increased average traffic speed and the increased likelihood of crashes, some studies find negative or neutral relationships, particularly when attempting to account for the effects of other roadway attributes like speed variance, roadway geometry, design speed (Garber & Gadiraju, 1989), and road environment (Baruya, 1998). This reflects the complex relationship of factors beyond traffic speed that can affect the likelihood of crashes within specific environments. An increase in crash incidence, despite an overall decrease in vehicle speed, may therefore reflect other confounding factors such as pedestrian cross-traffic or visibility. However, the overall trend holds that for every one mile per hour (mph) reduction in average speed, crash frequency may decrease by 2-7%. Some difference in opinion exists as to whether this decrease is more strongly related to the relative or absolute change in speed. Greater reductions may be more likely when speed is decreasing from speeds that are already low (Grembeck, et al., 2020).

Average Vehicle Speed and Severity of Crashes

The relationship between average vehicle speed and crash severity is much more clear. A large group of road user fatalities are pedestrians who are hit by motor vehicles, typically making up 10-30% of road crash fatalities, globally. The risk of death for pedestrians is commonly identified as increasing as a function of car impact speed, with fatality risk reported at 40-90% when impact speeds are approximately 30 mph (Rosen & Sander, 2009). Additionally, related to one of the core tenets of a Vision Zero philosophy, it also holds that reducing average vehicle speed is a clear determinant of reducing severe injuries and death, even if overall crash incidence is not reduced.

Vulnerable Road Users

Vulnerable Road Users are the group made up of pedestrians, bicyclists, motorcyclists, and other users who utilize road systems but lack the protection offered by travelling inside enclosed motor vehicles. As mentioned above, this group makes up 10-30% of road crash fatalities and is therefore critical to target in order to achieve Vision Zero goals. Recent studies have begun to analyze car impact speed within the context of other demographic characteristics, such as age, weight, and gender. In particular, as age increases, vehicle speed has a much greater impact on fatality risk, which emphasizes the importance of considering local population demographics when planning interventions (Rosen & Sander, 2009). Therefore, when comparing neighborhoods with equal exposure to fast-moving vehicles, those with a higher proportion of older adults may be a better target for reducing serious injuries and deaths.

Studies have also indicated a safety in numbers effect where, as pedestrian and bicyclist traffic increases, the number of crashes do not increase proportionally, with crash elasticity expected to be ≈0.41. This could be influenced by confounding factors. Pedestrians and cyclists may be more likely to walk or cycle if they note others are already engaging in these activities. Similarly, roads that are already designed with pedestrians in mind may selectively recruit more pedestrians, who accurately perceive them as safer (Elvik & Bjornskau, 2017). This may indicate that thoroughfares with high pedestrian or bicyclist traffic may already offer a buffer against crashes, whether due to existing infrastructure or higher visibility to vehicle users.

Equity

MTC is committed to equity and ensuring that mobility options are available to all Bay Area residents. MTC's Equity Platform, launched in 2019, envisions a "just and inclusive Bay Area where everyone can participate, prosper, and reach their full potential." The importance of considering equity as a cross-cutting issue is codified in Plan Bay Area 2050, the region's long-range Regional Transportation Plan and Sustainable Communities Strategy, which outlines five guiding principles, emphasizing affordability, connectedness, diversity, health and community vibrancy (Metropolitan Transportation Commission, 2020).

While equity in transportation has been developing a substantial research base, research typically focuses on accessibility to transportation, particularly transit. Several studies are point to the necessity to consider equity when designing for safety. For example, low-income people are twice as likely to be killed in a traffic-related incident as high-income people (Governing, 2014); African-American children and Latino children are, respectively, twice and 40% more likely to be killed in a traffic-related incident than white children (Smart Growth America, 2017); and low-income communities have sidewalks on approximately 50% of roads, compared to 90% in high-income communities (Bridging the Gap, 2012).

One example of centering equity within Vision Zero efforts comes from the Portland Bureau of Transportation (PBOT). In developing a Vision Zero Action Plan, it identified 10 of 26 of its task force members as representatives from organizations who centered or incorporated the advancement of equity in their missions. This was intended to develop safety policies that would not have disproportionately negative outcomes for communities of color or low-income communities such as increased penalties or fines, or enforcement checkpoints. Instead, they relied on extensive community participation to decide to focus on more inclusive actions such as prioritizing street redesign, revising and clarifying driving laws, and increasing educational programming (Fox & Shahum, 2017).

Several agencies across the United States are incorporating various equity data into their Vision Zero Plans to better measure how underserved areas of the city are affected by crashes and help prioritize investments, including:

- **Equity indices** – Comparing neighborhoods or census tracts by quantitatively assessing a combination of demographic and other factors
    - Los Angeles' Health and Equity Index (Commission, 2018)
    - Chicago Department of Health's Hardship Index
    - Portland's Communities of Concern Index (Commission, 2018)
    - San Antonio's Equity Atlas
    - MTC's Communities of Concern
- **Geographic overlays** – Overlaying injury data with areas of economic hardship, or other demographic characteristics
- **Equity reporting requirement** – City departments are required to report on how policies further citywide equity goals
- **Incorporating qualitative data**, such as community observations, in addition to quantitative, through meaningful community engagement

The Los Angeles High Injury Network (HIN) combined maps showing high concentrations of traffic collisions resulting in serious injury or death with existing data from the Health and Equity Index. This data combines demographic, socio-economic, health, land use, transportation, food environment, crime and pollution burden data. Using this existing index as an input allowed LA to quickly identify that high injury streets are concentrated in communities already burdened with poor health outcomes and economic conditions.

Analytic Methods

Finding data that is timely, accurate, and complete is a first step toward translating these inputs into meaningful applications, such as identifying hot spots and target areas, as well as identifying what characteristics of these areas may be useful toward making predictions. Analysis is also an iterative process – as new data sources and analytic methods are developed and outcomes are studied, analysis should also be leveraged for continuous improvement as a Vision Zero program evolves over time (Shahum & Vanderkooy, 2017).

Crash Analysis

Vision Zero cities across the country have identified priority locations where they will invest in safety improvements—and some cities have also looked at intersections or targeted areas in addition to corridors. A common practice is to limit crash data analysis to killed and severely injured (KSI) crashes, which is a best practice supported by the Federal Highway Administration (FHWA) and the National Highway Transportation Safety Administration (NHTSA). KSIs can be applied in different ways, including normalizing KSI crashes by road segment length and use these values to identify high injury corridors, using kernel density maps, or calculating the absolute number of KSI crashes along a corridor. Intersection analyses sometimes included identifying locations with the greatest number of KSI within a buffer (Commission, 2018).

Since one of the key tenets of Vision Zero policies is prioritizing the reduction of serious injuries and fatalities over the reduction of crash incidence, it may useful to systematically code crash severity in greater detail than KSIs. The KABCO system is a standardized way of coding injury severity so that data can be compared across states or regions. The KABCO system uses the following codes (Waldheim, et al., 2014):

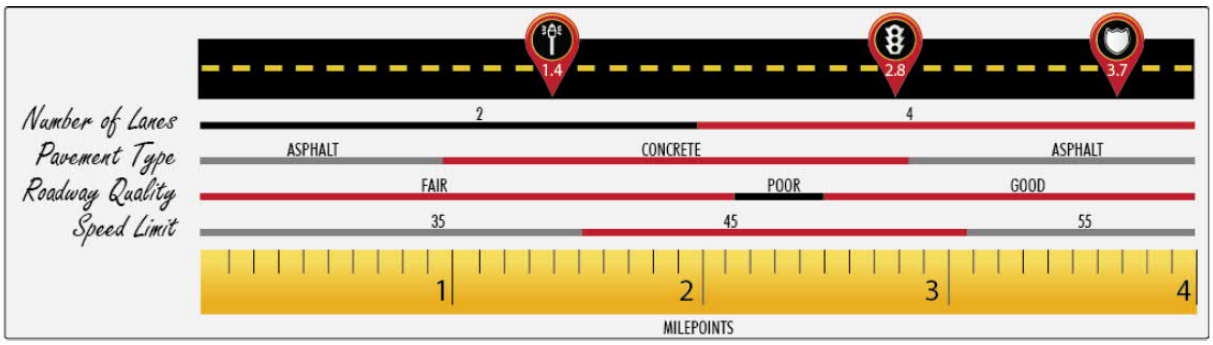
- K – fatality
- A – serious injury
- B – non-incapacitating injury
- C – possible injury
- O – no injury

When analyzing safety data to allocate resources along urban arterials, a potential approach is to stratify collision data according to relevant attributes (e.g., crash outcome, location, environment, etc.) in order to determine specific hazards at an intersection and to identify characteristics of certain types of collisions. Pedestrian and bicycle crashes have different spatial distributions and are affected by different environmental features (e.g., light and weather conditions), and therefore the analysis should reflect these differences. Comparisons can then be made between characteristics of the same traffic mode for different stratifications, or between different traffic modes for the same stratification (Grembeck, et al., 2013).

It is also important to consider environmental characteristics in addition to crash data, particularly when considering other goals such as predictive analysis. Linear referencing

is a common way to store roadway characteristics; it allows roadway attributes, such as shoulder presence or speed limit, to be stored individually and to be defined by the route, along with the start and end points. Crashes also can be referenced using the same system. This approach enables a detailed delineation of features along a route without breaking the route into small segments. **Figure 1** illustrates an example of linear referencing (Waldheim, et al., 2014).

Figure 1: Linear Referencing Conceptual Diagram



Source: Maryland Transit Administration, One Maryland Centerline Linear Referencing

Crash Modeling

Another promising, emerging strategy in road safety is to use data to conduct predictive modeling, moving beyond simply reacting to past problems. This method proactively prioritizes safety interventions by analyzing locations with repeated problems and observing the characteristics of those crashes and sites, then applying that to sites throughout the city, even where serious crashes may not have happened yet (Shahum & Vanderkooy, 2017).

Many crash frequency models employ crash data that are aggregated using spatial criteria (e.g., crash counts by link), which is a highly aggregated average measure that may be inappropriate when considering time-sensitive variables such as speed and volume. New studies are reexamining crash-speed relationships by creating improved representation of road conditions just before crashes. Aggregating crashes by these conditions, rather than by link, and modeling these datasets with techniques such as multivariate Poisson lognormal regression enforce the relationship between high speeds and crash frequency to a greater extent. This reinforces the need to reassess data aggregation methods when considering data modeling approaches (Imprialou, et al., 2016).

Analyzing Predictive Factors

When data are available, vehicle speed remains one of the most important predictive factors for serious injury or death due to vehicle crashes. Rosen et al. summarized the reports of 11 studies on pedestrian fatality risk as a function of vehicle speed from around the world, grouping them by whether they were biased toward fatal crashes, based on data collected prior to 1980 which was adjusted to better reflect national

statistics, or based on data collected after 1980 which was relatively unbiased. These groups exhibited vastly different fatality risks at impact speeds of approximately 30 mph. However, most studies still support a consensus that pedestrian fatalities gradually increase with speeds up to approximate 20 mph before increasing much more rapidly in an S-shaped curve. The risk of injury and death increases exponentially per increase in mph. However, fatality risks also strongly depend on the availability of medical treatment and the age of the pedestrian victim (Rosen, et al., 2011).

