WSDOT Vulnerable Road User Safety Assessment

2023

Washington State Department of Transportation

Disclaimer

Disclaimer

Under 23 U.S. Code § 148 and 23 U.S. Code § 407, safety data, reports, surveys, schedules, lists compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential crash sites, hazardous roadway conditions, or railway-highway crossings are not 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.

A message from Roger Millar

As Secretary of the Washington State Department of Transportation (WSDOT), I continue to be concerned by the increasing trends in traffic fatalities and serious injuries on Washington's roads, especially for those who rely on walking and rolling as a means of transportation.

The numbers reported in this assessment on vulnerable road users represent lives lost and injured. They are our families, friends, and neighbors. Each tragic loss should instill a sense of urgency and a desire for a more proactive safety culture in Washington State.

Building upon Washington's Target Zero Strategic Highway Safety Plan, the Vulnerable Road User Safety Assessment presents a summary of the people, locations, and the contributing factors to crashes. It highlights the use of data to identify patterns and to understand and select strategies that will reduce the severity of crashes for vulnerable users and all travelers.

We need bold actions and change. We have adopted the Safe System Approach to road safety which recognizes that all people who use the state's roads should be treated equitably to be able to reach their destinations safely. It emphasizes the need to explicitly consider and address the needs of people walking, rolling, and biking in the planning, design and operation of the roadway system. When we make roads safer for those who have been made most vulnerable, we make roads safer for everyone.

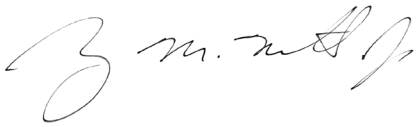
In the Safe System Approach people involved in every part of the system share responsibility to make our roads safer. This includes WSDOT's own staff, our safety partners in other agencies, emergency services and first responders, vehicle designers and regulators, and people using the roads and making decisions that affect the safety of others such as their driving speed. Everyone needs to work together to create a focused and sustained approach to safety. WSDOT is committed to actively engaging with all our partners and working proactively to reduce the frequency and severity of crashes.

In this values-based, evidence-informed assessment we evaluated socioeconomic and demographic factors in vulnerable road user crashes to better understand how equity influences road safety. We highlight our findings of overrepresentation in crashes among those in poverty, people of color, and where health disparities exist, and the assessment provides a method to identify and address these challenges.

The strategies and actions outlined for vulnerable road users in this assessment will rely heavily on reducing vehicle speeds to minimize injury potential and will move us towards creating a culture of safety within our respective safety disciplines and communities.

By working together with our partners and the public we can reverse the increasing crash trends and move towards our mutual goal of zero fatalities and serious injuries.

Sincerely,



Roger Millar, PE, FASCE, FAICP
Secretary of Transportation

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List of Acronyms

AADT	Average Annual Daily Traffic
CDC	Center for Disease Control
CPDM	Capital Program Development and Management
DEI	Diversity, Equity, and Inclusion
DOH	Department of Health
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
HSIP	Highway Safety Improvement Program
I-2	WSDOT Investment Category: Improvement Program - Safety Sub-Program
KA	KABCO injury classification for crashes: K = fatal crash, A = serious injury crash
MAP-21	Moving Ahead for Progress in the 21st Century Act. Now called Transportation Performance Management (TPM)
MIRE	Model Inventory of Roadway Elements
RCW	Revised Code of Washington
SHSP	Strategic Highway Safety Plan
TPM	Transportation Performance Management (formerly MAP-21)
VRU	Vulnerable Road User
WA	Washington state
WSDOT	Washington State Department of Transportation
WTSC	Washington Traffic Safety Commission

Vulnerable Road User Safety Assessment

Purpose

Washington State Department of Transportation's Vulnerable Road User Assessment is designed to assess the safety performance of Washington state regarding its plans to improve the safety of vulnerable road users as described under 23 U.S.C. 148(l) and in federal guidance dated October 21, 2022. This assessment is a value-based, data informed process to identify areas for potential strategies and countermeasures for vulnerable road users. For purposes of this assessment, vulnerable road users are people who are walking, rolling, or cycling. The term "pedestrian" includes people using a variety of small, human propelled and low powered personal conveyances or assistive devices such as wheelchairs and scooters that are not defined as bicycles in state law. WSDOT uses "walking and rolling" to be inclusive of the movements of people using these devices. The assessment does not include motorcyclists and data related to these important road users.

WSDOT is applying the Safe System Approach to road safety and is guided by Executive Order 1085.01: Road Safety – Advancing the Safe System Approach for All Users. Through Safe System implementation, WSDOT is developing roads that consider the context, modal priorities, and design and operating speeds of facilities in their design and operations, as well as in the selection and implementation of effective countermeasures to reduce the potential exposure, likelihood, and severity of crashes.

Introduction

Washington state's Strategic Highway Safety Plan (SHSP), Target Zero, sets a goal for zero motor vehicle-related deaths and serious injuries by 2030. Washington was the first state in the nation to set zero as its goal—the only acceptable number of deaths and serious injuries on Washington roadways is zero. To reach zero, partners continue to develop safety implementation strategies to reduce the exposure, likelihood, and severity of crashes. In Washington, while all crashes are important, WSDOT is leading a shift in focus toward eliminating the highest injury severities by changing the criteria for program and project selection.

WSDOT approaches safety management through planning based on analyzing crashes that result in deaths or serious injuries. Using evidence-based practices WSDOT develops an understanding of past, current, and potential future trends. Better understanding leads to proactive strategies that effectively and efficiently reduce the potential for fatal and serious injury crashes for all road users before they occur. Strategies address road characteristics, contributing factors, and social equity considerations. These characteristics and contributing factors form the basis for developing a screening tool based on a systemic approach, from which a ranked list of potential projects is derived.

Consistent with RCW 47.05: Priority Programming for Highway Development, WSDOT analyzes and evaluates projects based on benefits and costs. This allows the agency to prioritize and program projects that have the greatest potential to reduce fatal and serious crashes. This process is a vital component of project planning, development, and operations. Many high priority projects are proactive and systemic in nature.

With the combined fatalities and serious injuries among people walking, rolling, and biking increasing, proactive countermeasures are intended to reduce the potential for injury crashes before they occur. WSDOT recognizes that vulnerable road users operate in a variety of environments and contexts. This reality makes it critical to develop context-focused strategies and countermeasures that benefit everyone using the road regardless of mode and whether they are traveling along a Washington state highway, county/city road, or local street.

This report is intended to address the entire state, including both local and state-owned roads. The report attempts to address both interests equally but cannot because of data limitations. Further work is necessary to address these differences but is outside the scope of this assessment. The report will suggest potential strategies to address these challenges.

Safe System Approach

WSDOT recently updated its Safe System Executive Order. The update expands direction to the department divisions and regions and continues to emphasize proactive systemic safety improvements. WSDOT created three proactive subcategories that emphasize walking, rolling, and biking including speed management, active transportation, and intersections (e.g., compact roundabouts). Spot locations are also considered where they meet criteria identified in the Collision Analysis Location/Collision Analysis Corridor and Intersection Analysis Locations methods. When spot locations are considered, they undergo review by a safety panel focused on both modal issues and VRUs. These discussions commonly include providing sufficient separation of VRUs from vehicle traffic; whether VRUs are being subjected to high speeds; and how specially designed active transportation facilities for VRUs are being connected into a functional network.

WSDOT safety subcategories are intended to reduce large crash forces, recognizing the context and road users on the system. Under state law, priorities to address locations need to be consistent with RCW 47.05 requiring a priority programming approach based on factual need, evaluation of life-cycle costs and benefits, defined objectives, and available revenue. WSDOT is considering a proposal to set up a safety office with the goal of reducing fatal and serious crashes across all roads and programs.

The VRU Safety Assessment considered elements of the Safe System Approach throughout the analysis, with the intent that the strategy identification process would be consistent with the Safe System Executive Order. For example, the analysis evaluated posted speeds and the strategy identification process and includes countermeasures that support safe speeds within the Safe System context.

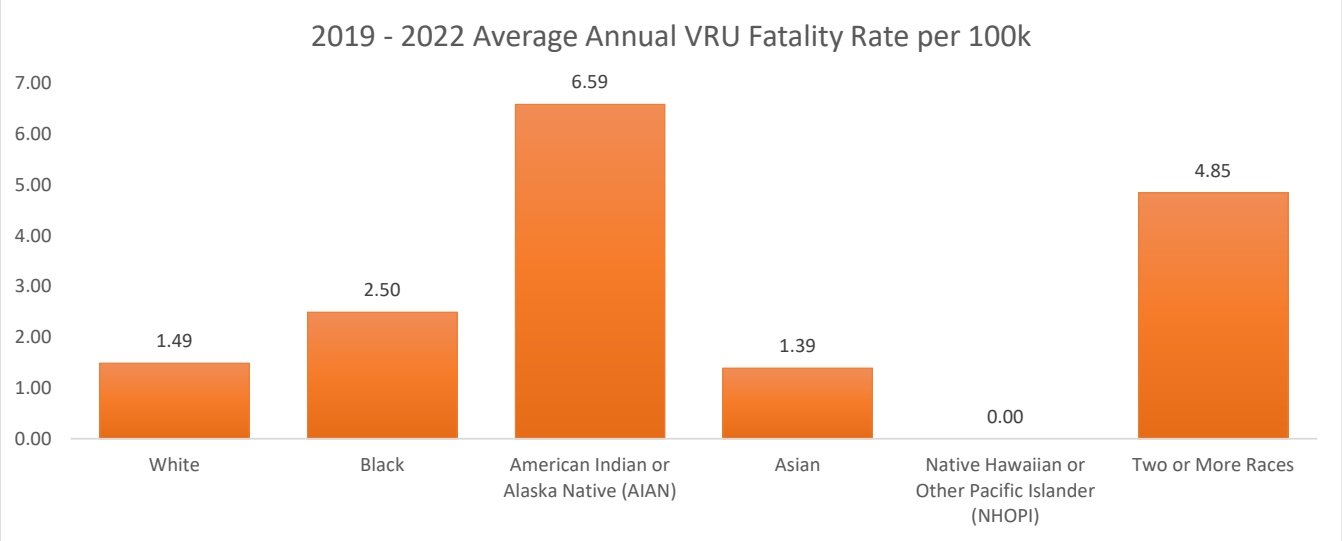
The assessment also documented how each strategy or countermeasure influences VRU crash exposure/conflicts, VRU crash frequency, and severity of VRU crashes (refer to Exhibits 17 - 20 on pp. 36-40). Findings from the assessment will support the proactive safety investment emphasized in the WSDOT Safe System Approach.

Equity

Considering equity as part of addressing VRU fatalities and serious injuries is critical to the success of WSDOT's efforts. WSDOT evaluated multiple socioeconomic/demographic variables associated with locations where fatalities and serious injuries were observed using correlation analysis (refer to Summary of Quantitative Analysis on p. 15). For people walking, rolling, and biking, more fatalities and serious injuries occur in areas with populations identified as socially vulnerable, historically disadvantaged, or experiencing persistent poverty. The analysis also showed how the fatality rates per 100,000 population for non-white groups can be as much as four times that of people identified as white (based on US Census categories; refer to Exhibit 1). Race/racial identification information is not available for serious injury data.

WSDOT assessed VRU fatal and serious injury crash densities alongside data from tools such as the USDOT Disadvantaged Communities, the CDC Social Vulnerability Index, the USDOT Areas of Persistent Poverty, and the Washington State Environmental Health Disparities Index. In each case, where these tools indicated the presence of disadvantaged populations, the locations were associated with higher vulnerable road user fatal and serious injury crash densities by census tract (all public roads) and for segments on the state highway network.

Exhibit 1. Washington state population-based fatality rates across race for people walking and biking (Source: Coded Fatality Crash files, WTSC; and Population Estimates, OFM)



Climate Change & Sustainability

During its 2023 session, the Washington State Legislature passed HB 1181 in an effort to improve the state's response to climate change by updating the state's planning framework. The bill is intended to help mitigate the impacts of climate change. A section of the bill requires multimodal transportation demand forecasts to inform the development of transportation plans. This will help plans balance

transportation system safety and convenience to provide safe, reliable, and efficient access and mobility for people and goods. This section recognizes the benefits of providing for modes that reduce emissions and promote transportation options. Importantly, the bill also states that transportation facilities and services providing the greatest multimodal safety benefit to each category of roadway user, for the context and speed of the facility, must be given priority. WSDOT recommended this bill language to correct a previous version that would have weighted safety concerns by number of recorded users, causing driver safety to be prioritized over vulnerable road users.

Complete Streets & Safety

The Washington State Legislature passed a transportation investment package in 2022 known as Move Ahead Washington. As part of that package, WSDOT was directed to apply Complete Streets approaches to projects on state routes over $500,000 beginning July 1, 2022. The criteria outlined in that directive in RCW 47.04.035 essentially define roadways that lack active transportation facilities and have characteristics that can lead to higher crash exposure, frequency, and severity for vulnerable road users. WSDOT moved rapidly to refine its processes for every stage of project development and updated the WSDOT Design and Traffic Operations Manuals to embed principles that align with the Safe System Approach, particularly safe speeds and safe roads.

Speed management for injury minimization, improved crossing treatments, separated or protected bike lanes, and other tools will be applied in future projects to carry out a Complete Streets approach that will advance safety for people walking, rolling, bicycling, accessing transit, and using other modes.

Consultation

Internal

WSDOT began internal agency consultation as a first step to gain support and understanding for the vulnerable road user safety assessment process. This included meeting with interested parties within the WSDOT Highway Safety Executive Committee and various agency divisions including Active Transportation, Project Development, Transportation Operations, and Local Programs. These groups and divisions were kept informed of the ongoing effort and had multiple opportunities to share, provide input, and review the progress throughout the process.

External

Washington Traffic Safety Commission
External consultation began with the Washington Traffic Safety Commission (WTSC), with individual meetings with leadership to discuss how the VRU assessment could be incorporated into WSDOT's update of the SHSP/Target Zero. This was an important step as WSDOT is aligning its SHSP to the Safe System Approach.

Washington State Cooper Jones Active Transportation Safety Council
On May 17, 2023, WSDOT also met with the Cooper Jones Active Transportation Safety Council (ATSC) to discuss the assessment and potential direction including incorporation of the equity component of the assessment. The ATSC serves in an advisory role to identify data gaps, study issues, and make recommendations to the legislature; for this effort they represent a statewide group that provides external input. At the ATSC meeting WSDOT provided preliminary results on the potential risk-based assessment method being developed.

Metropolitan Planning Organizations/Regional Transportation Planning Organizations
WSDOT met with the metropolitan planning organizations (MPOs) and regional transportation planning organizations (RTPOs) to discuss the VRU assessment on February 21 and August 8 of 2023 with the technical committee. In both meetings, the technical committee provided input on potential variables associated with crashes, as well as concerns with VRU speed-setting policies.

On May 9, 2023, a presentation was made to the WSDOT/MPO/RTPO Coordinating Committee This meeting highlighted consistency with the federal requirement as outlined in the Infrastructure Investment and Jobs Act. WSDOT discussed the purpose of assessing performance to identify areas for further analysis, and for identifying strategies to reduce or prevent fatal and serious injury crashes. At all meetings with MPOs/RTPOs, WSDOT outlined current performance, the people involved in the crashes, the potential improvements to crash reports, the types of crashes involved, socioeconomic considerations, and findings of the assessment.

Governor's Public Performance Review
WSDOT also presented to the Governor's Public Performance Review meeting on June 28, 2023, and discussed the vulnerable road user assessment at a high level. The presentation highlighted the value of potential speed safety cameras, challenges created by how crash data is collected related to vulnerable road users, and how the Safe System Approach could benefit all road users.

Strategic Highway Safety Plan Partners Meeting
WSDOT provided a detailed presentation on the VRU assessment at the SHSP partner's meeting on September 27, 2023. This was part of a two-day meeting to kick off the update for the 2024 Target Zero Plan. The presentation included discussion and feedback on the social equity component of the VRU assessment and findings from the assessment.

Data-informed Assessment

Consistent with Washington's Active Transportation Plan and WSDOT's approach to minimizing vulnerable road user crashes, 10 years of crash data are analyzed. Although overrepresented among fatal and serious injury crashes relative to users of other modes, vulnerable road user crashes are often dispersed, and the crash totals generally do not provide enough data points to allow reliable statistical analysis over a shorter time frame. The analysis focused on crashes where one or more person walking or biking were killed or seriously injured in a reported motor vehicle crash, referred to as VRU KA

crashes from hereon. The decision to focus on the fatal and serious injury crashes was part of the FHWA requirements for this safety assessment.

WSDOT's 10-year approach provides a larger, more robust dataset that allows for trends to be better understood. The agency recognizes that 10 years can introduce some anomalies when locations undergo change, but WSDOT's approach was to first cut the data, then perform secondary analysis for the selection of countermeasures.

Based on the SHSP, the data analysis and evaluation focused on crashes involving vulnerable road user fatalities and serious injuries and a motorized vehicle. Crash data is only available for vehicle/pedestrian and vehicle/bicyclist, not pedestrian/bicyclist or bicyclist/bicyclist crashes[1]. The data used in the assessment cover factors such as crash type, crash contributing factors, sociodemographic and equity characteristics, level of traffic stress for active transportation, and sidewalk and roadway characteristics.

The analysis followed a two-pronged approach: a statewide, all public roads review at the census tract level and a more in-depth review of the state highway network. The choice to perform two separate analyses was driven by the availability of data for analysis. For example:

- Detailed segment level information is not available for roadways other than state highways, limiting the statewide analysis of all VRU KA crashes to census tract level approaches. A systemic analysis of state highways was however completed because the segment level information are available for this portion of the network.
- Crashes are coded to the linear referencing system of state highways but only as coordinates for other roadways: non-state highway crashes therefore cannot be associated with specific segments, other than manually and this could not be accomplished on this assessment for the entire state. Other associated roadway characteristics on the non-state highway system are also not available, a necessity for systemic analysis.
- WSDOT does not currently maintain a database for intersection characteristics, so the analysis cannot consider intersection characteristics when analyzing the state highway network. The analysis relied on various crash data fields to identify, to the extent possible, which crashes were associated with an intersection and which crashes were associated with a segment. An effort is underway to collect intersection characteristics as part of the MAP21 MIRE requirements for 2026 and for improved intersection analysis.

The more detailed segment information available at the state highway level enabled characteristics to be identified that are more likely to be associated with higher densities of VRU fatal and serious injury

*Note: **1** While WSDOT does not currently have full access to EMS, hospital, or trauma data, Washington has shown leadership in studying how this data can be accessed by interested parties. In part, this effort led to a National Cooperative Highway Research Program Project NCHRP 17-120, A Method to Link Crash, Emergency Medical Service, and Trauma Registry. Another study in Washington looked at Emergency Records and Micromobility Crashes. WSDOT is also funding a study with Portland State University on understanding of the exposure rate based on VRU usage.*

crashes, a systemic analysis. An additional analysis using numerous crash data fields in the WSDOT Engineering Crash Datamart enabled the development of a set of crash types for crashes involving people walking or rolling and those involving people biking. Refer to Custom Crash Types for Pedestrians and Bicyclists (Exhibits 11 and 12) for more information.

Value-based, data informed safety analysis helps engineers to identify characteristics more likely to be associated with VRU fatalities and serious injuries, areas of focus, crash types, and countermeasures. The analysis approach is used to maximize the value of investments for projects, programs, and activities related to WSDOT's implementation of the Safe System Approach.

Fortunately, efforts to reduce exposure to potentially fatal or serious injuries for the most vulnerable road users lead to effective strategies for not just the VRU, but vehicle drivers as well. This represents a shift from modal-based selection to focus on the most effective countermeasures to reduce crash exposure for everyone.

This change is an evolution from a system oriented primarily around modes or numbers of specific types of users and was highlighted in Washington's SHSP (refer to Target Zero 2019, p. 194).

Overview of Vulnerable Road User Safety Performance

Historical trends

Exhibit 2 and Exhibit 3 illustrate the pedestrian and bicyclist fatalities and serious injuries in Washington state from 2013 to 2022. Unfortunately, pedestrian fatalities in 2022 were 141% higher than in 2013 based on the 2022-year end data file; serious injuries among those walking or rolling have also increased by 22% since 2013. Fatalities among those biking have remained stable since 2013 but fatalities among those rolling was 73.2% higher in 2022 compared to 2013.

Pedestrian fatalities in 2022 were 141% higher than in 2013.

Exhibit 2. Pedestrian and Bicyclist Fatalities in Washington State (Source: Preliminary fatality data from Coded Fatality Files (WTSC) (Dec. 2022)

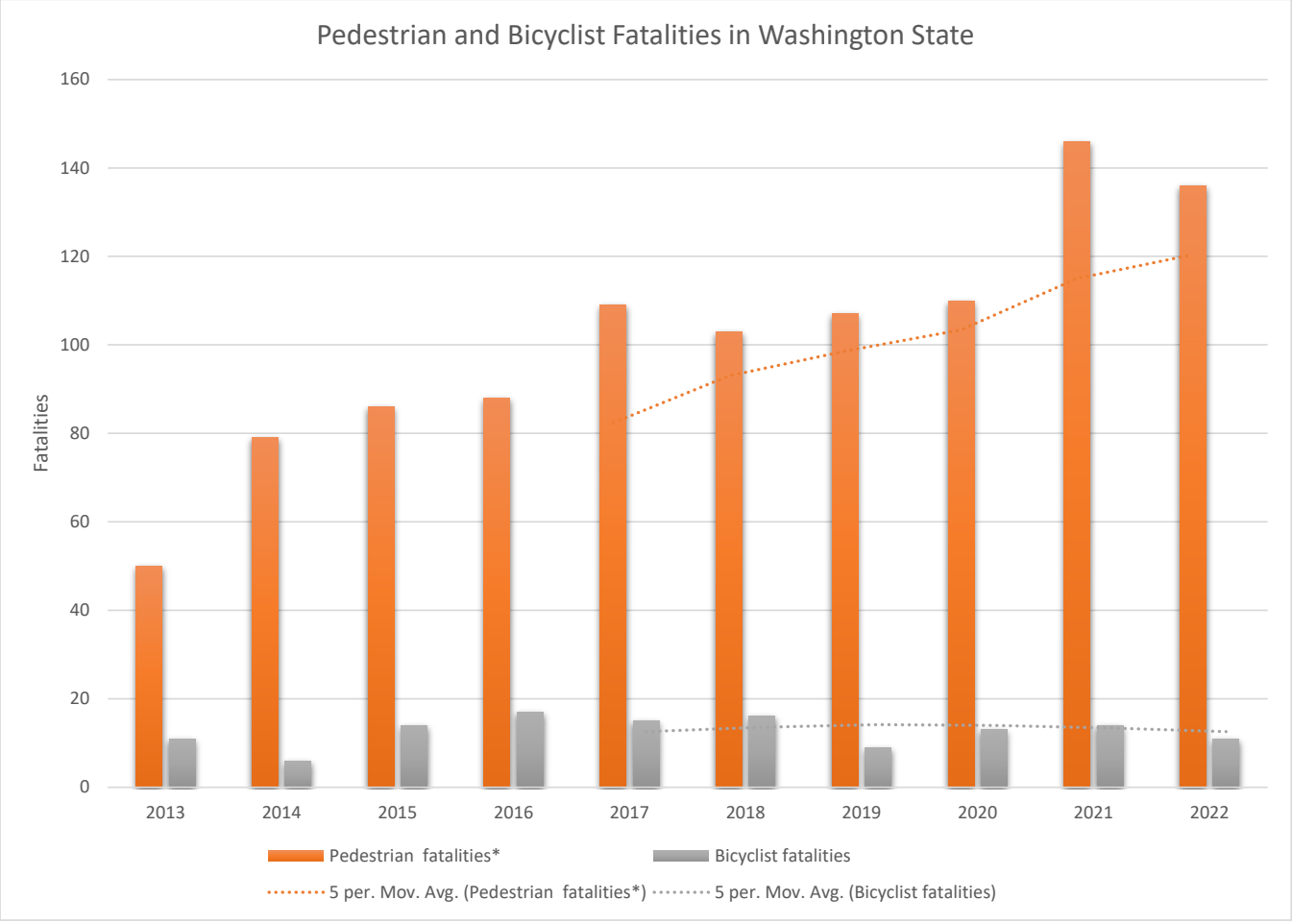
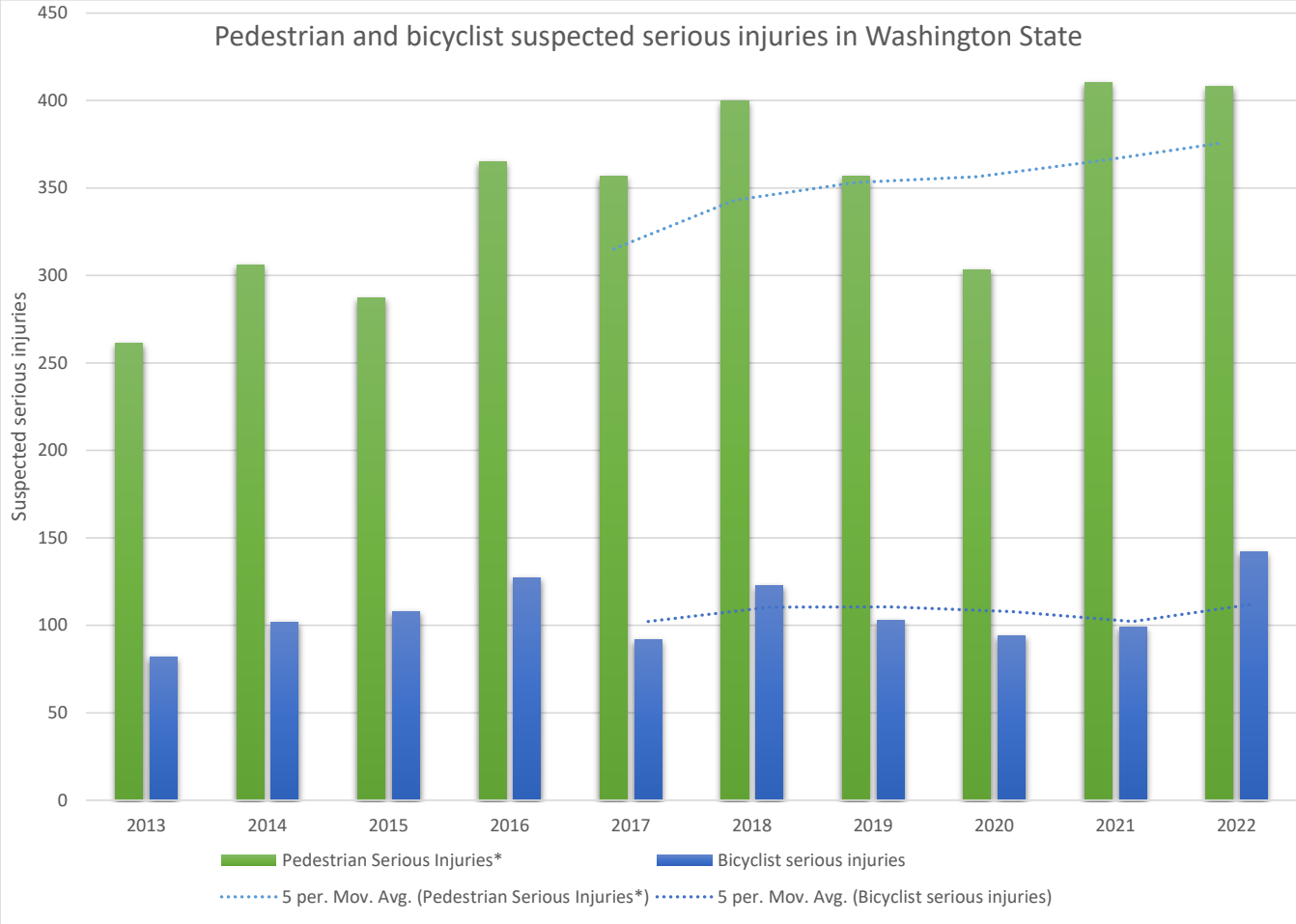
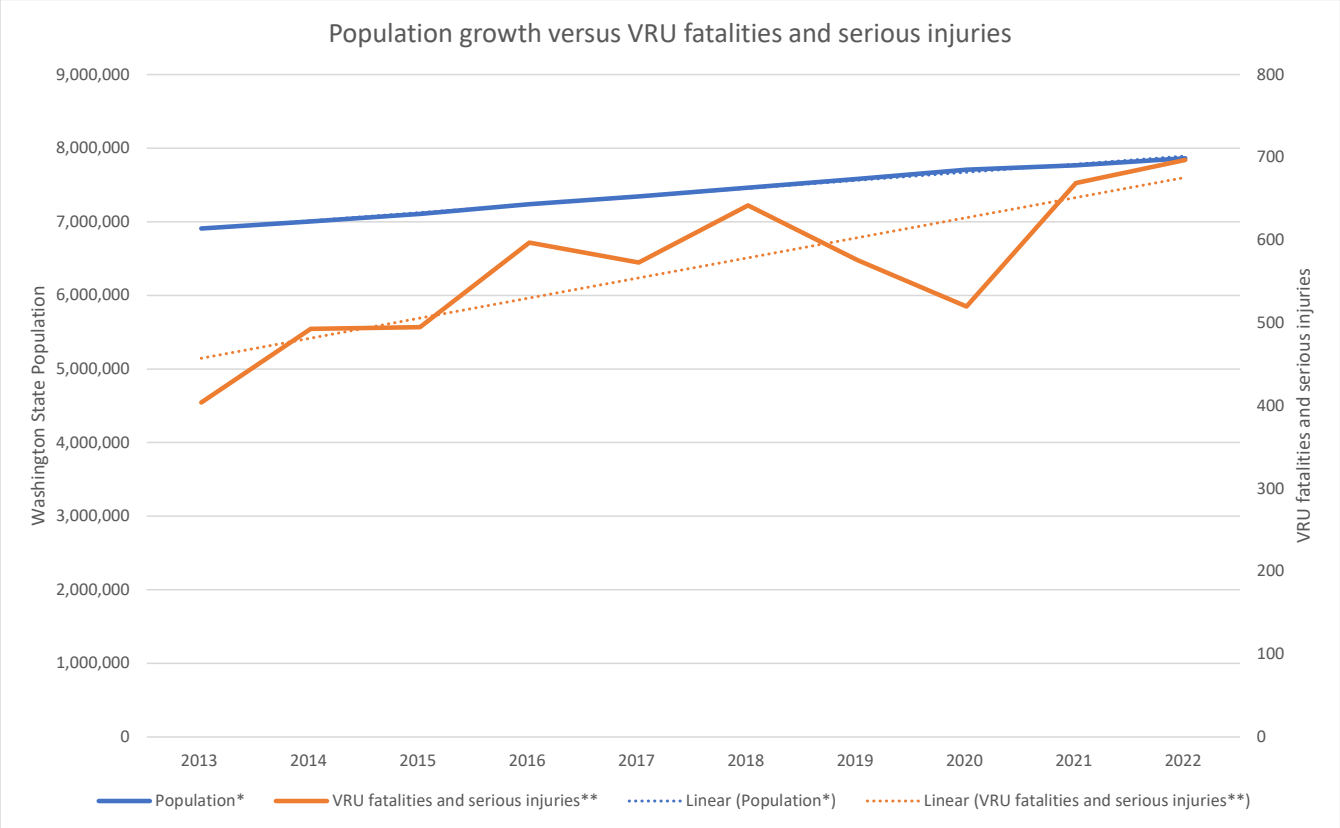