Cities have already become more proactive in predicting where crashes are mostly likely to occur. NYC DOT developed a risk model for its initial Vision Zero plan but decided to use the pedestrian KSI/mile metric instead. NYC DOT is now working with DataKind, a non-profit that provides pro bono technology services to create a new risk model. Seattle DOT worked to successfully develop a bicycle and pedestrian risk model and has incorporated this model into its Vision Zero prioritization system. Sweden prioritizes safety measures based on cross-section data rather than crash incidence because they understand the types of roads that lead to crashes and have made significant strides towards reducing dangerous roads over the last 20 years (Commission, 2018).

Accounting for Bias

The possibility of bias should be considered when attempting to estimate risks using available crash data. Crashes of greater severity may be reported with greater consistency than minor injury crashes that do not result in serious or fatal injury, causing bias when calculating injury risk. Crashes and injuries may only enter available data sources when they are severe enough to warrant police or emergency medical services (Rosen & Sander, 2009).

Other forms of bias may be introduced when attempting to characterize crashes at a geographically specific level, such as an intersection. In smaller geographies, the sample size of crashes may be too low over recent time periods to generate results with high statistical significance. Studies have suggested weighting local statistics by national crash statistics, however this may also generate issues if the available federal data are old (Rosen & Sander, 2009). In conducting safety data analyses, a common practice is to prioritize vulnerable users (e.g., bicyclists and pedestrians, older adults and children) by either introducing weights into a formula-based approach or limiting the data analysis to emphasize a priority user (Commission, 2018).

Case Studies in Safety Data Analytics

New York City

In developing its New York City Pedestrian Safety Study and Action Plan, NYC DOT analyzed potential factors associated with pedestrian injuries (e.g., street width, adjacent land use, nearby transit stops, socioeconomic status, racial/ethnic composition of neighborhoods, etc.), based on severe and fatal pedestrian crashes in New York City during 2002-2006. The study conducted two types of analysis—crash frequency analysis to determine the causes of a high frequency crash location, and

crash severity analysis, which aims to determine why the severity of crashes ranged from severe injury to fatality. The results of the study were used to inform the development of data-driven policies and programs that have the highest impact to decrease pedestrian fatalities and severe injuries, while safely maintaining traffic operations (Transportation, 2010).

Sweden

Sweden adopted Vision Zero as a road safety philosophy in 1997, prioritizing health and human safety in road design, and sharing the responsibility for road safety between users and designers. Sweden redesigned the road system around what the human body can endure in vehicle-pedestrian and vehicle-vehicle collisions. This resulted in introducing median barriers, safer roadsides, traffic calming, roundabouts, traffic separation and reduced speed limits. They also implemented parallel efforts on urban and rural roads, establishing guidelines for each road type classification while balancing traffic safety, environment, mobility, and regional differences (Grembeck, et al., 2020).

Auckland, New Zealand

In New Zealand, the Auckland Three Year Programme Review resulted in a Programme Business Case, which identified interventions based on extensive crash analysis over five years (2013-2017). These recommendations focused on six key themes: leadership, capability and policy change; interventions to manage demand; interventions to increase productivity; interventions to improve supply; enforcement; and education and engagement. In turn, these themes were developed into 11 programs, developed through team and stakeholder workshops, including among others: contributing as much as possible to Vision Zero; focusing on speed management and vulnerable road users; and targeting 60% death and serious injury reduction within current budget. The targeted decrease was identified as a recommended program and contained a combination of infrastructure and non-infrastructure responses (Auckland Transport, 2019).

Data Outputs

Agencies are leveraging the outputs of safety data analysis to create data visualizations to identify patterns and prioritize investments, develop countermeasures to improve safety, and evaluate performance of their Vision Zero programs.

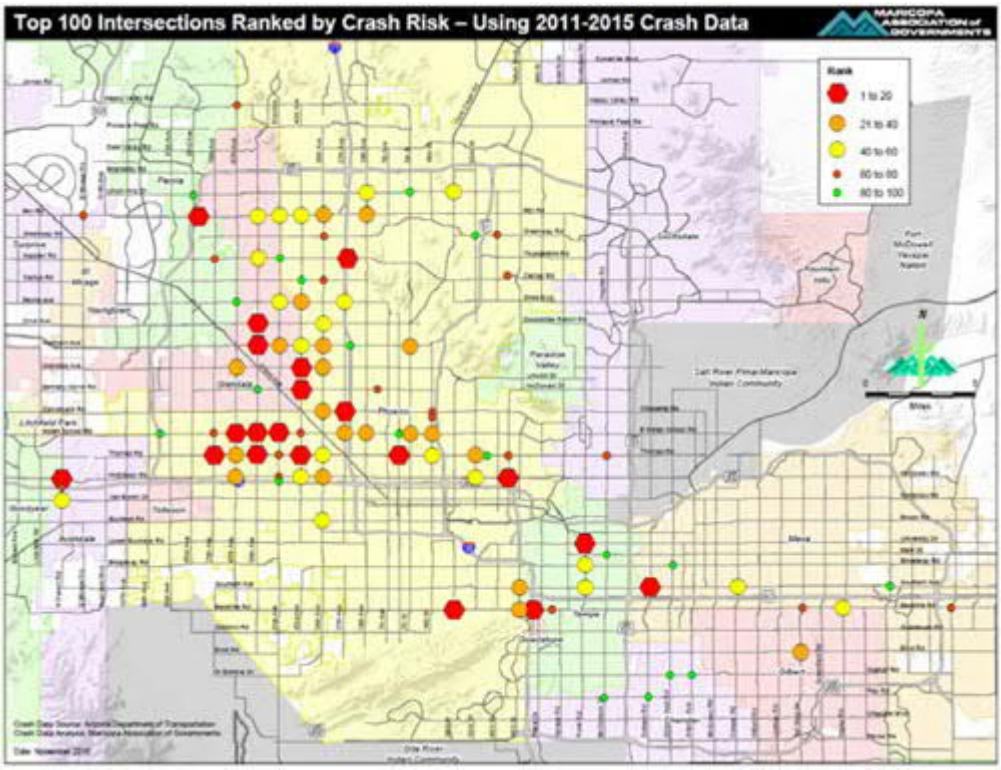
Data Visualization and Accessibility

Many agencies have developed databases and tools with a public-facing component, as part of their Vision Zero initiatives to increase data accessibility and enable data visualization. Open data platforms enable the public to provide input into areas of safety concern, supplementing data already being collected by the agency and improving overall data quality and accuracy. Platforms with internal and open components in New York City, San Francisco, and Sweden provide robust tools for

analysis, while enabling the public to contribute to the agencies' data sets and allowing the public to conduct their own analyses (Tang, et al., 2018).

Summarizing the results of a data crash analysis must be done in a way that is meaningful so that it can contribute to developing interim goals and target that will drive performance and implementation of the safety plan. Examples of data summaries may include high-injury or crash network maps or data reports that describe crash frequency, crash averages, crash trends, and crash rates. **Figure 2** illustrates an example of a crash analysis summary, as developed by the Maricopa Association of Governments to identify the top 100 intersections ranked by crash risk (Tang, et al., 2018).

Figure 2: Phoenix-Area Mapping



Source: Maricopa Association of Governments

New York

NYC DOT developed the Safety Data Viewer tool internally, which enables users to easily view and share safety-related data. The tool is primarily being used by project managers and the press office to identify crash location history. The tool uses a map interface that allows users to select geographies, create new projects, and review safety data. Users can select a corridor, intersections, or area, run a standardized crash summary with key data mile points, such as KSI/mile, and can produce mode detailed reports and provide before/after analysis. Users can select segments within a corridor to reflect the project's specific analysis limits (by drawing a rectangle around the analysis area on the map interface) and saving the corridor selection as a "project" will add it to

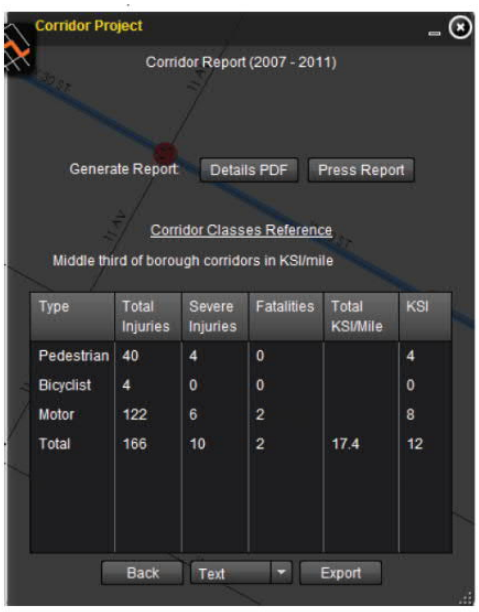
the project database. For each project, Safety Data Viewer will produce a predefined report that summarizes total injuries, severe injuries, fatalities, KSI, and total KSI/mile (**Figure 3**). The standardized report also identifies where the corridor falls in the corridor ranking by KSI/mile for the borough, which helps to determine whether the corridor is part of the Vision Zero priority network.

The Safety Data Viewer also allows users to perform analyses at the intersection level and perform before/after analysis of crash experience to use as an indicator of project benefit. The advanced query feature (**Figure 4**) allows users to generate a crash list by selecting an area (rather than corridor or intersection) and filtering the results by year, injury severity, and mode (i.e., pedestrian, bicycle, and motor vehicle).

The Safety Data Viewer is a web-based tool that uses Adobe Flash for the user interface, MS SQL Server for the backend database, and C# ASP.NET as the middle tier. The tool was initially designed using ArcGIS Adobe Flex API as the map interface, but since the product is no longer supported, NYC DOT is planning to migrate to the new ArcGIS JavaScript API or OpenLayers. Users can write to the MS SQL Server, but this capability is rarely used. Crash summary and before/after analysis reports are generally downloaded locally as PDF, Excel, or .csv files.

The Safety Data Viewer is comprised of three crash data sources, including the New York State Department of Transportation (NYSDOT) data (updated annually, manually), which requires a manual annual update, fatality data that NYC DOT maintains jointly with the New York Police Department (NYPD) (updated on a weekly basis, automatically), and NYPD data that is very limited (updated on a daily basis, automatically). NYSDOT data populates the corridor and intersection crash summary reports, while the limited NYPD data are used exclusively for the before/after analysis tool (Commission, 2018).

Figure 3: Corridor Summary



Source: NYCDOT (2017)

Figure 4: Query Tool

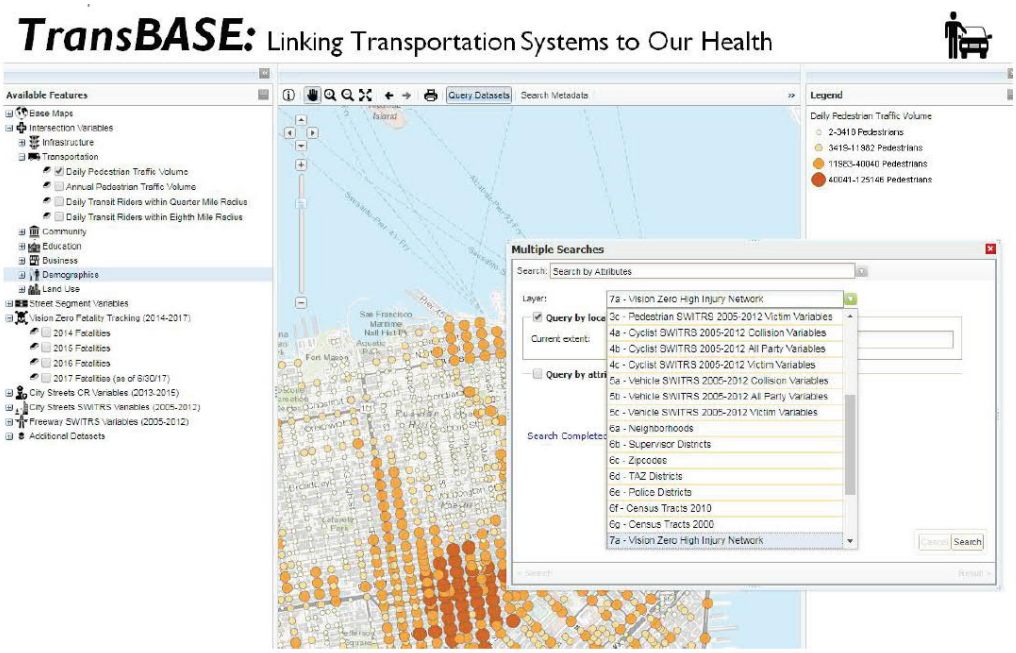


Source: NYCDOT (2017)

San Francisco

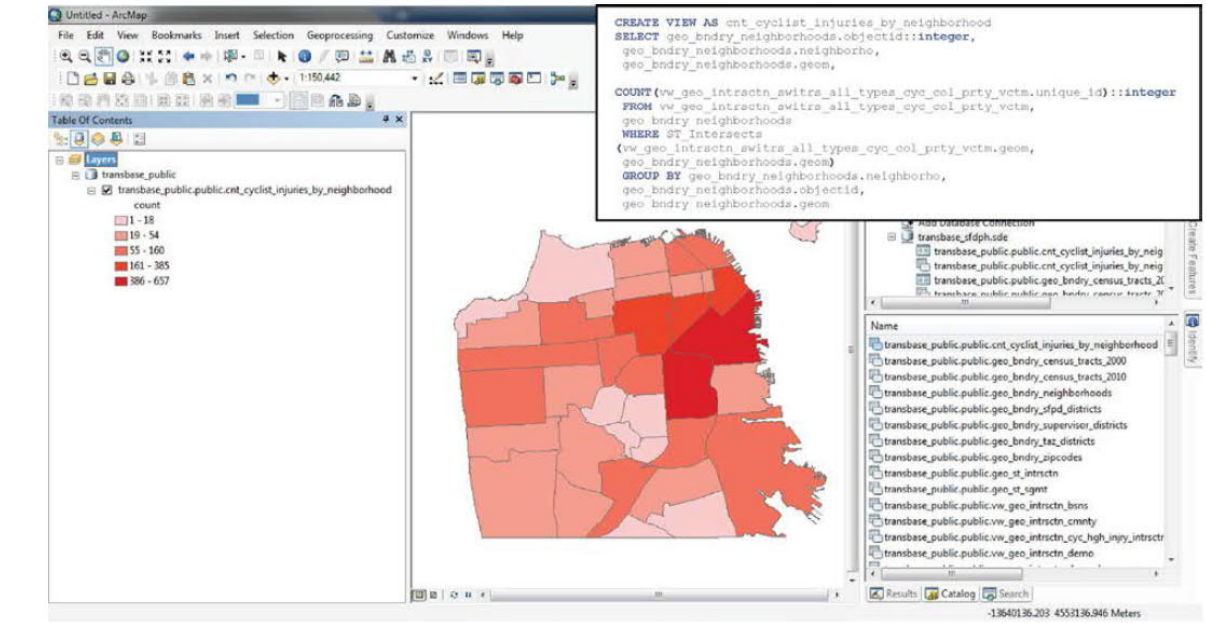
The San Francisco Public Health Department (SFPHD) developed TransBASESF.org to analyze and guide investments related to the intersection of health and transportation. The tool is a geospatially enabled relational database system that provides a centralized repository of crash data and other data sources that are relevant to Vision Zero analysis. In addition, the tool has a web-based interface (**Figure 5**) that allows users from within the city and the public to interact with data layers and produce standardized reports and has open database connectivity which enables platforms such as GIS-based systems (e.g., Esri) and spreadsheet-based systems (e.g., Microsoft Access) to access the underlying data tables within the tool. This interface allows multiple users across a network to create relationships between data tables and query the data using SQL language (**Figure 6**).

Figure 5: TransBASESF.org Web-Based Interface



Source: TransBASESF.org (2017)

Figure 6: TransBASESF.org Back-End Interface



Source: Morris and Wier, "Geospatially Enabled Database"

The database was built using open source software and code and is available to other municipalities for free on GitHub. The database was initially hosted by Amazon's Elastic Compute Cloud (which cost approximately $100 per month) but was eventually migrated into the City of San Francisco's virtual machine, a cloud-based environment

maintained by the City's IT department. As of 2016, SFDPH was working to automate regular updates that are needed to keep the data in TransBASESF.org up to date (Commission, 2018).

Sweden

The STRADA system in Sweden is notable for its ability to interface with a variety of stakeholders. The system contains three main applications: crash registration for police, a similar crash registration function for hospitals, and one for planners, engineers, and others using the data for statistical and planning purposes. A summary of the main data tables is presented in **Table 4**.

> Users can access the data in the STRADA system through a web-based client, as long as the user registers and participates in a one-day training course to ensure that the system and data are used correctly (Howard & Linder, 2014).

Table 4: Overview of the Main Data Tables in STRADA

Type	Name	Description
Both Police and Hospital	Accident	Used to match police reports with hospital reports
	Report	Crash information available in both police and hospital reports
	Road	Information on the road where the crash occurred
Police	PoliceReport	Police-specific crash information
	TrafficElements	Information on specific traffic elements (e.g. vehicles) involved in the crash
	Person	Information on specific persons involved in the crash
Hospital	HospitalReport	Hospital-specific information on crash, person and hospital care
	Injury	Information on specific injuries sustained
External Registries	PersonInfo	Driver's license information
	VehicleInfo	Vehicle information

Source: (Howard & Linder, 2014)

Depending on the purpose, statistics can be shown in a crash mode or a person mode. The person mode is especially useful while working with statistics and targets, while the crash mode might be the most convenient for geographical studies and planning. The applications have been developed further during the usage and several new editions have been launched. Today STRADA can be combined with different road data. There are also possibilities for researchers to work directly with the data.

Registering both police and hospital reports gives a more comprehensive, while still incomplete, illustration of the road safety problem, since neither the police nor the hospitals register all crashes. Police tend to visit mainly crash sites where a car is involved, regardless of the outcome in terms of fatalities or injuries. However, police

also tend to report minor injuries that occur from these crashes, which may not warrant a visit to the hospital. In contrast, crashes with only vulnerable road users can be very severe or fatal and are more likely to be reported through hospitals. Overall, comparing reports from the police and the hospitals shows that less than 2% of single-bicycle crashes reported by the hospitals also are reported by the police, with report matching handled automatically through an algorithm based on person identification number, report time, and crash location (Howard & Linder, 2014). Utilizing both data sources helps decision-makers make better decisions on where actions are needed.

The STRADA database has enabled a variety of studies focused on the characterization and analysis of unprotected road users, but also includes general traffic safety reports and cost-benefit analyses (Howard & Linder, 2014).

Decision-Making

Recognizing that resources are finite, data should be leveraged to support decision-making so that resources are directed and prioritized where they will make the greatest impact (Shahum & Vanderkooy, 2017). For example, data outputs can differentiate the number of fatalities and serious injuries in categories of crashes such as pedestrians, intersections, roadway departure, impaired driving, distracted driving, aggressive driving, commercial motor vehicles, and motorcycles. Ranking the crash categories from the highest number of fatalities and serious injuries to the lowest can help to determine which crash factors are most prevalent and would become emphasis areas (Tang, et al., 2018).

Having identified safety problems, data can be used to select appropriate strategies and countermeasures, monitor progress toward achieving goals and objectives, measure strategy and effectiveness, and identify needed improvements. In addition to project selection and prioritization, data will help agencies drive strategic direction, vision, goal setting, and crash factor identification. Safety plans should use the best available safety data to identify critical highway safety issues and safety improvement opportunities and be used to track and evaluate the progress made towards implementation. Several recent examples of how data was leveraged for decision-making include (Commission, 2018):

- The **City of Los Angeles**, in adopting its Vison Zero resolution, found that 65% of fatal crashes involved people walking on 6% of city streets. Los Angeles also passed a sales tax measure in 2016, which raises approximately $860 million/year for transportation improvements across the county.
- The **City of San Francisco's** analysis of safety found that people walking and bicycling are over-represented in traffic fatalities and severe injuries, which led to a focus on improving safety for those users—including a local bond measure that raised $500 million for roadway design improvements to improve safety for walking and bicycling.
- **New York City's** Vision Zero analysis highlighted locations where left-turning movements are mostly likely to cause serious harm, enabling the New York City

Department of Transportation (NYC DOT) to take a data driven approach to address potential future problematic areas.

- The **American Association of State Highway and Transportation Officials (AASHTO)** State Highway Safety Plan (SHSP) identified 22 key emphasis areas and contains strategies designed to address each area's key crash factor. If data are unavailable, emphasis areas may address concerns of the various stakeholders and the community obtained through public meetings, web-based surveys, or through an advertised request for comments (Tang, et al., 2018).

Identifying Effective Safety Countermeasures

Outputs of safety data analyses are used to inform development countermeasures for a safety plan. A potential approach to identifying strategies is to consider the 4 E's of transportation safety:

- **Education** strategies provide drivers information about making good choices, such as not texting while driving, avoiding driving while impaired, or wearing a seatbelt.
- **Enforcement** strategies focus on enforcing traffic laws and a visible police presence to deter motorists from unsafe driving behavior.
- **Engineering** addresses roadway infrastructure improvements to prevent crashes or reduce the severity of crashes.
- **Emergency response** strategies improve response and quality of care when responding to crashes.

> Data-driven and high-visibility enforcement is critical to efficiently use law enforcement to support speed reduction. Automated speed enforcement and point-to-point speed enforcement are effective in this regard; however, its implementation has been restricted nationwide due to state laws prohibiting its use (National Transportation Safety Board, 2017).

Leveraging multiple strategies will increase the likelihood of success in improving safety. In addition, countermeasures need to match the leading causes and locations of fatal and serious injury crashes. There are three main approaches to countermeasure implementation (Tang, Peach, DeFisher, & Eccles, 2018):

- **Spot location** involves implementing countermeasures at locations with a history of crashes; however, this approach is largely reactive and most dependent on data availability and quality.
- **Systemic approach** involves implementing improvements based on high-risk roadway features that correlate with specific severe crash types; this approach enables agencies to proactively broaden their traffic safety efforts, at a minimal cost.

- **Comprehensive approach** includes a mixture of approaches to address both infrastructure and behavioral improvements to address the crash issue.

Since systemic improvements are implemented at multiple locations across a network, they generally have a lower cost per site. The systemic approach provides a supplement to the hot spot approach—users can identify systemic hot spots which share the same high risk characteristics, then recommend countermeasures for systemic implementation across groups of location, which may offer economies of scale (Grembeck, et al., 2013).