Exhibit 3. Pedestrian and Bicyclist Suspected Serious Injuries in Washington State (Source: Crash data from WSDOT Engineering Crash Datamart, Year-end snapshot 2022, May 2022



Using population growth to understand potential increases in pedestrian volumes, it is noted that the fatalities and serious injuries among VRUs have increased faster than the population growth in Washington since 2013, as shown in Exhibit 4. The 2021 State Active Transportation Plan noted that population growth alone cannot explain the steady increase in fatalities. The ATP also compared mode use with data from the National Household Transportation Survey in 2009 and 2017 and noted that increases in commute trips by walking or bicycling grew faster than population growth. In addition, while not counted as a separate trip, in 2017 approximately 85 percent of public transportation users in Washington reported walking or bicycling to access transit.

Exhibit 4. Population growth versus VRU fatalities and serious injuries (Source: Preliminary fatality data from Coded Fatality Files (WTSC) (May 2023 Preliminary Data; serious injury data from WSDOT Engineering Crash Datamart, 2022 year end; and population data from WA OFM)



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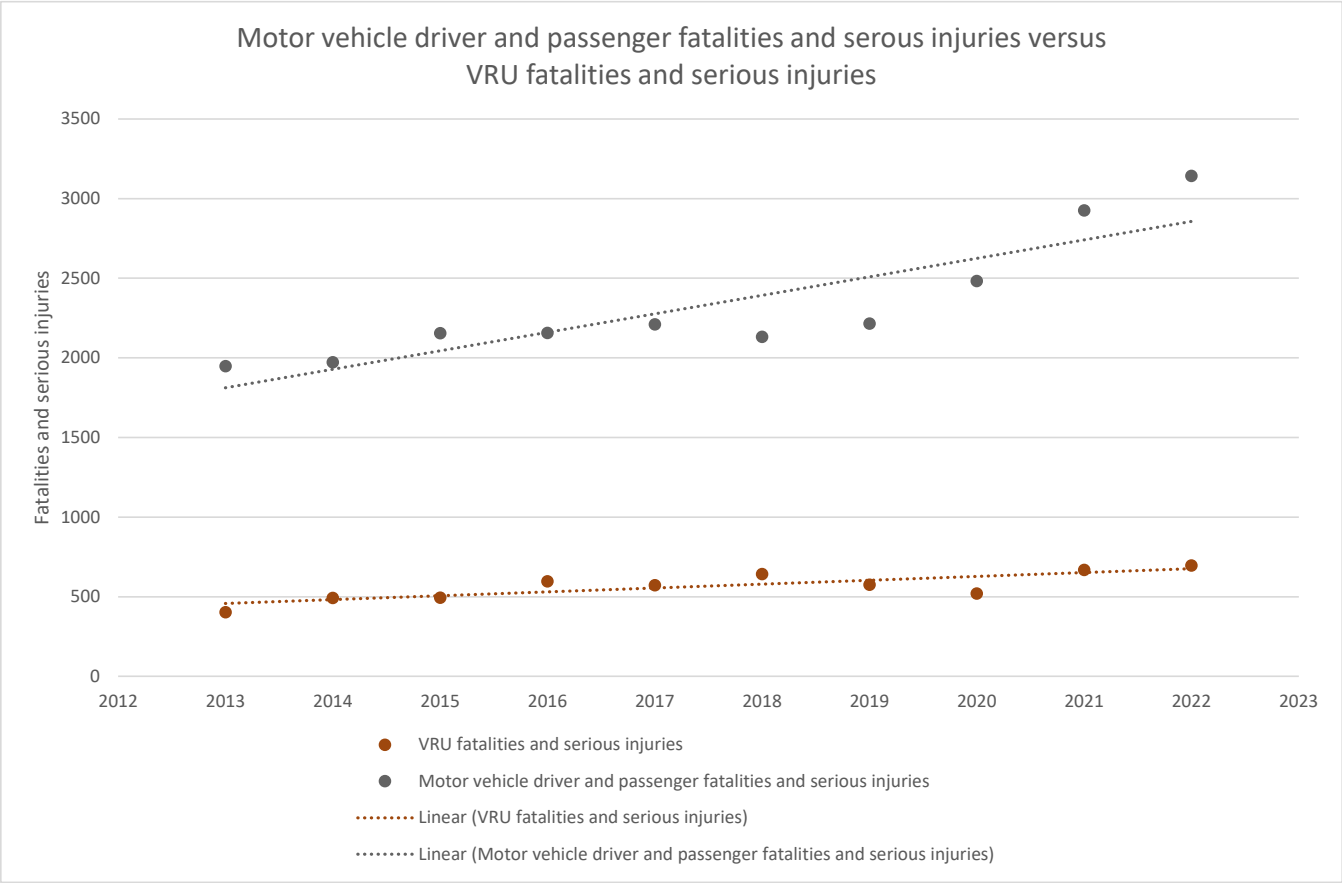
When comparing the fatalities and serious injuries for motor vehicle drivers and passengers over time with that of VRU fatalities and serious injuries, it is evident that fatalities and serious injuries among drivers and passengers have increased at a slightly faster rate than the VRU fatalities and serious injuries in terms of total fatalities and serious injuries, refer to Exhibit 5. Yet, as noted earlier, VRUs have seen a 72.5% increase in fatalities in this timeframe. WSDOT remains optimistic that the fatality and serious injury spikes from behavioral issues such as extreme speeding and impairment will drop below pre-pandemic levels but has not immediately seen changes in 2022. This points to the importance of implementing the mitigating measures of the Safe System Approach.

Exhibit 5. Statewide comparison between the motor vehicle driver and passenger fatalities and serious injuries and VRU fatalities and serious injuries (Source: Preliminary fatality data from Coded Fatality Files (WTSC) (May 2023 Preliminary Data; serious injury data from WSDOT Engineering Crash Datamart, 2022 year end)



WSDOT has set a target of zero fatal and serious injury crashes by 2030. Current trends make it unlikely that the state can achieve this goal in that time frame. In discussions with the Washington Traffic Safety Commission, the focus has been on identifying bold actions needed to reduce fatal and serious injury crashes. Safety agencies are working together to develop these actions. However, given the aspirational nature of WSDOT's target setting, it has failed to meet targets or make significant progress as defined by FHWA.

Exhibit 6 summarizes the progress the state of Washington has made for each of the Transportation Performance Management (MAP-21) safety performance measures. Fatalities and serious injuries among VRUs make up 22.2% of all road user fatalities and serious injuries when considering fatalities and serious injury counts for 2022.

Exhibit 6. Statewide Summary of Significant Progress for TPM Safety Performance Measures: 2018 through 2022

Performance Measure	Target: 2018-2022 rolling average	Outcome: 2018-2022 rolling average	Baseline: 2016-2020 rolling average	Target/ Baseline Met?	Significant progress?
Number of fatalities	440	615.00	550	No/No	No
Rate of fatalities per 100 million VMT on all public roads	0.735	1.049	0.919	No/No	No
Number of serious injuries	1819	2585.8	2271.2	No/No	No
Rate of serious injuries per 100 million VMT on all public roads	3.042	4.412	3.797	No/No	No
Number of non-motorized fatalities and serious injuries	464.6	620 .8	581.6	No/No	No

Summary of Quantitative Analysis

Data and Methodology

The Washington VRU Safety Assessment used data from 2013 through 2022, a 10-year period. The analysis used crash data from the WSDOT Engineering Crash Datamart and the Washington State Coded Fatality Files from the Washington Traffic Safety Commission, and only crashes which resulted in a vulnerable road user death or serious injury were included. The assessment leveraged sociodemographic and equity data at the tract level and was supplemented with segment data (such as posted speed, number of lanes, and cross-section) for the state highway analysis. WSDOT does not currently have an intersection database and is taking actions to collect this information as part of the upcoming MIRE requirements from MAP-21 (TPM).

The first step in the analysis was a statewide review of factors describing people, place, and context for the crash. These include population characteristics, race, age, time of day, equity, and sociodemographic metrics referred to in the FHWA Guidance for Vulnerable Road User Safety Assessments, and the Environmental Health Disparity Index v.2.0 from the Washington Department of Health. The analysis also included the Social Vulnerability Index of the Centers for Disease Control; various USDOT metrics such as the Disadvantaged Communities Sum of Scores and Transportation Disadvantaged Score, Areas of Persistent Poverty, Historically Disadvantaged Communities, the USDOT Travel Barriers Score, and the red line indicator.

The second step was to develop a custom set of crash types for pedestrians and bicyclists, respectively. This was necessary as the current crash reporting form and system do not provide for detailed crash typing but rather only identify crashes as involving a pedestrian or bicyclist. The crash types developed for this purpose will help WSDOT identify potential countermeasures.

The third step was to study and assess the equity and sociodemographic information for the state and to use this knowledge to develop a custom and WSDOT-Specific VRU DEI score that can be used to prioritize or screen locations on state highways for further analysis or investments or for informing grant program technical assistance and decision making. This custom score was discussed throughout the department and with interested parties as part of the collaboration process.