Design and Engineering Interventions

There are several countermeasures related to design and engineering which may affect driving speed (Grembeck, et al., 2020):

- **Speed bumps, humps, and tables** inspire drivers to slow their vehicles to maintain control while going over vertical impediments. Installing multiple speed bumps in multiple succession can reduce average speeds by 8-12 mph in some areas.
- **Chicanes and lane shifts** apply a similar concept using horizontal deflection rather than vertical. These have been shown to reduce average speed by 1.3 to 3.2 mph, depending greatly on chicane design and the presence of other traffic features.
- The installation of **median barriers** has effects that are highly dependent on context. Studies in Sweden have shown that median barriers result in significant decreases to crash fatalities, however installation on suburban roads in Texas has shown increases in average driving speed.
- **Road diets and lane narrowing** reduces the availability or width of traffic lanes reducing driving speeds and the incidence of crashes.
- **Roundabouts** decrease the speed of traffic at intersections and reduce intersection crashes.

Speed Limit Interventions

The National Transportation Safety Board (NTSB) focuses on five countermeasures for speeding to improve safety measures: (1) speed limits, (2) data-driven approaches for speed enforcement, (3) automated speed enforcement, (4) intelligent speed adaptation, and (5) national leadership (National Transportation Safety Board, 2017) (Grembeck, et al., 2020).

Speed limits are typically determined by statute, and these are usually based on the 85th percentile speed of free-flowing traffic. The California Manual on Uniform Control Devices mandates the use of the 85th percentile speed in setting speed limits. Strong evidence does not exist that using the 85th percentile speed to set speed limits equates to low crash involvement rates, and alternative methods of determining speed limits are necessary to more strongly consider human factors (National Transportation Safety Board, 2017). There are a few reasons why the 85th percentile rule may not be effective. Drivers tend to underestimate their speed, and this effect is exacerbated at lower

speeds. Drivers may speed on local streets due to the lack of strong visual cues to assess safety and speed, as guardrails and shoulders do on highways (Ben-Bassat & Shinar, 2011). Spatial speed creep is a phenomenon that occurs when high highway speed limits encourage drivers to drive faster on connecting local roads.

Only a fraction (20-40%) of the change in posted speed limit results in observed changes in average speed. A 5 mph decrease in speed limit is only likely to result in a 1-2 mph decrease in actual speed (Elvik, et al., 2019). However, reducing speed limits also reduces the speed of the fastest drivers to a greater extent, which may explain why they have a marked effect on safety (Silvano & Bang, 2016).

Since one of the first before-after speed limit reduction studies in Sweden was conducted, several before-after studies since then have shown marked decreases in crash injuries due to speed limit decreases. Studies show that a 5 mph reduction in speed limits on limited access roads resulted in an 8-15% reduction in injuries, with some reporting as much as a 39% reduction, as well as a 10-30% reduction in fatalities (Grembeck, et al., 2020).

The effects of speed limit reduction in urban areas are more complicated due to the increased amount of other road and environmental characteristics and the higher density of vulnerable road users. Most studies suggest that roads with speed limits of 30-35 mph have 17-32% more injuries and 21-45% more fatalities than roads with speed limits of less than 30 mph. A 45 mph speed limit offers a sharp contrast, resulting in 32-54% more injuries and 274-326% more fatalities compared to speed limits of less than 30 mph (Grembeck, et al., 2020).

Policy Strategies to Address Safety Concerns

In addition to the development and implementation of countermeasures, **Table 5** summarizes key examples of policy strategies to address safety concerns.

Table 5: Description of Policy Tools

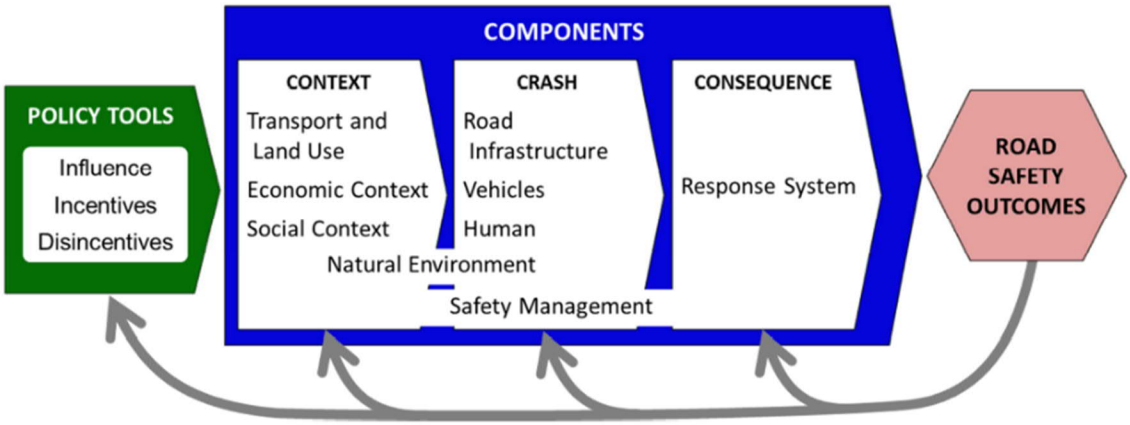
Policy Tool	Description
INCENTIVES	
Funding and investment	Application of finances to increase the amount of facilities, services, assets, product, or level of deployment
Financial incentives, pricing, and subsidies	Voluntary monetary or in-kind payments, costs, and rewards to encourage desired behavior or practice; financial transfers and cross subsidies
DISINCENTIVES	
Regulation, enforcement, penalties, and sanctions	Activities to develop and apply a legislative authority
Taxes, fees, levies, and charges	Financial charges applied to discourage undesirable behavior or practice
INFLUENCE	

Policy Tool	Description
Leadership, integration, implementation, and participation	Desktop, office, personal and relational activities regarding the planning and delivery of policies, programs and projects to optimize safety outcomes – excludes actual delivery of a policy
Behavior change	Activities that encourage people to behave more safely – separate from, but may be linked to incentives, pricing, subsidies, and regulatory mechanisms
Skills, expertise, capability, and professional practice	Development of personal capacity, competency, and fitness to undertake a task Development of professional skills and practice
Standards and guidelines	Voluntary application of written authoritative agreements or references with respect to design and practice
Industry change, competition, and consumer change	Application of strategic advantage to provide a market advantage – influences in markets that result in a desired outcome
Innovation and research	Investigation and development of new information with respect to behavior, practice, product, or operations and initial deployment to prove and refine applicability

Source: Hughes et al. 2016

It is important to recognize that the individual components of a policy framework that includes the full range of road safety strategies are interconnected (**Figure 7**). It is therefore difficult to attribute outcomes to any one policy since they are often implemented in tandem, or in combination with design- or infrastructure-based countermeasures. As a result, it may be useful to group components of a policy framework into various categories to emphasize synergistic strategies, such as transportation and land use, economic, social, natural environment, safety management, road infrastructure, vehicles, human, and response system.

Figure 7: System Relationships in the Road Safety Network



Source: Hughes et al. 2016

Evaluating Performance

Setting performance targets and tracking progress made towards those targets will help agencies set goals and objectives, evaluate effectiveness of programs and strategies, provide feedback on further iterations of safety plans, and communicate with leadership and the public. Maryland has integrated safety performance measures into its agency-wide business plan, which provides a higher and broader level focus on safety performance, while Washington and Idaho have developed SHSP evaluation plans that include emphasis-area goals and objectives and the output and outcome performance measures used to help measure progress (Tobias, et al., 2016).

In addition to evaluating the effectiveness of safety plans and programs, it is also important to analyze the effectiveness of completed safety improvement projects to quantify the benefits of the project and identify future projects that may provide similar benefits. In general, highway safety improvement projects must be economically justified by showing that their expected benefits will outweigh the anticipated costs. To translate the expected safety benefits into monetary terms, analysts apply financial equivalents to various crash severities—therefore projects with larger net safety benefits may be more economically justified when evaluating potential projects (Harmon, et al., 2018).

Crash modification factors (CMF) are a research-based baseline to quantify the expected effectiveness of a countermeasures. A CMF less than 1.0 indicates the potential to reduce crashes. The FHWA CMF Clearinghouse is a web-based database of CMFs with supporting documentation (Grembeck, et al., 2020). However, events such as cyclist collisions are relatively rare events compared to vehicle crashes, and few data sources are available for cyclist exposure data, making the development of CMFs for bicycle safety treatments difficult. The effectiveness of countermeasures in this regard may be less rigorous, and needs more research on exposure, how to obtain accurate crash and exposure data for bicycles, and what impact safety treatments have on injury severity (DiGioia, et al., 2017).

Vision Zero Best Practices

Integrating a Vision Zero mindset into road safety activities requires a long-term commitment from a range of stakeholders. Development of a Vision Zero action plan is recommended to serve as an overarching guide to inform the integration process and provide a framework to monitor and evaluate results. Every action plan should identify context-particular measures that can be implemented to reach specific targets—through a comprehensive review of contextual information, engagement with stakeholders, and evaluation of resources and data. The action plan should clearly convey how, by when, and by whom the identified measures will be carried out. This document outlines a high-level list of guiding principles and elements that should be incorporated into the development of a Vision Zero Action Plan.

Guiding Principles

An effective Vision Zero Action Plan must have several key elements. At its core, the plan must focus on the guiding principles of Vision Zero. These guiding principles are show in the Figure 1 below. If any one of these elements is excluded in the development of the Action Plan, the impact of the Action Plan will be severely limited.

Figure 8: Fundamental Guiding Principles of Vision Zero

	Traditional/Prevailing	Vision Zero
Issue	Preventing all crashes	Preventing fatalities and serious injuries
Premise	Deaths are inevitable	Deaths are preventable
Focus	Perfecting human behavior	Designing a road system that accounts for human error
Responsibility	Individual road users	Shared: road users and system designers

In addition to being focused on the Vision Zero guiding principles, a Vision Zero Action Plan must have the following key elements to be successful.

- **Data Driven** - In the past it was thought that fatal traffic crashes were random occurrences and could not be predicted or prevented. Modern analytical techniques have shown this premise to be false. Fatal and serious injury crashes are generally predictable and preventable. Relying on data analysis—specifically the analysis of fatal and serious injury crashes—is the foundation of understanding traffic safety issues within a jurisdiction.
- **Actionable** – Once the data analysis has been completed and a full understanding of where fatal and serious injury crashes are happening, what kinds of crashes are leading to deaths and serious injuries, and who is most impacted by fatal and serious injury crashes, an action plan must be put in place with specific steps. The elimination of deaths and serious injuries on our roadways is a complex and difficult task. Without specific actionable steps, it can be difficult to identify what should be done and by whom to achieve the goals

of Vision Zero. A Vision Zero Action Plan should identify a series of specific tasks based on short-, medium-, and long-term timeframes, and should assign these tasks to specific individuals or departments.

- **Accountable** – Unless a mechanism is in place to track and report on the actionable steps from the Vision Zero action plan, it is difficult to continue progress towards achieving Vision Zero. Key Performance Indicators (KPIs) of success should be identified with desired targets in the Action Plan that can be tracked and used to improve accountability. These KPIs can then be used to track success of the plan and hold individuals and departments accountable. KPI reporting can be achieved annually through compiled reports and/or continually through automated reporting of performance indicators using an online dashboard. Practitioners should understand that Vision Zero is not a quick process—many countries who have seen 50% - 80% reduction in their fatal crash rates have been working to implement Vision Zero for decades. Because of this, an immediate reduction in fatal and serious injury crashes may not be seen but eventual reduction of fatal and serious injury crashes remains the most important KPI.

Action Plan Development

A complete Vision Zero Action Plan is an involved document that requires a substantial amount of work by practitioners and outreach to community members, public agency staff, and other stakeholders. **Figure 9** depicts the key steps in the process to developing a Vision Zero Action Plan. These steps are highlighted below.