The fourth and last step was the review of the state highway network across a multitude of factors to identify characteristics associated with higher VRU fatal and serious injury crash densities per mile than others. Factors reviewed included, for example:

- Environmental Health Disparity Index v.2.0 (WA DOH)
- Social Vulnerability Index (CDC)
- Disadvantaged Communities Sum of Scores (USDOT)
- Transportation Disadvantaged Score (USDOT)
- Areas of Persistent Poverty (USDOT)
- Historically Disadvantaged Communities (USDOT)
- Travel Barriers Score (USDOT)
- Red line indicator (USDOT)
- Posted speed limit
- Number of lanes
- Federal functional class
- Urban versus rural status
- Proximity to highway urbanized areas, cities, population centers, urban growth boundaries, schools, transit stops
- Presence of sidewalks
- Tribal lands
- Urban areas
- Jurisdiction
- AADT

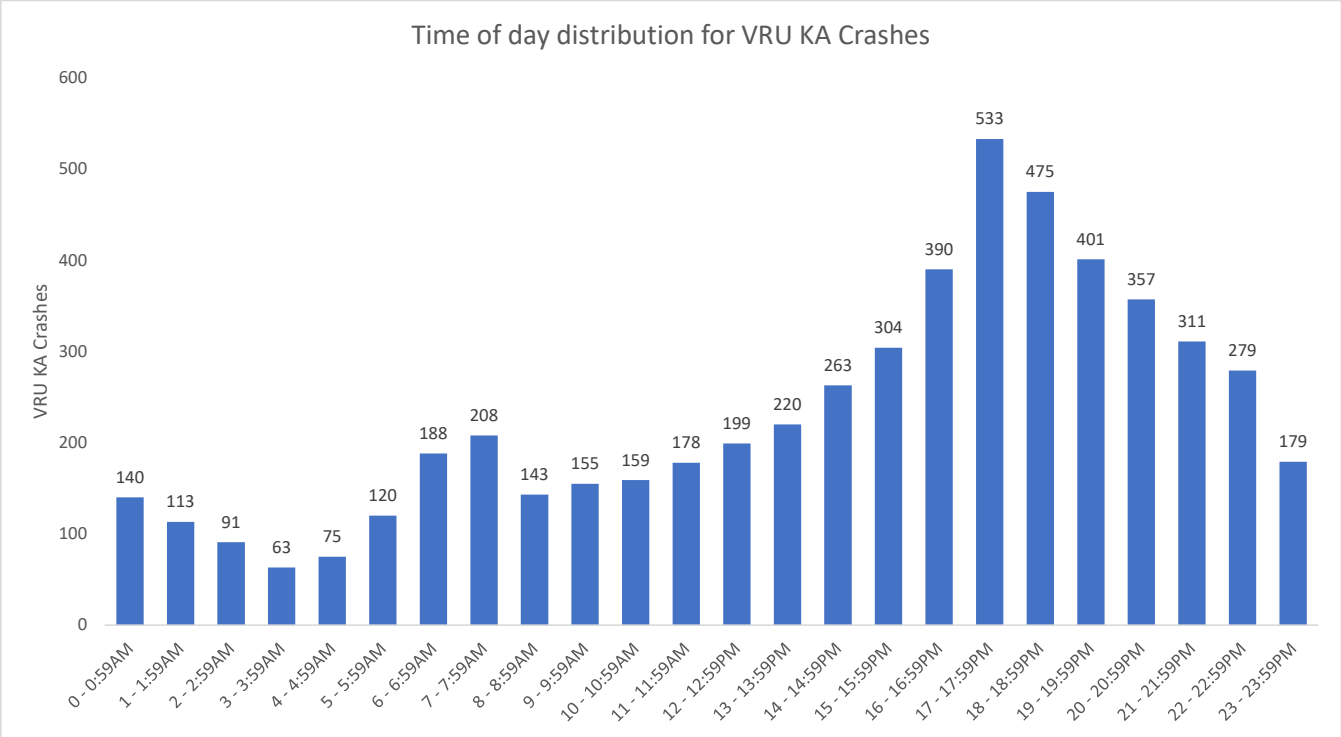
Findings

The VRU Safety Assessment included an in-depth analysis of crashes on all public roads by census tract and then state highways. The following sections summarize some of the highlights of the analysis.

Time of Day

Exhibit 7 provides the time-of-day distribution for VRU fatal and serious injury (KA) crashes. There is a slight peak from 5-8 a.m. and then a higher peak around 5-6 p.m. The morning and evening peak periods are more pronounced for pedestrian KA crashes than they are for bicyclist KA Crashes.

Exhibit 7. Time of day Distribution of VRU KA Crashes Statewide (WSDOT Engineering Crash Datamart, 2022 year end)



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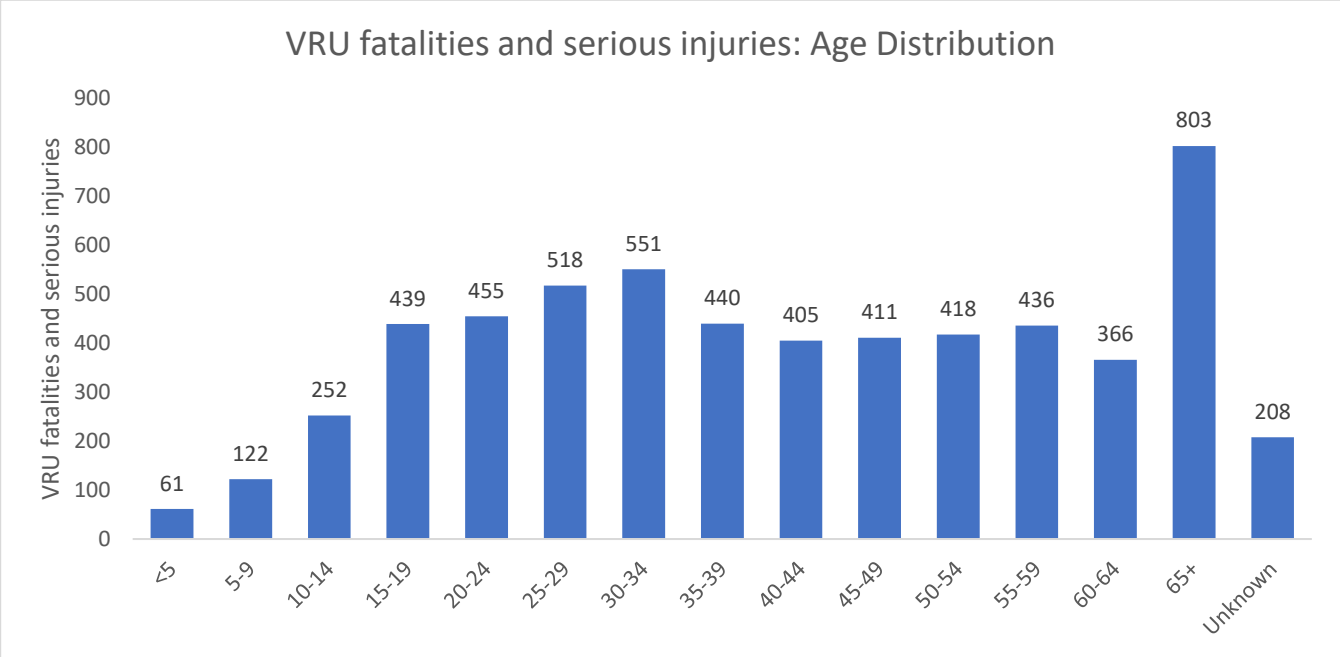
Age

The age distribution for VRU fatalities and serious injuries differs slightly between pedestrians and bicyclists but all age groups are affected by these injuries. Exhibit 8 shows the distribution of VRU fatalities and serious injuries across the different age groups.

People older than 65 represent the age group with the highest number of crashes resulting in deaths and serious injuries.

Exhibit 8. Statewide Age Distribution of VRU fatalities and serious injuries (WSDOT Engineering Crash Datamart, 2022 year end)



Contributing Factors

The sections below summarize the prevalence of aberrant behaviors identified by the reporting officer as part of the crash report form for VRU KA crashes. The intent of the section is to provide insights into factors that may or may not have contributed to these crashes, possible countermeasures, and the likelihood that these countermeasures may minimize future crashes. It is important to note that impairment, distraction, and speeding factors are underreported in crash report forms. For example, NHTSA reports that only 44% of the drivers in fatal crashes in 2021 had known BAC levels in Washington state (Traffic Safety Facts 2021 Data: State Alcohol-Impaired-Driving Estimates (dot.gov)).

Alcohol/drugs for VRU-KA crashes

- 12.2% of the VRU KA crashes involved one or more road user impaired by alcohol/drugs
- 5.92% of the drivers in VRU KA crashes were impaired by alcohol/drugs
- 7.03% of the pedestrians in VRU KA crashes were impaired by alcohol/drugs
- 2.69% of the bicyclists in VRU KA crashes were under the influence of alcohol/drugs

Distraction

- 20.22% of the drivers in VRU KA crashes were distracted
- 13.94% of the pedestrians in VRU KA crashes were distracted
- 15.87% of the bicyclists in VRU KA crashes were distracted

Failure to use crosswalk

- 7.67% of the pedestrians in VRU KA crashes failed to use the crosswalk (WSDOT has not individually verified if a crosswalk was available)

Disregarded stop and go light (traffic signal)

- 0.78% of drivers in VRU KA crashes disregarded the stop and go light.
- 1.13% of pedestrians in VRU KA crashes disregarded the stop and go light
- 3.53% of bicyclists in VRU KA crashes disregarded the stop and go light

Failure to grant right of way

- 17.17% of drivers in VRU KA crashes did not grant right of way to the VRU
- 17.43% of pedestrians in VRU KA crashes did not grant right of way to the vehicle
- 18.72% of bicyclists in VRU KA crashes did not grant right of way to the vehicle

Speeding

- In 3.3% of the VRU KA crashes the driver exceeded the speed limit or exceeded reasonable safe speeds
- 2.06% of drivers in VRU KA crashes were exceeding reasonable safe speeds and 1.24% exceeded the speed limit

Hit and run

- 16.4% of the VRU KA crashes were hit-and-run crashes

Equity and Demographics

WSDOT performed an in-depth investigation into each of the equity measures listed in the guidance for VRU safety assessments issued by FHWA.

Some of these metrics consisted of multiple variables or what is more commonly known as an index. WSDOT wanted to view each of the metrics/indexes independently, including whether WSDOT had the data accessible, and whether the data was useful in the equity analysis in the Washington context. WSDOT's initial review also considered whether the equity metric/index was correlated to VRU fatal and suspected serious injury rates by 100 thousand people population for Washington Census Tract (a population grouping used for planning purposes) and VRU crash densities (how many crashes occur on state highways per mile).

After review of the FHWA metrics/indices, WSDOT also reviewed a number of Washington state proposed indices. With multiple indices, WSDOT was concerned that variables in different metrics/indices overlapped, meaning that more that more than one metric/index had the same input variable

which would lead to overcounting the value of a particular variable in comparison to a different but equally important variable that did not overlap. To avoid this overcounting, WSDOT recommended in its outreach, a Washington Specific VRU DEI score be calculated as the maximum value of any of the following as shown in Exhibit 9:

Exhibit 9. Selection of Statewide Washington-specific VRU DEI scores from existing metrics

Variable	Variable scoring
If Area of Persistent Poverty (USDOT)	0= no, 10 = yes
If tribal land	0= no, 10 = yes
Social Vulnerability Index (CDC)	A score of 12 converted to a score out of 10
Environmental Health Disparities Index (WA DOH)	1 to 10
Disadvantaged Communities score (USDOT)	1 to 10
Using census tracts, using range of highest and lowest values divided in equal parts to create a score out of 10 for school density.	1 to 10
Using census tracts, using range of highest and lowest values divided in equal parts to create a score out of 10 for transit stop density.	1 to 10
Using census tracts, using range of highest and lowest values divided in equal parts to create a score out of 10 for transit route mileage density	1 to 10

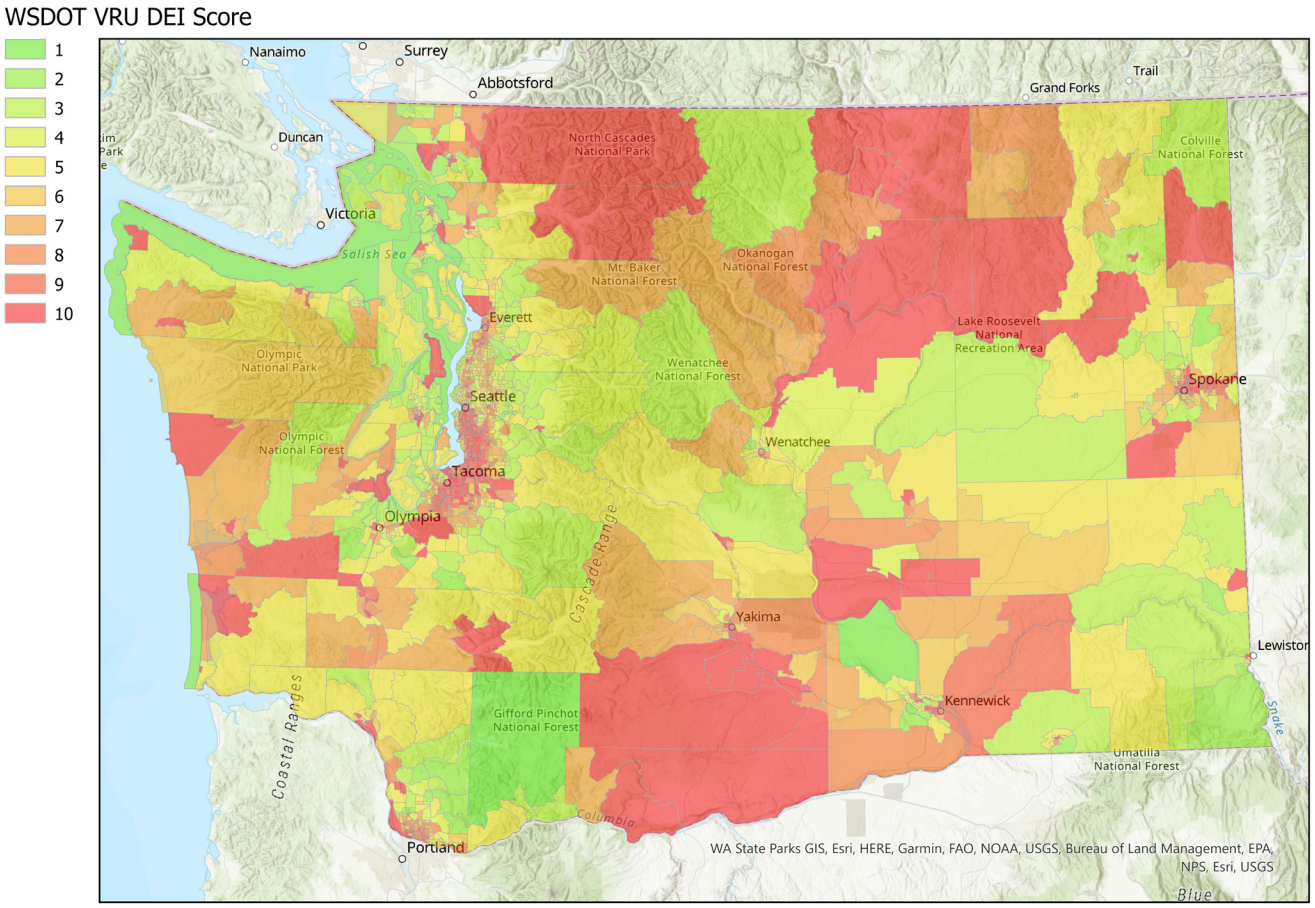
In other words, if a census tract scored high on any of the listed variables above, that became the variable used as its equity metric, the Washington-specific VRU DEI score.