Figure 9: Vision Zero Action Plan Elements



A. Review of Current Road Safety Practice

An evaluation of previous road safety efforts should be undertaken to ensure a fundamental understanding of the current road traffic safety situation. It is essential to have a solid comprehension of the current situation in order to understand and communicate the efforts needed to change the situation.

Key Elements:

- Complete a high-level review of previous efforts in road traffic safety, including the safety management system and processes.
- Evaluate standards and guidelines used to help address and treat road safety issues.
- Evaluate the traffic safety culture including different stakeholders and their relationships.
- Perform a gap-analysis between existing road safety management and Vision Zero and identify key priorities for improvement.
- Share the current situation with stakeholders of the road safety process. (See Step G: Outreach and Communication Initiatives.)

B. Literature Review

A review of Vision Zero and other road safety literature will help ensure that activities outlined in the action plan align with Vision Zero proven practices and are workable in the current context. Based on the priorities identified in the gap analysis of existing safety initiatives, the literature review can be tailored to answer key questions about Vision Zero for the specific jurisdiction. A comprehensive literature review should be completed to guide a fundamental understanding of the Vision Zero perspective, if this is not already the case.

Key Elements:

- Research case studies, interviews, scientific papers, etc.
- Benchmark with other communities that have adopted Vision Zero/Safe System.

C. Development / Modification of Road Injury Database

Vision Zero is a data-driven approach to road safety. A centralized, comprehensive and georeferenced crash database helps provide a full picture of current road safety performance, enabling in-depth analysis. A database should ideally draw upon both police reports and hospital/emergency room data. Individually, neither dataset will typically account for all deaths and serious injuries as a result of road crashes; although when combined they should provide a reasonably accurate picture of a region's road safety situation.

Key Elements:

- Identify if there is an existing road injury database.
- Identify the types of data needed and/or its availability: police report, trauma center registry, etc.
- Centralize the data into one database.
- Specify guidelines for interpreting the data.
- Only collect crashes resulting in fatalities and injuries in the database (This step is critical as it maintains the Vision Zero focus, potentially differentiating the

Vision Zero goal from previous road safety initiatives.) It is advisable to classify injuries in more than one group of severity.

D. Data Analysis

Using the road injury database developed in Step C: Development/Modification of a Road Injury Database, the data should be analyzed with a focus on fatalities and serious injuries. This analysis will lead to better qualitative and quantitative understanding of the current road traffic safety situation through screening the data for both locational and system-wide trends. Data analysis will be contextual based on the source and compilation strategy of the database as well as the available software that will be used for analysis. In all cases, the purpose of the data analysis should be to identify key trends that can inform the recommended policy changes and implementation measures of the Vision Zero strategy document.

Development of a High Injury Network is an important part of data analysis. More information related specifically to High Injury Network development is included in a subsequent section.

Key Elements:

- Analyze the georeferenced database to extract trends, such as conflict movements, user types, environmental factors, common contributory factors and/or movements at specific locations.
- Develop a "high-injury network" (a map of the fatalities and serious injuries aggregated by corridors) to help prioritize investment.
- To ensure road safety measures are inclusive of the subject population, add socio-demographic data (such as income levels and age groups) to inform the analysis.
- Assess whether certain road safety issues result in wider negative impacts for the local community (such as reduced mobility and/or induced stress).

E. Strategy Development

A collaborative approach is essential for developing a long-term and high-level strategy that integrates Vision Zero into the existing policy structure. It should be clearly understood and communicated that reaching the aspirational target of zero deaths and serious injuries requires long-term commitment from all stakeholders involved. The strategy should state and justify the Vision Zero road safety targets and provide direction to integrate Vision Zero into the larger policy structure.

Key Elements:

- Continually engage local leaders (e.g. agency and bureaucratic leadership, advocacy organizations, road safety engineers) over the long term.
- Publish the new strategy on relevant websites and other digital and print communication platforms.

- Adapt the strategy to the local context and define specific objectives customized to the region and its road safety challenges.
- Identify long- and short-term targets for the jurisdiction.
- Recommend contextual implementable actions and indicators.
- Reference the strategy whenever feasible in other jurisdictional documents.
- Share the strategy with stakeholders and local residents. (See Step G: Communication-Outreach Initiatives.)

F. Implementation

Steps A-E provide a comprehensive guide to support developing an informed Vision Zero action plan that will provide a roadmap for the short, medium and long term of road safety. Moving forward, it is equally important that the plan is implemented, monitored and updated to foster long-term success using KPIs.

Key Elements:

- Engage key stakeholders (including officials from different departments).
- Secure budget, resources and expertise.
- Set ambitious, yet achievable interim objectives and targets based on the data analysis.
- Plan actions to reach the objectives and targets, by prioritizing countermeasures to match crash profiles.
- Develop contextual KPIs of success for the Vision Zero action plan.
- Identify responsible parties and set up a timeline with milestones.
- Rely on evidence-based techniques that have proven to reduce the severity or likelihood of crashes.
- Adopt a systematic approach to addressing road safety issues based on a theme (such as geography, infrastructure type, crash type or road user).
- Make the document available and accessible.

G. Outreach and Communication Initiatives

A Vision Zero communication plan should be developed to promote meaningful discussion with the public regarding Vision Zero. A successful communication plan is transparent and should work proactively with key stakeholders, including public officials, law enforcement, media, and road safety professionals. For each action with the plan, a specific engagement should be developed. Each engagement should address when, how and with whom there should be communication.

Key Elements:

- Develop a communication plan that encourages ongoing and inclusive engagement
- Develop specific training material for key staff.
- Develop additional mainstream communication material to be shared. (Vision Zero fact sheets, FAQs, myth busters, etc.)

- Tailor information to suit certain groups.

H. Monitoring

As documentation of proven practice is vital for the continued implementation of Vision Zero, monitoring is especially important to its success. The monitoring KPIs (Step F: Implementing the Action Plan) should be collated into a monitoring and evaluation plan. This plan will provide indicators of success based on intermittent targets and implemented improvements to the transport network.

Key Elements:

- Based on the KPIs identified in Step F: Implementing the Action Plan, determine how to monitor the KPIs and the timeframe for reporting.
- Align these KPIs with a timeline for review.
- Engage with stakeholders to ensure the plan is achievable.
- Continuously report on the analysis to inform the progress report.

I. Progress Report

The purpose of the progress report is to enable the continued evaluation and monitoring of conditions, test the efficiency of the actions undertaken, and provide feedback to politicians and other system designers regarding the success, or otherwise, of actions. Progress reports should be presented each year, with extra emphasis given to certain actions during their target years.

Key Elements:

- Analyze and report on the findings of Step H: Monitoring.
- Cross reference the KPIs of Step H to the objectives and targets set out in the action plan.
- Recommend and reflect further actions if monitoring indicates that the actions taken are insufficient for reaching the intermittent targets.
- Inform any changes or updates to the Vision Zero strategy through review of the findings and recommendations of the progress report and modifying the overall Vision Zero action plan lifecycle.

High Injury Network Development

High Injury Networks are an important analytic tool to better understand existing conditions in an area of study. Building off of the key tenets of Vision Zero plans which seek to eliminate traffic fatalities and serious injuries by addressing the three key elements of road systems (roads, vehicles, and speed), High Injury Networks use data to localize certain crash types, locations, times, and user demographics to specific corridors so that causes and specific solutions may be identified.

The City/County of San Francisco was the first jurisdiction to establish a High Injury Network according to the Vision Zero Network. Working in concert with its Vision Zero Plan, staff found that 12 percent of city street miles contributed to 70 percent of fatal

and serious injuries. This points to the benefits of developing High Injury Networks, which include:

- Identifying facilities in need of improvement;
- Providing agencies with information for prioritization;
- Providing context to relate High Injury Networks with equity priority communities; and
- Building communication and support in political and public spheres.

Since the City/County of San Francisco's initial efforts, subsequent developments in government and policy have furthered the concept. California Assembly Bill 2363 (2018) required the California Secretary of Transportation to establish and convene a Zero Traffic Fatalities Task Force, which emphasized speed's relationship to traffic fatalities and injuries, and recommended creating a statewide definition of a High Injury Network to help classify locations where posted speed should be reduced. Following this, the Southern California Association of Governments proposed defining these statewide High Injury Network recommendations, with special consideration for vulnerable road users like bicyclists and pedestrians.

Since November 2020, a multi-jurisdictional High Injury Network subgroup reviewed existing High Injury Networks among California cities, counties, and metropolitan planning organizations. Based on extensive review, the subgroup identified the following core components common to High Injury Networks:

Core Component	Considerations
Data Sources	• Statewide Integrated Traffic Records System (California Highway Patrol) • Transportation Injury Mapping System (SafeTREC) • Jurisdictionally specific police departments
Years of Data	Three to five years of collision data, with a median and average of four
Collision by Intersection or Corridor	• Most High Injury Networks are analyzed at the corridor level • High-Injury intersections may warrant special study, and specific countermeasures
Collision by Roadway Facility	Depending on geography, it may be appropriate to include freeway mainlines and ramps in addition to local streets. However, many localities lack authority to change freeway speed limits
Collision by Mode	Collisions may include users of different modes such as automobile, bicycle, and pedestrian. It may be helpful to distinguish between types of collisions such as auto-auto, auto-pedestrian, etc.
Collision Weights	Weighting allows for prioritization according to specific priority goals by more strongly assigning weight to collisions that involve vulnerable populations such as children or older adults, different injury severities, or equity considerations

Normalization	The number of collisions may be divided by other factors such as facility length or population to better compare road segments or intersections for inclusion in the High Injury Network
Thresholds	For prioritization purposes, it may be helpful to include thresholds for inclusion based on factors like a certain number of serious injuries or fatalities per unit distance, or the top 15% of roadways with serious injuries

Developing a robust system that incorporates these core components can be challenging. The High Injury Network subgroup recommends the following ways to address a variety of concerns:

- Access to reliable data: If jurisdictions lack their own collision tracking data system, or face delays in timely data reporting, additional data such as hospital records or local law enforcement may help supplement existing data;
- Lack of robust collision data: Particularly for smaller jurisdictions, a low amount of collision data may be supplemented by using high-risk roadway characteristics or other contextual factors that may lead to unsafe conditions;
- Access to software and staff resources: Challenges around access to transportation staff with GIS experience and relying upon interagency data-sharing agreements may be overcome by seeking out regional, state and federal funding for Vision Zero staff and/or creating an interagency taskforce at the outset of Vision Zero Action Plan/High Injury Network development;
- Risk and liability concerns: Jurisdictions should work with legal staff on concerns of risk and liability around identifying locations with known safety issues;
- Education and understand of High Injury Networks: The specific and technical nature of High Injury Networks presents educational challenges which may be overcome by curating informational materials and providing targeted outreach to staff; and
- Potential Overpolicing: Identifying high risk areas may coincide with Equity Priority Communities, which may also be known as Communities of Concern or Disadvantaged Communities, for whom increased law enforcement presence may be harmful. It is therefore important to consider alternatives to law enforcement and programs determined through community outreach and participation (Strategic Highway Safety Plan: Bicycle and Pedestrian Challenge Area Team, 2021).

Examples of Action Plans

This section summarizes examples of Vision Zero Action Plans both nationally and internationally that incorporate best practice and the key action plan elements previously described. These plans all incorporate some or all the key elements and all of them embody the guiding principles of Vision Zero.

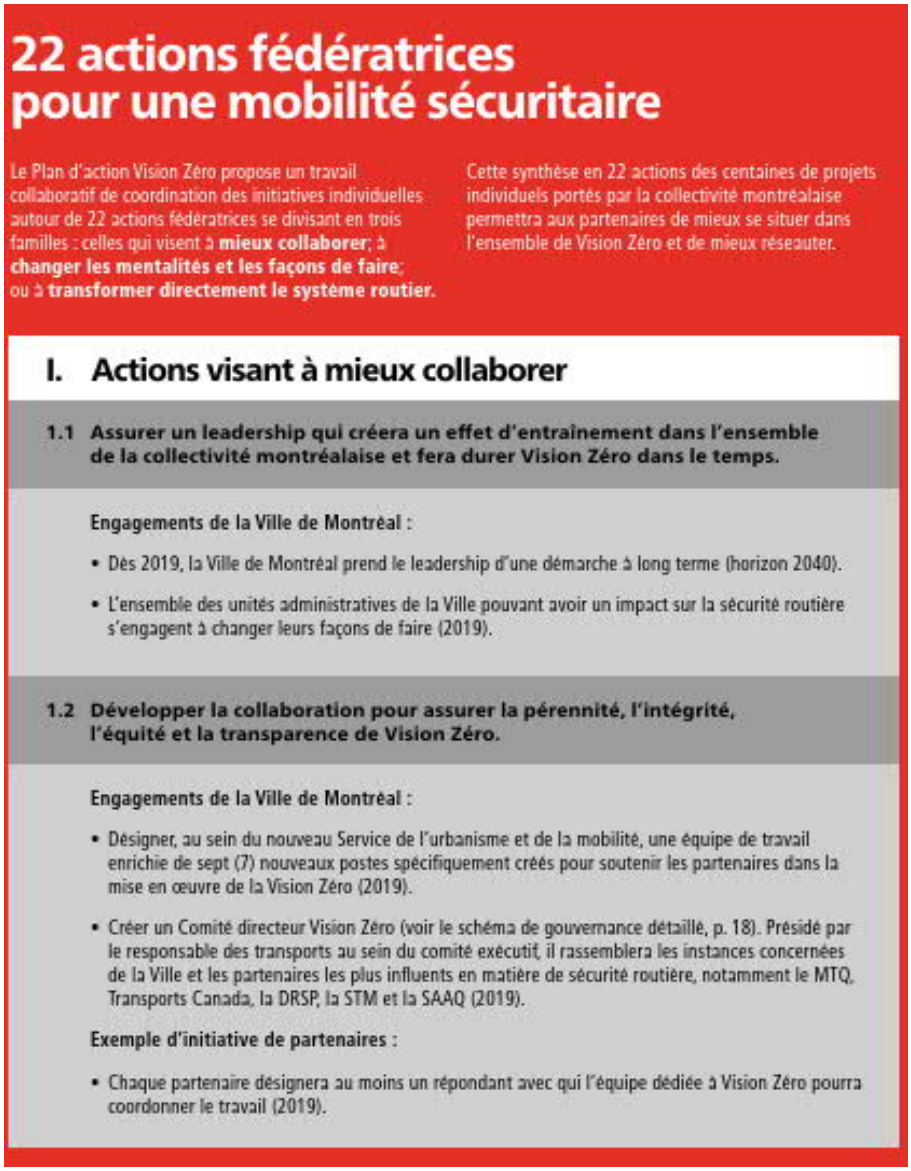
Montreal Toward a Vision Zero Action Plan

Montreal's Vision Zero Action Plan (Ville de Montreal, 2021) is centered around 22 actions to reflect the commitment to safety made by the city and its partners. The three key themes are as follows:

- Promote Collaboration
- Change Attitudes
- Transform the Road System

A snapshot of the actions is illustrated in **Figure 10**.

Figure 10: Montreal Vision Zero Action Plan Actions



22 actions fédératrices pour une mobilité sécuritaire

Le Plan d'action Vision Zéro propose un travail collaboratif de coordination des initiatives individuelles autour de 22 actions fédératrices se divisant en trois familles : celles qui visent à **mieux collaborer**; à **changer les mentalités et les façons de faire**; ou à **transformer directement le système routier.**

Cette synthèse en 22 actions des centaines de projets individuels portés par la collectivité montréalaise permettra aux partenaires de mieux se situer dans l'ensemble de Vision Zéro et de mieux réseauter.

I. Actions visant à mieux collaborer

1.1 Assurer un leadership qui créera un effet d'entraînement dans l'ensemble de la collectivité montréalaise et fera durer Vision Zéro dans le temps.

Engagements de la Ville de Montréal :

- Dès 2019, la Ville de Montréal prend le leadership d'une démarche à long terme (horizon 2040).
- L'ensemble des unités administratives de la Ville pouvant avoir un impact sur la sécurité routière s'engagent à changer leurs façons de faire (2019).

1.2 Développer la collaboration pour assurer la pérennité, l'intégrité, l'équité et la transparence de Vision Zéro.

Engagements de la Ville de Montréal :

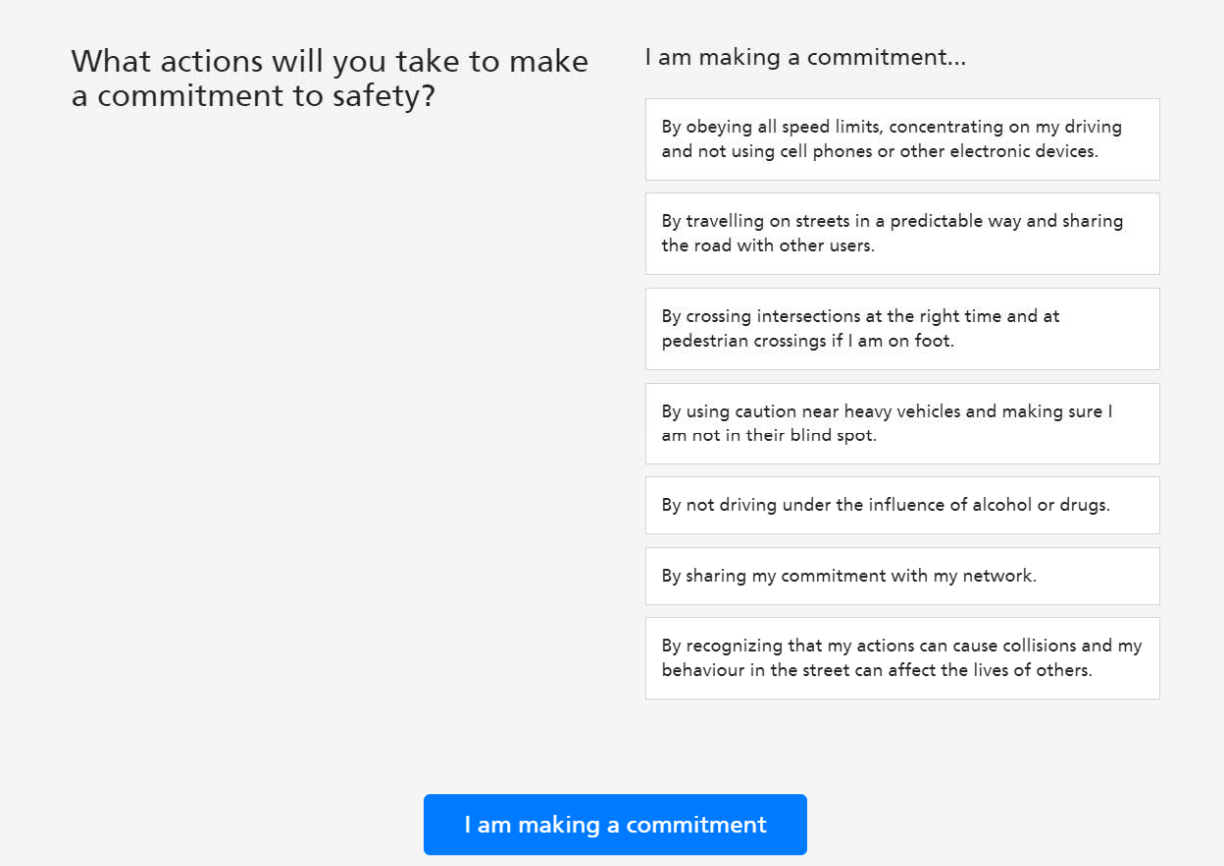
- Désigner, au sein du nouveau Service de l'urbanisme et de la mobilité, une équipe de travail enrichie de sept (7) nouveaux postes spécifiquement créés pour soutenir les partenaires dans la mise en œuvre de la Vision Zéro (2019).
- Créer un Comité directeur Vision Zéro (voir le schéma de gouvernance détaillé, p. 18). Présidé par le responsable des transports au sein du comité exécutif, il rassemblera les instances concernées de la Ville et les partenaires les plus influents en matière de sécurité routière, notamment le MTQ, Transports Canada, la DRSP, la STM et la SAAQ (2019).

Exemple d'initiative de partenaires :

- Chaque partenaire désignera au moins un répondant avec qui l'équipe dédiée à Vision Zéro pourra coordonner le travail (2019).

Montreal focused on outreach and communication by presenting materials in multiple languages and sharing information with a lens of personal/collective responsibility, as shown in **Figure 11**.

Figure 11: Montreal Vision Zero Action Plan online information framing



Australia Direction Zero

Direction Zero (Regional Integrated Transport Strategy Implementation Advisory Group, 2015-2018) defines the vision to "support, assist and advocate for the development of a fatality and serious injury free road network in Perth's Eastern Region." The plan focuses on actions related to:

- Improving safety in four Key Focus Areas: roads and roadsides, speed, road use, and vehicles;
- Road safety planning; and
- Governance.

For each of the key focus areas, Direction Zero illustrated the expected impacts on goals that were organized by strategy and described specific actions for implementation, as shown in **Figure 12**.

Figure 12: Direction Zero Strategy Development and Action Implementation

Based on *Towards Zero WA's Road Safety Strategy* and the identified road safety issues in the Region, providing safe roads and roadsides can be expected to have the following impacts:



KFA 1. Safe Roads and Roads Sides

	Actions	Timeframe	Priority
1.1	Undertake and assist member Councils to carry out walking and cycling audits to identify infrastructural issues, taking particular account of safety elements associated with these road users.	Ongoing	Medium
1.2	Assist member Councils to identify routes with high numbers/rates of motorcycle killed and serious injured crashes and carry out audits against the motorcycle guidelines.	Medium	High
1.3	Advocate and support member Councils with annual blackspot and black route applications focussed on fatal and serious crashes.	Ongoing	High
1.4	Monitor and review the priority infrastructure list as set out in the RITS with respect to the number of crashes over the past five years and emerging crash trends.	Ongoing	Medium
1.5	Advocate for infrastructure initiatives that have demonstrated road safety benefits in the Region including safety improvement upgrades, for example on Great Eastern Highway (Greenmount to Mundaring).	Ongoing	High
1.6	Assist member Councils to develop Road Safety Audit policies with regards to new road designs and construction.	Ongoing	Medium

Miami-Dade County Vision Zero Implementation Plan

The development of Miami-Dade County's Vision Zero Plan (Miami-Dade Transportation Planning Organization, 2018) was the culmination of five key tasks:

- Task 1 | Vision Zero Task Team Engagement
- Task 2 | Literature Review (**Figure 13**)
- Task 3 | Data Collection/Data Analysis
- Task 4 | Countermeasure Selection
- Task 5 | Project Documentation



Figure 13: Literature Review

The Action Plan is based on the 5 E's: Engineering, Enforcement, Education, Encouragement, and Evaluation—recognizing that a combination of these strategies is necessary to lead to long-term results. **Figure 14** illustrates the Action Plan that includes proposed priority improvements.