Washington's custom VRU DEI score is strongly correlated with VRU KA crash density per mile.

WSDOT proposed that tribal lands receive a high score (10) given the disproportionate rate of fatalities as outlined by our Active Transportation Plan, other studies within Washington, and as substantiated in this assessment. WSDOT notes that the score of 10 for tribal land was higher than other indices provided for tribal lands.

WSDOT used different variable weights to test different scenarios before finalizing its recommended method of selecting a maximum score of 10. Included in the equity assessment were school density, transit stop density and transit route mileage density. These variables were included to indicate that walking and rolling to transit and schools in lower income communities is an equity consideration as an affordable form of transportation, and one that may increase crash exposure. The next step was to use the scores of each index as an individual variable in the Washington-specific DEI score. Each of the six variables shown were independently correlated to VRU crashes. Exhibit 10 shows a map of Washington-specific VRU DEI scores.

Exhibit 10. Statewide WSDOT Vulnerable Road User DEI score per census tract



This Washington-specific VRU DEI score was assessed for correlation with VRU KA crash and injury metrics. WSDOT found that the custom VRU DEI score is strongly correlated with VRU KA crash density. This Washington-specific VRU DEI score can be considered to support systemic analysis, screening, and prioritization of locations for analysis and/or investment.

Custom Crash Types for Pedestrians and Bicyclists

As part of the VRU Safety Assessment WSDOT developed custom crash types for pedestrians and bicyclists for use in analysis and countermeasure selection. The purpose of the crash typing was to identify location type (segment or intersection), pedestrian or bicyclist action, driver action, etc. that could help support analysis and countermeasure selection. Exhibits 11 and 12 provide this custom crash typing based on currently available data fields from the WSDOT Engineering Crash Datamart along with distribution for each group of crashes. Note that the "Other" category is a compilation of crashes that could not be categorized in the listed crash types, and that the counts and metrics provided are statewide for the 10 years from 2013 through 2022.

The most common crash type for both pedestrians and bicyclists was crossing movements on segments and drivers going straight.

Exhibit 11. Custom Pedestrian Crash Types developed for Statewide VRU KA analysis and countermeasure selection; 2013-2022, 10-year total (VRU KA Crash Data Source: WSDOT Engineering Crash Datamart, 2022 year-end)

VRU Custom Pedestrian Crash Types	Number of Pedestrian KA Crashes	Percent of total Pedestrian KA Crashes (%)
No signal/traffic control: Pedestrian not crossing at crosswalk & driver going straight	865	19.87%
No signal/traffic control: Pedestrian crossing at crosswalk & driver going straight	484	11.12%
At signal: Pedestrian crossing at crosswalk & driver going straight	368	8.45%
At signal: Pedestrian crossing & driver turning left	356	8.18%
Pedestrian walking in roadway (not crossing) & driver going straight	356	8.18%
Standing or working in roadway	203	4.66%
No signal/traffic control: Pedestrian crossing & driver turning left	185	4.25%
Not in Roadway	170	3.91%
At signal: Pedestrian Crossing & driver turning right	117	2.69%
Pedestrian walking on shoulder (not crossing) & driver going straight	117	2.69%
No signal/traffic control: Pedestrian crossing & driver turning right	60	1.38%
Pushing or working on vehicle	49	1.13%
At signal: Pedestrian not crossing at crosswalk & driver going straight	40	0.92%
Other	983	22.58%

Exhibit 12. Custom Bicyclist Crash Types developed for Statewide VRU KA analysis and countermeasure selection; 2013-2022, 10-year total (VRU KA Crash Data Source: WSDOT Engineering Crash Datamart, 2022 year-end)

VRU Custom Bicyclist Crash Types	Number of Bicyclist KA Crashes	Percent of total Bicyclist KA Crashes (%)
No signal/traffic control: Bicyclist crossing and driver going straight	191	16.05%
Bicyclist riding along roadway and driver turning left	171	14.37%
Bicyclist riding along roadway and driver going straight	130	10.92%
Bicyclist riding along roadway and driver turning right	86	7.23%
Bicyclist riding along roadway and driver not going straight or turning left or right	81	6.81%
At signal: Bicyclist crossing and driver going straight	74	6.22%
Bicyclist turned into path of vehicle, same direction, driver going straight	74	6.22%
Bicyclist riding along shoulder and driver going straight	58	4.87%
Bicyclist turned into path of vehicle, opposite direction, driver going straight	31	2.61%
At signal: Bicyclist crossing and driver turning right	23	1.93%
Bicyclist riding along designated bike route and driver going straight	23	1.93%
At signal: Bicyclist crossing and driver turning left	21	1.76%
No signal/traffic control: Bicyclist crossing and driver turning left	19	1.6%
No signal/traffic control: Bicyclist crossing and driver turning right	18	1.51%
Other	190	15.97%

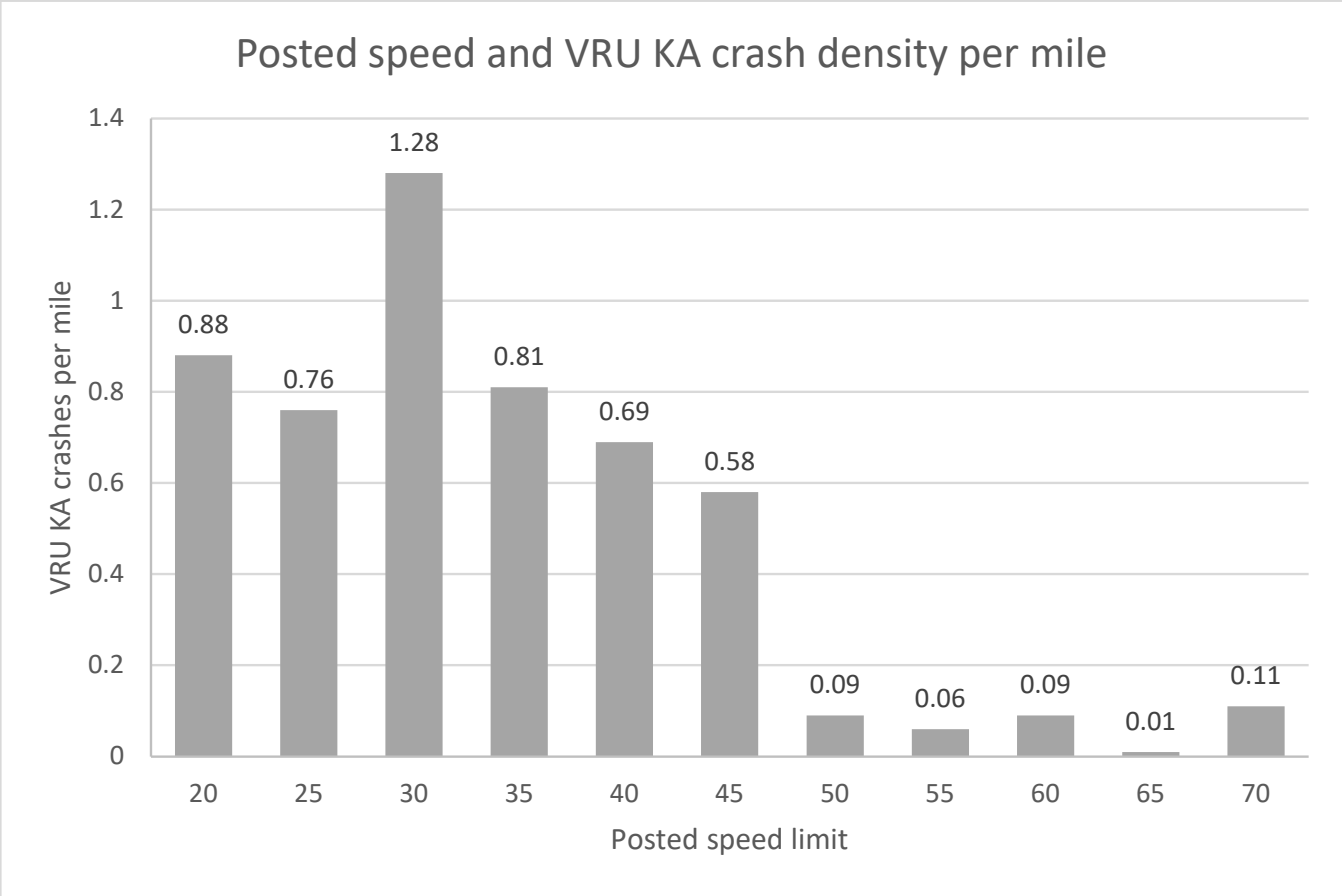
Locations and Location Types

The VRU KA crashes are more prevalent on urban roads, with a VRU KA crash density of 0.53 per mile compared to rural roads at 0.04 per mile. These crashes happen most frequently on urban arterials but occur on other parts of the network (refer to Exhibit 13). When considering the VRU KA crash density on state highways, the assessment showed that the crash density on state highways under city jurisdiction is significantly higher at 2.27 per mile than on state highways under WSDOT jurisdiction: 0.12 per mile. These roads are typically urban/suburban arterials.

Crash density on state highways under city jurisdiction is significantly higher than on state highways under WSDOT jurisdiction.

While VRU KA crashes occur on all parts of the state highway network, they are particularly prevalent at posted speeds from 25-45 mph for all roads. Speeds are an exponential factor in the forces on the humans involved in motor vehicle crashes. Exhibit 13 below shows the distribution of the VRU KA crashes on state highways. This means that small changes can result in much higher forces. At lower posted speeds it is not uncommon to see higher pedestrian volumes (exposure), and fewer pedestrians

Exhibit 13. VRU KA Crash Density per Mile for Posted Speed Limits on State Highways (WSDOT Engineering Crash Datamart, 2022 year-end)



as posted speeds increase. The fact that more VRU are using the system at posted speeds from 20-25 means that VRU crash frequency is potentially higher, and some of those crashes will result in fatalities or serious injuries. Research shows that sedans traveling at speeds 30 mph, 50% are likely to result in deaths and for 40 mph, 90% in deaths[2]. As speeds increase it is also more difficult for pedestrians to judge how fast a vehicle will close on their location or how a driver might be able to perceive and react to their presence. When considering the number of lanes, the data shows that facilities with more than two lanes are associated with much higher VRU KA crash density per mile. For one-way urban arterials this increase in VRU KA density occurs when there is more than one lane. One-way facilities with more than one lane also had higher associated VRU KA crash densities per mile.

The next section provides a list of characteristics associated with higher KA crash densities per mile. It reflects the results of some of the analysis completed on state highways. Note that multifactorial analysis was performed for the VRU safety assessment but that it is not included in the report because of complexity. Rather, results from the more in-depth analysis are presented as part of findings throughout the report.

Location considerations

Exhibit 14 summarizes the factors or characteristics associated with higher VRU KA crash densities per mile on state highways. WSDOT will consider using these factors as part of the process of identifying areas for further analysis, ranking, or prioritization. From this table, the following are the type of locations shown to predominate in VRU KA crashes, and facilities with these characteristics will receive emphasis in project selection on state highways:

- locations with speeds between 25-45 mph
- urban/suburban principal and minor arterials
- with volumes 5,000 to 50,000
- within a mile of schools and transit stops

For speeds posted 30 mph and above, death and serious injury potential rapidly increases. Target speeds and adjustment to achieve targets speeds is an important concept for these locations to bring speed and crash forces down. Appropriate speed management techniques and self-enforcing/explaining roads concepts will help reduce speeds at these locations.

Lower vehicular volume and lower speed 20-25 mph local roads commonly see increased volumes of people walking and biking. This increase in exposure is likely to increase the likelihood of crashes with people walking and rolling. While the crash forces are lower, more crashes will occur and as numbers increase so will serious injuries and fatalities. In addition, drivers will not always travel at or below the

*Note **2**: This research is based on sedan-sized vehicles and does not reflect the changing mix of vehicle sizes and types, or that larger vehicles have been dominating sales in recent years.*

posted speed limit of 20-25 mph and will sometimes drive at much higher speeds. These lower posted speed crashes occur with vehicles of different height, size, and mass.

Humans differ in body type and characteristics, and there exists different injury tolerances between individuals. In these urban situations, distractions and impairment also increase for all road users, both for drivers and those walking and rolling. Exhibit 14 below shows characteristics correlated with higher density of VRU KA crashes on state highways only. The exhibit does not include local roads as information on roadway characteristics was not available and could therefore not be assessed in this effort.