Figure 14: Miami-Dade County Vision Zero Action Plan Implementation

Identifier	Location	Suggested Countermeasure	Cost	Responsible Party	Time Frame
A	NW 207TH DR and NW 37TH AVE	Signalize	$250,000	Miami Gardens	2-5 years
B	NE 215TH ST and NE 2ND AVE	Add left-turn phasing (Reconstruct Signal)	$250,000	Miami Gardens	2-5 years
C	AVENTURA BLVD and NE 29TH PL	Restrict left-turn phases	$75,000	Aventura	0-2 years
D	NW 122ND ST and W 32ND AVE	Add Channelized left-turn lane and phasing SB	$400,000	Hialeah Gardens	3-5 years
E	NW 95TH ST and NW 32ND AVE	Add Channelized left-turn lanes E-W and modify phasing	$750,000	Miami-Dade County (West Little River CDP)	3-5 years
F	NW 9TH ST from RED RD to FLAMINGO RD	Reduce Speed Limit	$20,000	Hialeah	0-2 years
G	NW 29TH AVE and NW 56TH ST	Convert to All-Way Stop	$2,500	Miami-Dade County (Brownsville CDP)	0-1 year
H	NW 13TH ST from 3RD AVE to BISCAYNE BLVD	Reduce Speed Limit	$20,000	City of Miami	0-1 year
I	NW 3RD AVE and NW 5TH ST	Add Signal Heads and Reflective Backplates (Reconstruct Signal)	$500,000	City of Miami	2-5 years
J	NW 12TH ST and NW 127TH AVE	Widen Median E-W	$1,500,000	Miami-Dade County (Unincorporated)	5-10 years
K	SW 26TH ST and SW 122ND AVE	Widen Median N-S	$1,500,000	Miami-Dade County (Unincorporated)	5-10 years
L	SW 24TH ST from SW 87TH AVE to SW 82ND AVE	Speed Study and Revise Speed Limit	$25,000	Miami-Dade County (Westchester CDP)	0-1 year
M	SW 37TH AVE and PEACOCK AVE	Restripe NB left-turn Receiving Lanes	$10,000	City of Miami	0-1 year
N	SW 152ND ST from SW 112TH AVE to SW 102ND AVE	Speed Study and Revise Speed Limit	$25,000	Miami-Dade County (Richmond Heights CDP)	0-1 year
O	SW 168TH ST and SW 112TH AVE	Add left-turn phasing	$50,000	Miami-Dade County (Palmetto Estates CDP)	0-2 years
P	SW 268TH ST and SW 134TH AVE	Signalize	$250,000	Miami-Dade County (Princeton CDP)	2-5 years
Q	SW 312TH ST and SW 152ND AVE	UNDER CONSTRUCTION	--	Homestead	--
R	SW 312TH ST and NE 43RD/137TH AVE	Add "Signal Ahead" Warning Sign NB	$1,200	Homestead	0-1 year

Denver Vision Zero Action Plan

The Denver Vision Zero Action Plan (City of Denver, 2017) is a five-year Action Plan that sets forth the strategies and actions that the city will take to achieve zero traffic deaths and serious injuries by 2030. The Action Plan is organized around five key themes:

- Enhance City Processes and Collaboration
- Build Safe Streets for Everyone
- Create Safe Speeds
- Promote a Culture of Safety
- Improve Data and Be Transparent

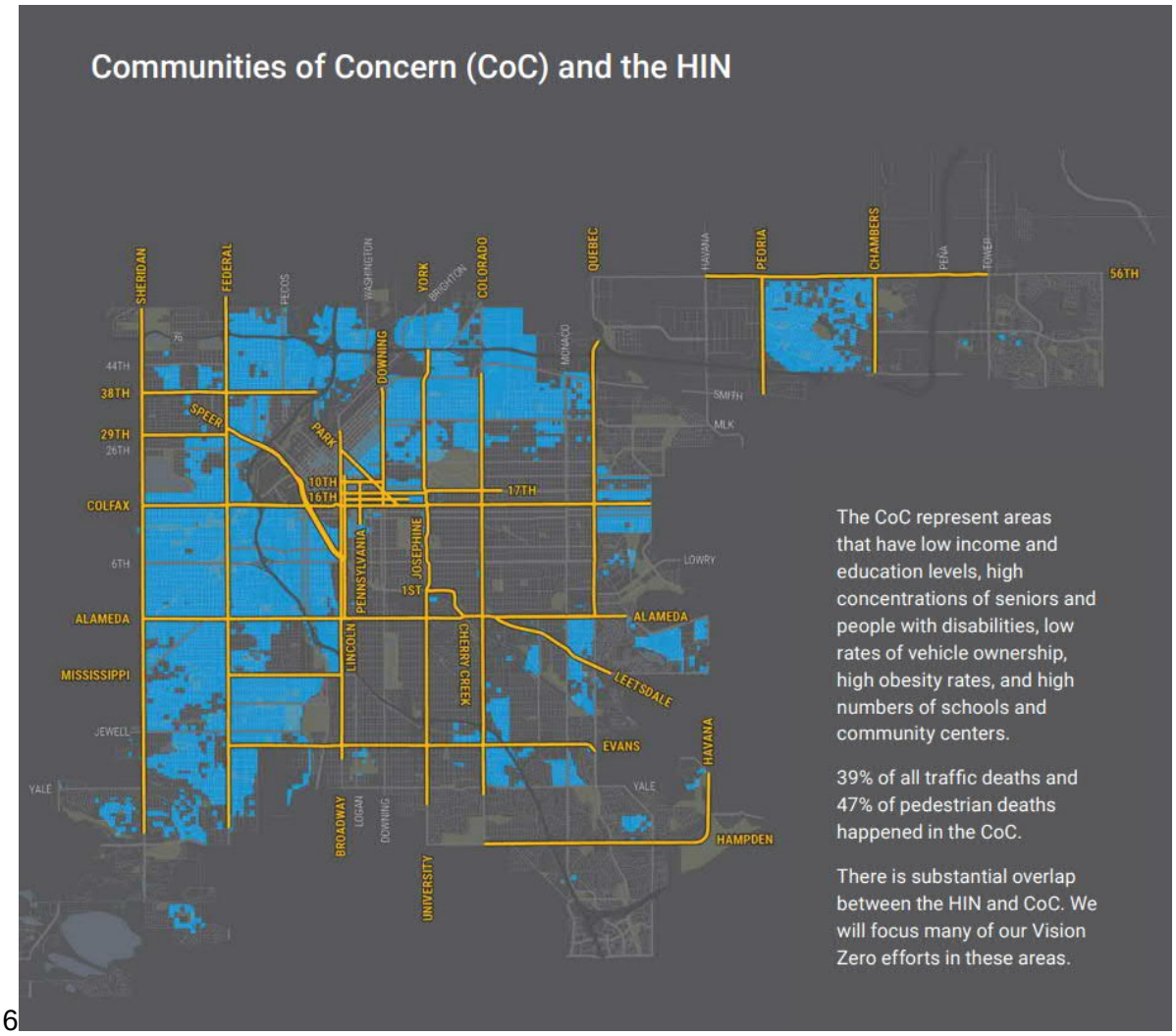
Each key theme is then further broken down by action, and each action includes detailed information on the resources (including financial resources, staffing, meetings, etc.) necessary for implementation. **Figure 15** illustrates and example of the Action Plan.

Figure 15: Denver Vision Zero Action Plan Example

Action	2018-2019	2020-2023	Partners*
Establish a Vision Zero program within the City			
Establish a permanent, dedicated funding source for Vision Zero implementation and coordination. Continue to create a Vision Zero program with dedicated staff.	$2M/year; 1.5 additional FTE/year	$3M/year; 2 additional FTE/year	DPW, *Mayor's Office, DPD, DEH, CDOT*
Coordinate existing funding already going to Vision Zero projects or that could be applied to such projects.	Ongoing action	Ongoing action	DPW, BMO, *CDOT*
Institutionalize Vision Zero as the City's approach to its transportation system			
Continue convening regular meetings of safety stakeholders (TAC) to review data and ongoing traffic safety performance and determine strategies for improvement.	6 meetings/year	6 meetings/year	DPW or Mayor's Office, *DPD, DEH, others*
Convene regular meetings of executive-level departmental representatives to coordinate Vision Zero efforts.	4 meetings/year	4 meetings/year	Mayor's Office, *Xcel Energy, DPW, DPD, DEH, others*
Ensure that Denver Vision Zero staff are represented at CDOT Region 1/City and County of Denver coordination meetings.	Ongoing action	Ongoing action	DPW, *CDOT*
Make the City and County of Denver a model Vision Zero adopter, including possible fleet modifications, operational changes, and training.	Ongoing action	Ongoing action	DPW
Perform engineering reviews at traffic fatality and high collision locations to identify risk factors that can be addressed citywide			
Until the end of 2017, convene rapid response meetings after pedestrian, motorcyclist, and bicyclist fatalities. Implement near-term safety improvements as appropriate and implement a strategy for rapid response meetings beyond 2017.	Complete action		DPW, *DPD, CDOT Region 1, VZC, DEH, RTD*
Using crash trends, rapid response information, and other data and analytics that are available and appropriate, systematically identify locations that need street modifications and implement changes. Collaborate across agencies to identify problems and solutions, and develop case studies or lessons learned where possible for future improvements.	2 locations/year modified	4 locations/year modified	DPW, *DPD, CDOT, DEH*

Denver used a variety of data-driven demographic and safety indicators to analyze where the most impactful investments could be made, as shown in **Figure 16**.

Figure 16: Denver Vision Zero Data Analysis



6

Auckland Road Safety Business Case

The Auckland Road Safety Business Case (Auckland Transport, 2019) is a 10-year program for road safety for the Auckland Transport road network. A Program Business Case (PBC) was commissioned to review the main safety problems—concluding that the level of deaths and serious injuries (DSI) is unacceptable and is only projected to increase. To respond to the results of the analysis and the need to invest in road safety, a series of investment objectives were developed—each mapped to a key problem and benefit. A sample of the confirmed problems, investment benefits, and measures are outlined in **Figure 17**.

Figure 17: Auckland Road Safety Business Case: Problems, Benefits, Investment Objectives Example

Problems	Benefits	Investment Objectives of the programme
Problem one: Insufficient leadership and priority for road safety in policy and decision making has prevented the full delivery of a safe system	Benefit one: Sustained reduction in road deaths and serious injuries	1. Reducing road deaths and serious injuries **by 60% from 690 in 2017 to no more than 276 by 2028.**
Problem two: Unsafe roadside and street design increases speeds, the impact of small mistakes, and discourages healthy transport choices	Benefit two: Safe and healthy streets for everyone	2. Safe and Healthy streets for everyone evidenced by increasing PT and active mode use **from 16% (Journey to work mode share 2013) to at least 21% by 2028.** 3. Safe and Healthy Streets for everyone by improving health, emissions and social outcomes (measure and baseline to be developed). 4. A safe roadside and street environment by increasing the proportion of vehicles surveyed travelling within posted speed limits from XX% to XX% by 2028. Baseline to be established. 5. A safe roadside and street environment by increasing the proportion of the road

San Francisco Vision Zero Action Strategy

San Francisco's Vision Zero Action Strategy (San Francisco Municipal Transportation Agency, 2019) outlines the initiatives and actions that the city will take to advance Vision Zero. The strategy is organized into three key areas (**Figure 18**) that will need to be addressed in order to achieve its zero goal, and those key areas are routed in a foundation of equity, to ensure goal and initiatives do not exacerbate existing inequities.