Exhibit 14. Summary of characteristics associated with higher VRU KA crash densities per mile on state highways in Washington state; 2013-2022, 10 year total (VRU KA Crash Data Source: WSDOT Engineering Crash Datamart, 2022 year-end)

Characteristic correlated with higher density of fatal and serious injury vulnerable road user crashes	Length	VRU KA Crashes	VRU KA Crashes per mile	% of Total Length	% of Total KA Crashes
State highways[1]	**8247.32**	**1559**	**0.19**	**100%**	**100%**
Posted speed: 25 - 45	1280.98	977	0.76	16%	63%
Number of lanes > 2 and <9 (bidirectional)	1707.16	658	0.39	21%	42%
Principal arterials and minor arterials	1252.45	998	0.80	15%	64%
Urban area	2464.66	1310	0.53	30%	84%
Highway urbanized area	2458.84	1310	0.53	30%	84%
Within population center: all state highways in population centers except limited access freeways	2544.63	1266	0.50	31%	81%
Within 1,000 feet of population center boundary: all state highways within 1,000 feet of population centers except limited access freeways	627.06	94	0.15	8%	6%
Tribal land	315.35	83	0.26	4%	5%
Within urban growth boundary	423.09	150	0.35	5%	10%
Within 5 miles of urban growth boundary	4016.24	1244	0.31	49%	80%
Level of Traffic Stress of 2 or 3	171.01	105	0.61	2%	7%
One-way urban arterials with 2 to 4 lanes	29	69	2.38	0%	4%
Undivided arterials with 4 to 7 lanes	84.83	216	2.55	1%	14%
AADT for rural roads: 75,000 to 100,000	13.08	7	0.54	0%	0%
AADT for urban roads: 5,000 to 50,000	1611.23	1122	0.70	20%	72%
Within 1 mile of schools	2346.8	1233	0.53	28%	79%
Within 1 mile of transit stops	3025.91	1350	0.45	37%	87%
Mileage used to identify active transportation needs and costs in the WSDOT Active Transportation Plan[2]	1844.95	1044	0.57	22%	67%
Individual State Routes with WSDOT VRU DEI score of 6 or greater	4382.7	1210	0.28	53%	78%

Notes: **1** This mileage includes all mainlines, ramps, spurs, couplets, alternative route types, reversible lanes and grade separated high occupancy vehicle lanes. **2** This mileage includes all mainlines, ramps, spurs, couplets, alternative route types, except limited access freeways.

Potential systemic measures for identification, screening, ranking, or prioritization

WSDOT continues to use the Safe System Approach to analyze and address road safety. While this Vulnerable Road User Safety Assessment is directed towards the Highway Safety Improvement Program, its findings and metrics can be applied across funding sources and jurisdictions to help reach Washington's goal of zero fatalities and serious injuries. In keeping with the principles of the Safe System, WSDOT recognizes that under the Safe System Approach, safety can be assessed by considering the exposure/conflicts between traffic (e.g., volume and crossing points of VRU with vehicles), the crash likelihood (the potential that a crash can occur), and the crash severity (i.e., given that a crash has occurred; the combination of factors that can lead to increased severity, such as speed, mass, angle, and protection of the occupant or VRU in the crash).

Safety increases as: (exposure/conflicts + likelihood of a crash + severity potential) decreases

This recognition is important in understanding how strategies work to reduce crashes resulting in death and serious injuries. Exposure as a measure is typically correlated to volumes; however, from a safety perspective, the importance of conflict reduction is important to highlight as indicated in the equation. Changes in VRU volumes and conflicts can be addressed by high quality treatments, such as separation by lanes, leading pedestrian intervals, removal of vehicle permitted turning movements. Robust tools for collecting VRU data or estimating volumes is important in understanding potential outcomes. When gaps in VRU systems are closed (network continuity increases) walking and rolling volumes can increase dramatically, yet methods to estimate the future changes and benefits can often undercount because of latent demand for the system. Engineers and planners use the context of the road to better understand land use interactions and the potential for more or fewer VRUs and the appropriate speed for the mix of modes. WSDOT has proposed national and state level research on the topic of exposure estimation and will continue to emphasize this concern at national, state, and local levels.

Understanding severity is critical in the Safe System Approach. The Safe System Approach directly addresses the fact that, by reducing kinetic energy, crash severity is reduced. Injuries occur when crash forces are greater than a human can withstand. It is important to understand that:

Kinetic Energy = (1/2) (Mass x Velocity^2)

What this means for the vulnerable road user is that, while the weight of the vehicle is important, vehicle speed is even more significant given its exponential effect (velocity x velocity). Small increases or decreases in speed can change the crash kinetic energy or injury potential substantially. Treatment solutions that reduce speeds, emphasize pedestrian presence, and provide improved conspicuity at intersections, or non-intersection midblock locations are important strategies for addressing VRU crashes. Visibility of pedestrians can lead to earlier slowing of vehicles because the walker or roller is recognized sooner.

WSDOT also recognizes that the height of the vehicle is an important factor in crash severity because a greater area of the vehicle comes into contact with a VRU's body during a crash and a blunt front end impacts the torso with its vital organs or, for larger sport utility vehicles or pickup trucks, the head. While WSDOT does not regulate vehicles, it provides this information to the public in meetings related to safety as an attempt to help others understand how vehicle choice influences crash severity.

A pedestrian next to a privately owned vehicle showing the threat larger vehicles present to vulnerable road users. Photo credit: Barb Chamberlain, WSDOT.

Methodology used to select strategies

WSDOT first reviewed the raw data using descriptive statistics. Doing so allowed the agency to consider characteristics of people and place, contributing factors, crash types, and when crashes were occurring. From this data, WSDOT found that VRU KA crashes are increasing and particularly those crashes where pedestrians are killed or seriously injured, and crashes where bicyclists are seriously injured.

Findings point not only to selection of treatments to address common crash types, but also to the need for top-level policy and guidance to support engineering decisions. WSDOT updated its design manual in 2023 to add a great deal of guidance for topics such as speed management and separation of vehicles and people walking and rolling. Specific treatments and strategies identified below will be supported by this guidance and future updates grounded in the Safe System Approach. These approaches include the need to explicitly consider VRUs in decision-making when design or operational decisions might lead to increases in: vehicle speeds, crossing distances and times for VRUs, and vehicle-oriented solutions that reduce available separation and useable walking and rolling space.

When reviewing time of day for VRU KA crashes, VRU KA crashes increase in the peak hours. This correlates with increased exposure, as driving, walking, rolling, and bicycling will increase during these periods. As the data illustrate, proximity to transit locations are strongly associated with VRU KA crashes. During peak traffic periods, demand for transit increases and transit headways are often shorter. With increases in the numbers of people walking, rolling, and biking to and from the transit stops exposure and conflicts increase. Decisions to cross in order to catch transit may result in an increase in mid-block crashes and crashes at marked and unmarked crossings.

Another factor to consider with time of day is signal progression and timing. Signal coordination reduces the number of drivers stopping at intersections. With longer signal cycles to keep up with vehicular demand, the wait times for those walking and biking at signalized locations increases. All of these factors could potentially increase driving speeds, which increases decision-making complexity for those crossing at locations. The longer signal times may also result in crossing against a don't walk or red signal. The complexity of crossing decisions increases at night and when driver turning movements are permitted against walk indications at crosswalks.

It is important to recognize that unmarked intersections of public roads are legal crosswalks in Washington. Washington state law allows pedestrians to enter the roadway to cross at locations other than marked and unmarked crosswalks as long as they yield the right-of-way to all vehicles upon the roadway (RCW 46.61.240). This statute also directs pedestrians to use marked crosswalks when crossing between adjacent signalized intersections; the distance to be considered "adjacent" is not defined in statute.

In general, strategies to address these challenges would include additional crossings, appropriate controls for crossings associated with transit stops and schools, consideration of route directness for pedestrian network connectivity, signal timing reviews, consideration of whether the posted speed is appropriate for the mix of uses in the corridor, application of speed management measures, and intersection modifications to reduce crossing times and distances, including midblock islands. Pedestrian scale lighting where crossing occurs could provide additional conspicuity.

Maintenance comes up anecdotally as a safety factor that does not currently have a good data source; shrubbery obscuring a driver's view of a pedestrian stepping into the street to cross provides an example of this as a topic to explore further in future. Reducing periodic sight and path obstructions (e.g., vegetation, parked vehicles) is important to VRUs at both segments and intersections of roads, shoulders, sidewalks, and paths.

As the assessment and Safe System Approach suggest, speeds are a critical factor in severity determination. One might question why at lower speeds are fatalities and serious injuries still high. While speeds between 20-25 crash forces are generally survivable, the number of all crash injury types will be high because of higher volumes and conflicts with walking and rolling. With more total crashes it is recognized that some will result in serious and fatal injury and therefore these injuries will be higher.

As stated previously, lower speeds are important when VRU volumes are higher to reduce injury potential. Solutions that calm traffic, provide speed feedback, and warn of speed zones are common at these speeds. At speeds 30 and above deaths and serious injuries rapidly rise because forces are much higher as this assessment described earlier. At these speeds, forces will commonly exceed the human tolerance levels for injury.

Engineering to reduce speeds through self-enforcing/self-explaining roads is important. These roads intend to elicit behaviors that result in proper speed choice for the context and presence of VRUs. In existing road systems, it is difficult to achieve driver compliance with posted speed limits when the road is designed with wider lanes, large curves, and no visual constraints. WSDOT developed the Injury Minimization and Speed Management Recommendations document for use by policy makers and professionals in efforts to reduce speed and subsequent crash forces. WSDOT has also incorporated a target speed setting approach in its manuals, guidance, and in how it treats speed setting requests. At higher speeds, visibility becomes important. Lighting that addresses driver visibility may not always make the walker and roller as visible as one might desire. Lighting at the human scale (e.g., pedestrian lighting) can increase the conspicuity of VRUs under dark conditions.

Data on VRU KA crashes indicate the presence of behavioral aspects in impairment, distraction, failure to use a crosswalk, failure to grant right of way, and hit and run as areas that could benefit from education and enforcement actions. Engineering to create self-enforcing roads and to provide appropriate facilities for vulnerable road users can shape the built environment people respond to as they make decisions about how to use the transportation system. Other solutions lie beyond engineering, such as the frequency and availability of transit service that could replace driving (reducing exposure and likelihood) as a way home for someone who is impaired, and the availability of first responders (reducing severity) to provide post-crash care in a timely manner.

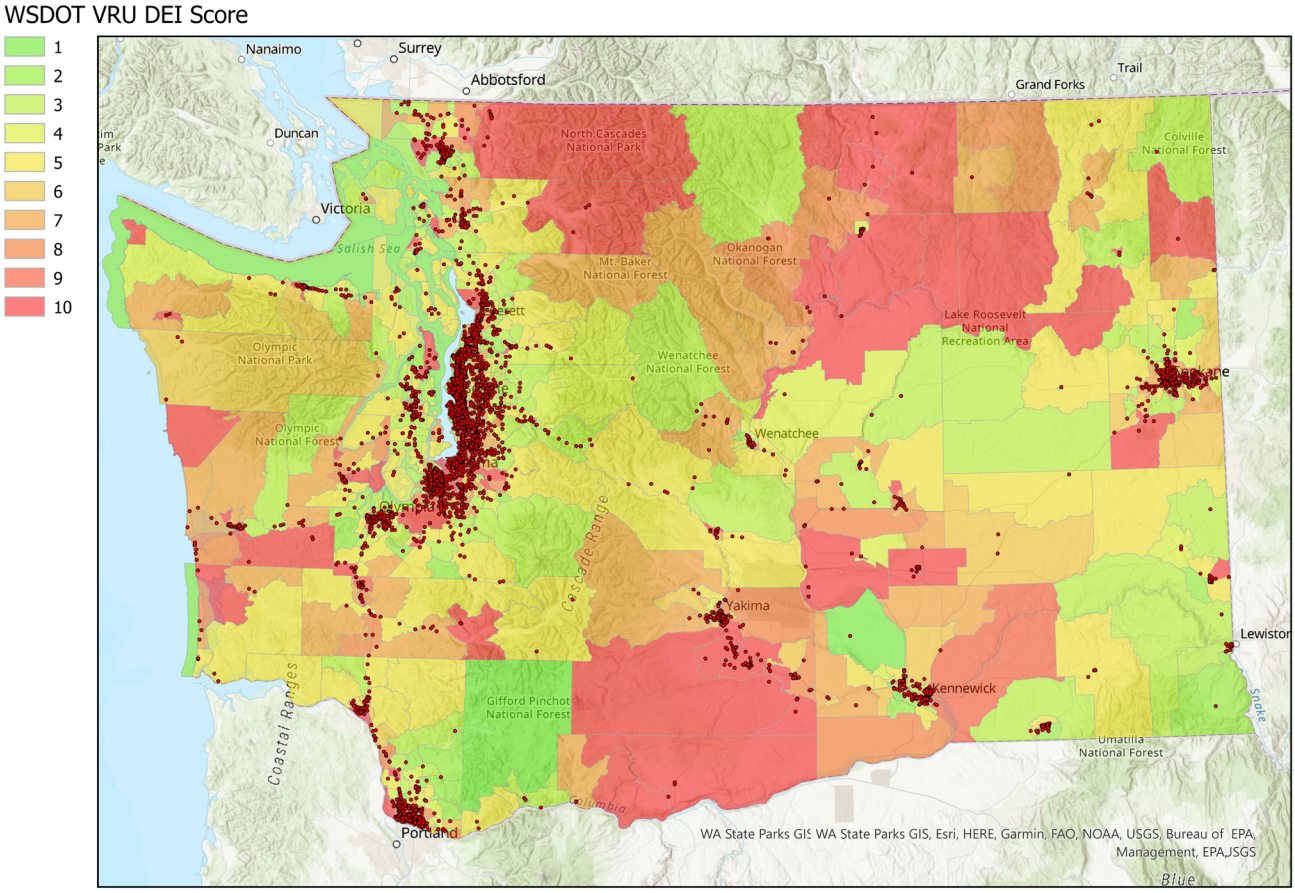
WSDOT will continue to work with the Cooper Jones Active Transportation Council, the Washington Traffic Safety Commission, and other partners on specific countermeasures or programs that would be grounded in equity and the Safe System Approach.

While "Failure to use crosswalk" is indicated in the macro-level analysis, WSDOT recognizes that coding relies on the officer knowing that an unmarked crosswalk is a legal crosswalk and that in some cases impact forces with the VRU may result in the person being thrown from the crosswalk location. It is important when reviewing these crashes for countermeasures to analyze individual crash reports and perform additional field reviews before determining the contributing factors and what the solution(s) are to reduce the likelihood and severity of crashes at the location.

WSDOT's review indicates a significant spike in crashes involving older people. As the population ages, a greater proportion of VRUs are people age 65 or older, resulting in increasing exposure for that demographic. Older individuals are more likely to exhibit reduced function for vision, mobility, and cognitive processing and are therefore more likely to be involved in crashes. Because they are more frail and susceptible to injury, these crashes tend to be more severe. Strategies outlined in this assessment that support all active transportation users will also support VRU emphasis areas pertaining to older pedestrians and bicyclists.

Exhibit 15 shows the WSDOT VRU DEI Score and is overlayed with crashes occurring throughout the state over a 10-year period.

Exhibit 15. Statewide vulnerable road user fatal and serious injury crashes 10-year total (VRU KA Crash Data Source: WSDOT Engineering Crash Datamart, 2022 year-end)

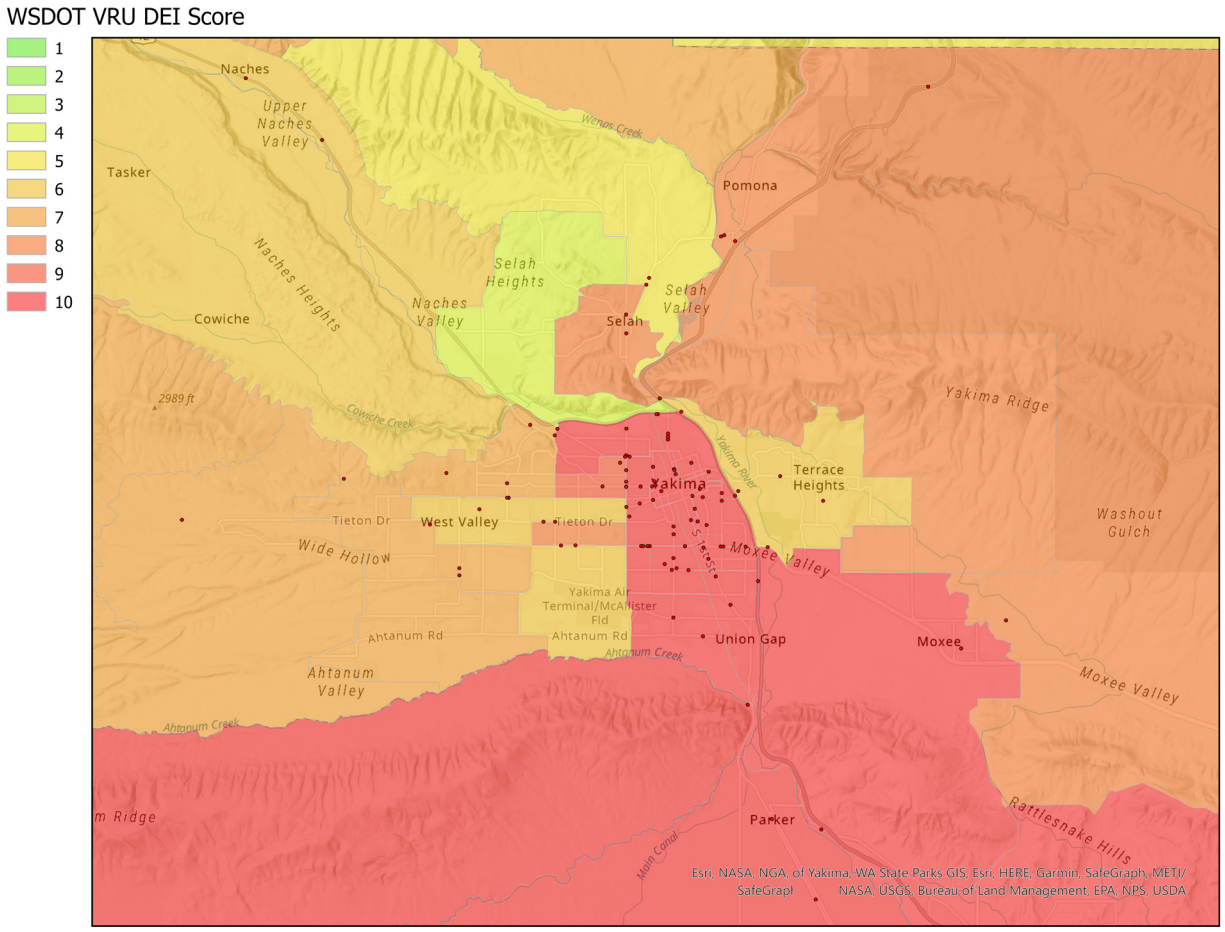


Equity and demographic considerations

WSDOT found a significant correlation to VRU KA crashes based on socioeconomic and demographic factors using the max 10 scoring method (WSDOT's custom VRU DEI score). This approach will be used to identify locations based on rank order with the low of 0 and high of 10. In locations within cities and on county roads, this information will be used in considering grant applications for these projects, coupled with other requirements specific to each funding program. For WSDOT, this list will also supplement the agency's current method outlined within its HSIP Implementation plan. Doing so will ensure project equity considerations.

WSDOT found a significant correlation between crashes and socioeconomic and demographic factors.

Exhibit 16. Yakima area vulnerable road user fatal and serious injury crashes showing higher crash density in census tracts with high WSDOT VRU DEI scores. (VRU KA Crash Data Source: WSDOT Engineering Crash Datamart, 2022 year-end)



Crash type considerations

WSDOT found that the highest number of VRU KA crashes occur when pedestrians are not at a crosswalk and the driver is going straight. The second highest number of VRU KA crashes are when pedestrians are at uncontrolled locations and using a crosswalk with the driver going straight. When at a signal, VRU KA crashes are evenly split between those involving a driver going straight and left-turn crashes. While not as high in number as left-turn crashes, right-turn crashes are significant as well.

The data also shows that VRU KA crashes are occurring when pedestrians are walking or rolling in the roadway and on shoulders but not in the roadway. The data indicates that an emphasis toward mid-block crossings along between intersection and at locations where there are no traffic controls at intersection would be beneficial. Consideration of locations where pedestrians are walking or rolling along or on the road surface would be beneficial as well, with identification of whether a lack of appropriate and ADA-accessible facilities forces pedestrian movements into the roadway. For bicyclists, VRU KA crashes

are most likely to occur when they are crossing the road. Other relatively frequent VRU KA crashes for bicyclists occur when they are struck by a driver who is going straight or turning, while the bicyclist is riding along the road. Protected bike lanes can reduce these types of crashes.

Program of Strategies

WSDOT's intent is to screen locations based on its equity analysis approach, together with the HSIP Implementation Plan methods, in order to select projects that address VRU crashes before they happen in a systemic and proactive manner. WSDOT will develop ranked lists for locations on the state and local system and will also provide a GIS map online for consideration and use for all project types. Many grant programs have individual criteria and scopes, and for these programs the VRU analysis may serve as an informative tool but will not supersede statutory requirements and criteria.

WSDOT is providing a list of strategies in this section that can be used in projects to prioritize the needs and safety of vulnerable road users. The list shows which projects address the three categories—exposure/conflicts, likelihood, and severity—and also align with a wide range of potential countermeasures. Within the Safety Program at WSDOT these projects will fall into the proactive category and will generally focus on systemic treatments, with individual locations also being considered. Within local grants, and within the funding and legislative requirements, it is the intent is that cities and counties will address individual locations as appropriate to reduce exposure, likelihood, and severity through both spot and systemic safety approaches.

How the VRU relates to the SHSP, HSIP, and Local Safety Plans

The VRU assessment will become part of the next Strategic Highway Safety Plan. An updated version of Target Zero is intended for publication in 2024, and this VRU assessment will be an appendix to that document. WSDOT recognizes the value of a VRU safety assessment, analysis and evaluation of data, particularly as they can inform more proactive approaches to reduce the likelihood of serious and fatal crashes.

In previous iterations of the SHSP, crashes involving walking, rolling, and biking were part of the road user chapters. In the future, with the updated version of the SHSP focused on the Safe System Approach, this VRU assessment will likely form the base data analysis for an emphasis area within Target Zero. Similar to the approach WSDOT is taking to develop its Safety Program, both the local and state HSIP funding approaches will be consistent with the Target Zero emphasis areas and strategies/countermeasures when developing a programmatic approach to investment within the proactive and reactive subcategories. WSDOT has developed a subcategory for active transportation and speed management as part of the safety subprogram for state highways under WSDOT jurisdiction.

WSDOT currently requires local governments, cities, and counties to develop a Local Road Safety Plan to receive HSIP funding. The VRU assessment will inform the selection of countermeasures through the WSDOT Local Programs Division grant cycles with the cities and counties. Because of the importance of VRUs, it is recommended that processes for inclusion of a VRU component in Local Road Safety Plans be developed.

Conclusion and Actions

WSDOT remains concerned as the number of vulnerable road user fatal and serious injury crashes continues to increase. To offset these increases, WSDOT is adopting the Safe System Approach as its primary strategy. With the Safe System Approach, the agency continues to adjust its design and operations policies and practices to benefit vulnerable road users. These changes remain focused on addressing speeds, increasing separation (time and space), decreasing exposure, and increasing VRU conspicuity through engineering measures to improve their visibility to drivers. One example of this effort is the preference for the installation of roundabouts versus signalized intersections and optimizing those roundabouts for VRUs. Another is a study of lighting and pedestrian safety being undertaken by WSDOT in partnership with the Washington Traffic Safety Commission with funding from the legislature.

The findings in this report suggest a number of specific actions and directions for WSDOT to prioritize its funds to improve the safety of people walking, rolling, and bicycling. With the new Complete Streets directive in place, this provides for the opportunity to integrate these not only into projects funded with the HSIP, but across the agency's work. The agency's commitment to the Safe System Approach will guide its work. Other solutions will rely on the actions of partner agencies, from local jurisdictions to transit agencies, to first responders.

The Safe System recognizes the importance of data in enabling meaningful data analysis for actionable insights. WSDOT found data availability to be a challenge in assessing VRU KA crashes. The analysis was performed at a macro level, and important information on VRU volumes, sidewalks, and intersection configurations and operations was not availble at the local and state level. WSDOT has subsequently collected sidewalk information and has started a process to gather additional intersection information. The ability to estimate demand based on data such as origins, destinations, transit stops, and intersection density is important to understanding VRU system needs and in the development of proactive safety strategies. Information on route directness recognizes the human element and potential choices a VRU will make to cross or travel along a segment of road or at an intersection. This leads to greater understanding of VRU KA crashes.

Crash data is typically provided from a driver's perspective, and pedestrian and bicyclist information is relatively limited. WSDOT created crash types to categorize the type of crashes involved for pedestrians and bicyclists. It is recommended that determining how information for VRU crashes could and should be collected, development or refinement of common definitions, and the deployment of the custom crash types presented in this report for agency analysis would greatly improve these types of assessments.

The assessment found that the frequency of VRU KA crashes increases during the peak hours. Crossings by VRUs increase, as does vehicle travel along the road during the peak hours. These crossings include midblock, and non-intersection crossings that may be the result of people trying to catch transit. The pedestrian's route directness need, location of existing crossings if any, and larger vehicle volumes lead to increased vehicle-VRU conflict.

Individuals 65 and older walking and biking are experiencing the most fatalities and serious injuries. WSDOT will consider locations with aging populations to identify appropriate projects for speed management, pedestrian visibility, and additional information to drivers and VRUs on such as markings and signage (such as speed feedback signs, Pedestrian Hybrid Beacons/Rectangular Rapid Flashing Beacons and additional crossing controls and signs).

Crashes involving bicyclists were highest when the bicyclist was crossing, but for bicyclist riding along the roadway, crashes involving both through and turning movements predominate.

The assessment indicated impairment, distraction, failure to use crosswalk, failure to grant right of way, and hit-and-run as contributing factors to crashes. WSDOT will work with the Washington Traffic Safety Commission, Cooper Jones Active Transportation Council, Washington State Patrol, and local law enforcement to determine best approaches for education and enforcement, as well as determine what infrastructure might help reduce crash exposure, likelihood and severity for VRUs.

The data showed the majority of VRU deaths and serious injury crashes occurring between 25-45 mph, on urban principal and minor arterials with AADTs between 5,000 and 50,000, within a mile of a school or transit stop which are identified by the WSDOT VRU DEI score of 6 or greater. WSDOT also found a high percentage of crashes occurring within a thousand feet of transit locations and schools. Further research on this topic could help uncover typical origin and destinations and reasoning for VRUs in the vicinity of schools, transit, and other origins and destinations. This research could help generate guidance to help designers analyze origins and destinations for VRU in the vicinity of schools, transit stops, and other significant destinations, so that safe routes and crossings can be designed to provide for VRU needs including route directness.

WSDOT developed—and will implement—a socioeconomic equity-based method for screening VRU safety performance. The variables included in this method are: Area of Persistent Poverty, tribal land, Social Vulnerability Index, Washington State Environmental Health Disparities Index, Disadvantaged Communities Score, school density, transit stop density, and transit route mileage density. WSDOT found correlation to be high with VRU KA crashes, and the method provides for a good means to identify locations for further analysis and potential systemic or individual projects.

Summary of Proposed Actions

The proposed actions that follow represent a number of actions WSDOT will consider. WSDOT intends to prioritize and schedule these actions in consultation with Highway Safety Executive Committee.