Figure 18: San Francisco Vision Zero Action Strategy



The Action Strategy includes an analysis of San Francisco's high injury network (**Figure 19**) to ensure that programs are targeted toward where they are needed most.

Figure 19: San Francisco High Injury Network

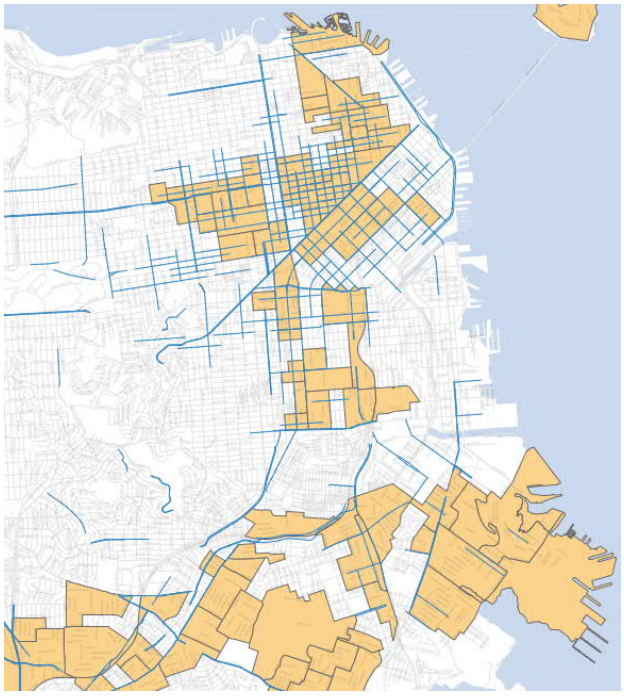


Figure 20 illustrates a sample strategic action for reducing traffic deaths in San Francisco, developed by San Francisco's city agencies and with input from community groups. These strategic actions reflect the city's continued commitment to stakeholder engagement.

Figure 20: San Francisco Vision Zero Sample Strategic Action

ACTION	TIME FRAME	LEAD AGENCY
PLANNING		
Develop and complete two neighborhood-specific safety/transportation plans by partnering with community organizations in two San Francisco neighborhoods.	2 years	SFMTA
Update Condition of Approval for new development to include transportation mitigation measures that advance transportation safety.	2 years	SF Planning
Develop guidance on culturally competent outreach based on past successful projects and train Sustainable Streets project managers.	2 years	SFMTA
Develop recommendations for pricing strategies that advance the San Francisco County Transportation Authority's (SFCTA) Mobility, Access and Pricing Study.	2 years	SFCTA
Evaluate effectiveness of five street safety improvements every year to develop best practices for safety.	2 years/ 5 years	SFMTA
Create and implement improved design policies for accessibility and protected bicycle facilities and present findings to the Mayor's Office on Disability (MOD), and the Multimodal Accessibility Advisory Committee (MAAC), key stakeholder partners that represent vulnerable populations.	2 years	SFMTA

Fremont Vision Zero 2025

The Fremont Vision Zero 2025 Status Report and Action Plan (City of Fremont, 2021) includes a progress report that summarizes the accomplishments that the city has made towards safer and more complete streets (e.g., Fremont has rebuilt five intersections as protected intersections and installed over 30 quick-build bulb outs) and highlights key projects (**Figure 21**). This plan builds on the Freemont Vision Zero 2020 Status Report and Action Plan (City of Fremont, 2016). This plan is a good example of a Vision Zero effort that provides monitoring and progress reporting on a regular basis.

Figure 21: Fremont Vision Zero Action Plan Accomplishments



LA County Vision Zero Plan

The LA County Vision Zero Action Plan (Los Angeles County, 2019) will help the County focus its efforts to eliminate traffic-related fatalities by 2035. **Figure 22** illustrates the guiding principles that direct decision-making for Vision Zero implementation.

Figure 22: LA County Vision Zero Guiding Principles



LA County conducted an extensive community engagement process as part of the Vision Zero Plan development that included the Los Angeles Traffic Safety Survey to better understand traffic safety concerns and experiences in unincorporated communities. **Figure 23** illustrates a few examples of the findings.

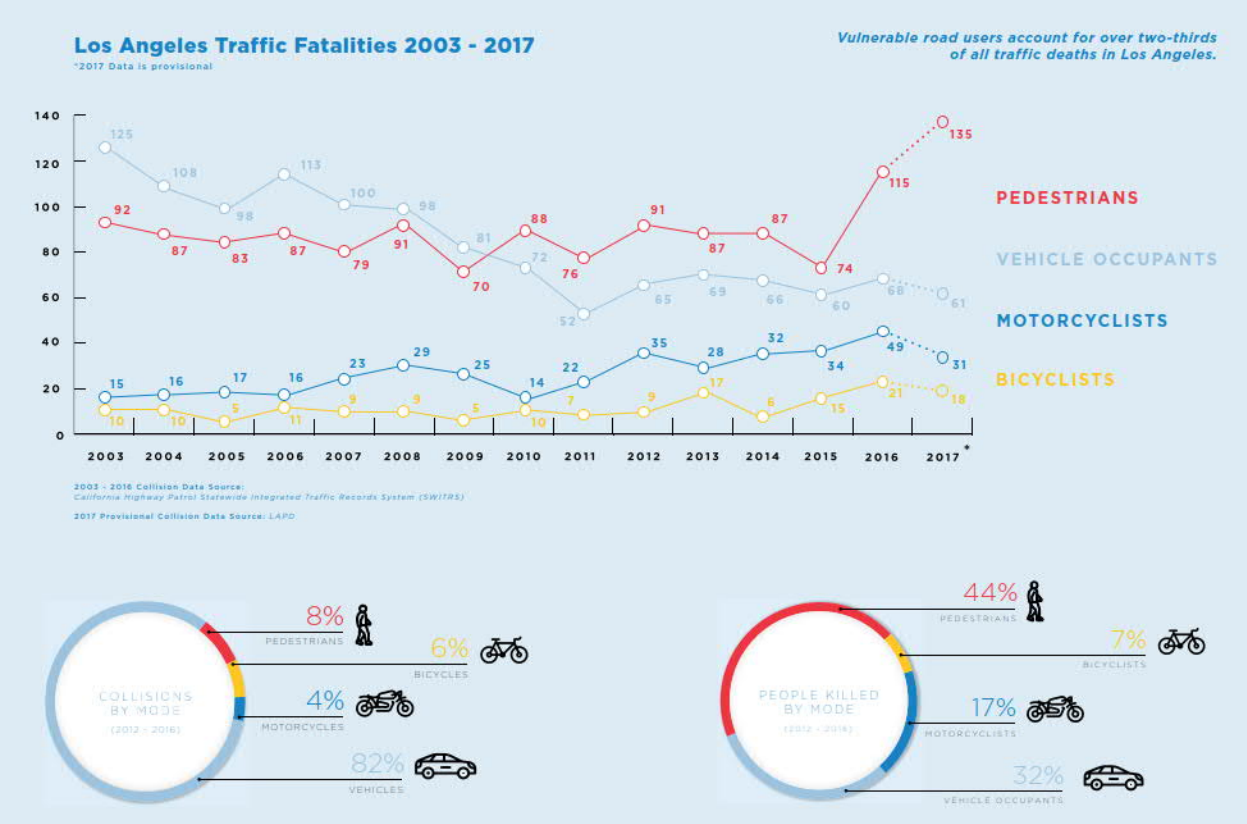
Figure 23: Los Angeles County Vision Zero Plan Traffic Safety Survey Findings



LADOT Vision Zero 2018 Action Plan

The 2018 Action Plan (Los Angeles County, 2018) was developed based on LADOT's Vision Zero Safety Study. The study found that the most vulnerable user is the pedestrian, and unsafe speed is the top contributor of collisions resulting in death. Through a collision and data analysis and a community prioritization effort, LADOT identified specific intersections and corridors within the High-Injury Network to target its Vision Zero efforts. **Figure 24** summarizes the key findings from the safety study.

Figure 24: Los Angeles County Fatalities



LADOT emphasized the importance of a road injury database that emphasizes cross-agency collaboration, frequent updates, and making data publicly available, as shown in **Figure 25**.

Figure 25: LA Vision Zero Database Development

Respond to Relevant Data				
Collision database	• Work with LAPD on a more streamlined hand-off of collision data; incorporate 2014–16 collision data to update the High-Injury Network.	• Continue to update the High-Injury Network annually.	• Expand collision data reporting to include weekly collision updates.	LADOT, LAPD, *LACDPH*
Using data	• Publish the top five traffic violations on the GeoHub. • Identify areas for education by LAPD's Community Relations Office and Community Traffic Services unit.	• Continue to add additional data overlays (e.g., race, ethnicity, income, alcohol outlet density, adjacent land use, crime hotspots)	• Expand use of GeoHub in Vision Zero project planning.	LADOT, *Mayor*
Consideration for data-driven enforcement strategy	• Emphasize traffic enforcement on major moving violations, especially those affecting youth and older adult victims; deploy enforcement and education units to high-risk intersections.	• Prioritize enforcement along High-Injury Network on the top collision factors that result in deaths and serious injury collisions.	• Reassess and prioritize enforcement along High-Injury Network on the top collision factors that result in deaths and serious injury collisions.	LAPD, LADOT *NOTE: Support agency in italics*

Figure 26 illustrates the extensive engagement strategy that LADOT employed to ensure an equitable and inclusive planning process—which included both public outreach and community engagement. LADOT focused on building genuine relationships with its community.

Figure 26: LA Vision Zero Engagement Strategy



Conclusion

Agencies recognize the value of data-driven decision-making to inform safety measures and improvements that can foster a safer road network and community. Many agencies have made significant strides towards collecting and analyzing safety data, leveraging data from a range of sources to ensure both a depth and breadth of crash data. These data are not only critical to form the basis of informed decisions to improve safety, but also to ensure that improvements are applied equitably.

With the right data, a range of analytic methods can be leveraged to better allocate resources where they are needed most and are likely to have the greatest impact. While most of the analysis is reactive to problem areas that have high crash rates, agencies are also exploring how to shift toward more predictive analyses—using predictive and risk models to prioritizes safety interventions. Agencies are evolving their methods and approaches as more data and tools become available.

The outputs of these analyses are being used to implement policy changes, improve enforcement, and implement design and engineering interventions to reduce KSI crash rates and improve overall safety for all transportation users. The public availability of many of these outputs is additionally democratizing the collection of safety data, simultaneously recruiting the public to supplement data and informing the public through accessible visualization. In line with the human-emphasis of a Vision Zero plan, this and other best practices outlined above form the basis of a safety data system focused on preserving the health and well-being of Bay Area communities.

Next Steps

This report will serve as the basis for subsequent tasks for this project, including:

- Supplying and customizing the mySidewalk platform for MTC's regional safety data system, including the prototype development and user testing
- Developing a State of Safety in the Region report to highlight the increasing safety problems in the San Francisco Bay Area, and increase the regional focus on safety

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