- Assess with the WTSC the current status of the Rapid Health Information Network (RHINO) program, which links emergency department, hospitals, urgent care and outpatient clinics, for future inclusion in WSDOT VRU assessments.
- Assess with the WTSC the current status of the Traffic Records Integration Program (TRIP) which is linking crashes to toxicology, driver licensing and vehicle registrations, injury data from emergency rooms, inpatient, outpatient, trauma, and adjudication for future inclusion in WSDOT VRU assessments.
- Identify data gaps related to vulnerable road users, including methods to address, collect, use, and analyze appropriate data.
- Work with the WSDOT Transportation Data Office to incorporate new pedestrian and bicyclist crash types into crash reporting post processing efforts so that agencies and consultants have access to this information for analysis.
- Finalize development of Active Transportation and Speed Management subcategories and ranking methods in the WSDOT I-2 Safety Program.
- Develop systemic safety approaches to address specific leading crash type(s), road characteristics, or contributing factors to VRU crashes.
- Incorporate a requirement for Vulnerable Road User components into Local Road Safety Plans.
- Form a statewide team of local and state transportation agencies to address issues related to City Streets as Part of State Highways. Address identification of VRU locations for further assessment, funding opportunities and constraints, current and potential focus areas on projects, and specific considerations during design and operational decision making.
- Incorporate Washington-specific VRU DEI assessments or information into grants application and decision processes where appropriate and not limited by legislative and regulatory requirements.
- Continue to review and update design and operational guidance as necessary to incorporate self-enforcing/self-explaining roads criteria.
- Develop polices and processes by defining safety performance as a measure of exposure/conflicts, likelihood of a crash, severity of a crash.
- Develop policies and processes on the explicit consideration of vulnerable road users where projects have the potential to affect exposure/conflicts, likelihood of a crash, and/or severity of a crash.
- Develop and evaluate a context-based target speed setting approach statewide that focuses on injury minimization.
- Develop a process for inclusion of a Vulnerable Road User component in Local Road Safety Plans.

WSDOT sees the VRU assessment as an important component of the Safe System Approach's implementation, as it helps prioritize proactive safety investment. WSDOTs goal is to provide an environment of safe mobility for all road users. Lessons learned during the VRU assessment can be used to inform safety practices and change these practices as new knowledge is brought forth through improved understanding.

Appendix

Exhibit 17. Summary countermeasures and how they influence pedestrian crash exposure, likelihood and severity at intersections

Intersections[1]				
FHWA Category	**Pedestrian Safe System Treatment**	**Exposure**	**Likelihood**	**Severity**
Intersection Treatments	ADA Curb Ramps	✓	✓	
Markings, Signs, Signals	High-Visibility Crosswalks	✓	✓	
Intersection Treatments	Curb Extension	✓	✓	
Shared Roadway	Pedestrian Refuge Island	✓	✓	
Shared Roadway	Raised Crosswalk	✓	✓	✓
Shared Roadway	Raised Intersection (incl. Raised Pedestrian Crossings)	✓	✓	✓
Shared Roadway	Pedestrian Scale Lighting/Illumination (crossing)		✓	
Intersection Treatments	Roundabout with Pedestrian Facilities	✓	✓	✓
Shared Roadway	Physical Barrier to restrict parking near crossings	✓	✓	
Shared Roadway	Pedestrian Overpasses/Underpasses	✓	✓	✓
Markings, Signs, Signals	Automated Pedestrian Detection		✓	
Markings, Signs, Signals	Pedestrian Crossing Advance Atop Lines	✓	✓	
Other Measures	Access to Transit (Bus stops)		✓	
Intersection Treatments	Improved Right-Turn Slip-Lane Design	✓	✓	
Traffic Calming	Modified T-Intersections & Mini-Circles		✓	
Traffic Calming	Compact Roundabouts		✓	✓
Intersection Treatments	Intersection Median Barriers	✓	✓	
Intersection Treatments	Reduced Corner Radii	✓	✓	
Intersection Treatments	Modify Skewed Intersections for Better Perpendicular Alignment	✓	✓	
Other Measures	Full Street Closure	✓	✓	✓
Other Measures	Partial Street Closure	✓	✓	
Intersection Treatments	Left Turn Prohibitions	✓	✓	
Markings, Signs, Signals	Pedestrian-only Phase/Scramble	✓	✓	
Intersection Treatments	Prohibit Turn-On-Red	✓	✓	
Markings, Signs, Signals	Signal Timing	✓	✓	✓
Markings, Signs, Signals	Pedestrian Hybrid Beacon (PHB)		✓	✓
Markings, Signs, Signals	Leading Pedestrian Interval (LPI)	✓	✓	
Markings, Signs, Signals	In-Street Pedestrian Crossing Sign	✓	✓	✓
Intersection Treatments	Eliminate Right Turn Lane	✓	✓	
Intersection Treatments	Eliminate Slip-Lane	✓	✓	
Markings, Signs, Signals	Rectangular Rapid Flashing Beacon (RRFB)		✓	✓
Markings, Signs, Signals	Half Signal for Pedestrians	✓	✓	
Markings, Signs, Signals	Pedestrian Traffic Signal	✓	✓	
Markings, Signs, Signals	Pedestrian signal phase separated from left turn phase		✓	
Intersection Treatments	Protected Intersection	✓	✓	✓
Markings, Signs, Signals	Stop Sign (Standard)	✓	✓	✓
Markings, Signs, Signals	Flashing Stop Sign	✓	✓	✓
Markings, Signs, Signals	Accessible Pedestrian Signal	✓	✓	
Markings, Signs, Signals	Traffic signal timing to accommodate slower pedestrian speeds	✓	✓	
Traffic Calming	Neighborhood Traffic Circle		✓	✓
Markings, Signs, Signals	Full Traffic Signal		✓	✓
Markings, Signs, Signals	Turning Vehicles Stop for Pedestrians Sign		✓	✓
Markings, Signs, Signals	Pedestrian Countdown Signal	✓	✓	

Note: **1** Refer to https://wsdot.wa.gov/publications/manuals/fulltext/m22-01/1310.pdf for more information.

Exhibit 18. Summary countermeasures and how they influence pedestrian crash exposure, likelihood and severity on segments

Segments				
FHWA Category	**Pedestrian Safe System Treatment**	**Exposure**	**Likelihood**	**Severity**
Shared Roadway	Pedestrian Scale Lighting/Illumination (Segment)		✓	
Shared Roadway	Sidewalks with curb and gutter	✓	✓	✓
Shared Roadway	Sidewalk with buffer	✓	✓	✓
Shared Roadway	Paved Shoulders	✓		
Other Measures	Transit Stop Improvements (Includes transit stop shelters and platforms)	✓		
Shared Roadway	Road Reconfiguration including narrowing	✓	✓	
Shared Roadway	Lane Width Reduction (Road Diet)	✓	✓	
Shared Roadway	Driveway Ramps to reduce speed	✓	✓	
Shared Roadway	Consolidate Driveways	✓	✓	
Shared Roadway	Narrow Driveway Entrances	✓	✓	
Traffic Calming	Chicanes		✓	✓
Traffic Calming	Speed Humps		✓	✓
Traffic Calming	Speed Tables		✓	✓
Traffic Calming	Placemaking Gateway Treatment		✓	
Traffic Calming	Specific Paving Treatments (Color, Type, Markings)		✓	
Other Measures	Full Street Closure	✓	✓	✓
Other Measures	Partial Street Closure	✓	✓	✓
Markings, Signs, Signals	Traffic signal timing through multiple traffic signals to lower driver speeds	✓	✓	✓
Other Measures	Speed-Monitoring Trailers		✓	✓
Markings, Signs, Signals	High-Visibility Crosswalks		✓	
Intersection Treatments	Roundabout	✓	✓	✓
Markings, Signs, Signals	Speed Feedback Sign		✓	
Other Measures	Automated Traffic Safety Cameras		✓	
Shared Roadway	Shared Use Path/Sidepath	✓	✓	✓
Markings, Signs, Signals	20 mph speed zone designation and signs for residential or business districts		✓	✓
Markings, Signs, Signals	School/playground 20 mph speed zone with flashing beacons and signage		✓	✓
Traffic Calming	Chokers or pinch-points		✓	✓
Shared Roadway	Walkway with bio-swale/ditch buffer	✓	✓	✓
Other Measures	Pedestrian-only streets	✓	✓	

Exhibit 19. Summary countermeasures and how they influence bicyclist crash exposure, likelihood and severity at intersections

Intersections				
FHWA Category	**Bicyclist Safe System Treatment**	**Exposure**	**Likelihood**	**Severity**
Shared Roadway	Bridge and Overpass Access	✓	✓	
Shared Roadway	Tunnel and Underpass Access	✓	✓	
Shared Roadway	Lighting Improvements		✓	
Shared Roadway	Streetcar Track Treatments		✓	
Shared Roadway	Physical Barrier to restrict parking near crossings	✓	✓	
Intersection Treatments	Reduced Corner Radii	✓	✓	
Intersection Treatments	Roundabout with Bicyclist Facilities	✓	✓	✓
Intersection Treatments	Bicycle Intersection Crossing Markings		✓	✓
Intersection Treatments	Sight Distance Improvements		✓	
Intersection Treatments	Turning Restrictions	✓	✓	
Intersection Treatments	Left Turn Prohibitions	✓	✓	
Intersection Treatments	Turn-On-Red-Restrictions	✓	✓	
Intersection Treatments	Left Turn Phasing	✓	✓	
Intersection Treatments	Merge and Weave Area Redesign	✓	✓	
Intersection Treatments	ADA Curb Ramps	✓	✓	
Intersection Treatments	Curb Extension	✓	✓	
Intersection Treatments	Modify Skewed Intersections for Better Perpendicular Alignment	✓	✓	
Intersection Treatments	Eliminate Slip-Lane	✓	✓	
Intersection Treatments	Protected Intersection	✓	✓	✓
Maintenance	Repetitive/Short-term Maintenance	✓	✓	✓
Maintenance	Major Maintenance	✓	✓	✓
Maintenance	Hazard Identification Program	✓	✓	✓
Traffic Calming	Neighborhood Traffic Circle		✓	✓
Trails and Shared-Use Paths	Path Intersection Treatments		✓	
Markings, Signs, Signals	Optimizing Signal Timing for Bicyclists		✓	
Markings, Signs, Signals	Bike-activated Signal Detection		✓	
Markings, Signs, Signals	Bike detection confirmation light and signage	✓	✓	
Markings, Signs, Signals	Sign Improvements for Bicyclists		✓	
Markings, Signs, Signals	Pavement Marking Improvements		✓	
Markings, Signs, Signals	School-zone Improvements	✓	✓	✓
Markings, Signs, Signals	Rectangular Rapid Flashing Beacons (RRFB)		✓	
Markings, Signs, Signals	Bicycle Signal Heads		✓	
Markings, Signs, Signals	High-Visibility Crosswalks	✓	✓	
Markings, Signs, Signals	Stop Sign (Standard)	✓	✓	✓
Markings, Signs, Signals	Flashing Stop Sign	✓	✓	✓
Other Measures	Law Enforcement		✓	
Other Measures	Bicyclist/ Motorist Education	✓	✓	✓
Other Measures	Transit Access	✓	✓	
Other Measures	Wayfinding	✓	✓	
Other Measures	Landscaping/ Aesthetics	✓	✓	
Other Measures	Full Street Closure	✓	✓	✓
Other Measures	Partial Street Closure	✓	✓	
Markings, Signs, Signals	Bicycle box	✓	✓	
Markings, Signs, Signals	Two-stage bicycle turn box	✓	✓	

Exhibit 20. Summary countermeasures and how they influence bicyclist crash exposure, likelihood and severity on segments

Segments				
FHWA Category	**Bicyclist Safe System Treatment**	**Exposure**	**Likelihood**	**Severity**
Shared Roadway	Roadway Surface Improvements		✓	
Shared Roadway	Bridge and Overpass Access	✓	✓	
Shared Roadway	Tunnel and Underpass Access	✓	✓	
Shared Roadway	Lighting Improvements		✓	
Shared Roadway	Parking Treatments	✓	✓	
Shared Roadway	Driveway Ramps to reduce speed	✓	✓	
Shared Roadway	Consolidate Driveways	✓	✓	
Shared Roadway	Narrow Driveway Entrances	✓	✓	
Shared Roadway	Lane Width Reductions (road diet)	✓	✓	
Shared Roadway	Road Reconfiguration including Narrowing		✓	
Shared Roadway	Streetcar Track Treatments		✓	
Shared Roadway	Sidewalks with curb and gutter	✓	✓	✓
On-Road Bike Facilities	Bike Lanes	✓	✓	✓
On-Road Bike Facilities	Wide Curb Lanes	✓	✓	
On-Road Bike Facilities	Paved Shoulders	✓	✓	
On-Road Bike Facilities	Shared Bus-Bike Lanes	✓	✓	
On-Road Bike Facilities	Contraflow Bike Lanes	✓	✓	
On-Road Bike Facilities	Buffered bike lanes	✓	✓	
On-Road Bike Facilities	Separated Bike Lanes	✓	✓	
Maintenance	Repetitive/Short-term Maintenance	✓	✓	✓
Maintenance	Major Maintenance	✓	✓	✓
Maintenance	Hazard Identification Program	✓	✓	✓
Traffic Calming	Chicanes			✓
Traffic Calming	Speed Tables/ Humps/ Cushions			✓
Traffic Calming	Traffic Diversion	✓	✓	
Traffic Calming	Visual Narrowing	✓	✓	✓
Traffic Calming	Specific Paving Treatments (Color, Type, Markings)		✓	
Traffic Calming	Chokers		✓	✓
Trails and Shared-Use Paths	Separate Shared-Use Paths	✓	✓	
Trails and Shared-Use Paths	Shared Use Path Treatments/Sidepath	✓	✓	
Markings, Signs, Signals	Sign Improvements for Bicyclists		✓	
Markings, Signs, Signals	20 mph designation and signs for residential or business districts		✓	✓
Markings, Signs, Signals	School/playground 20 mph signs with flashing beacons and signage		✓	✓
Markings, Signs, Signals	Bike Wayfinding Signs and Markings		✓	
Other Measures	Law Enforcement		✓	
Other Measures	Bicyclist/ Motorist Education	✓	✓	✓
Other Measures	Transit Access	✓	✓	
Other Measures	Wayfinding	✓	✓	
Other Measures	Landscaping/ Aesthetics	✓	✓	
Other Measures	Full Street Closure	✓	✓	✓
Other Measures	Partial Street Closure	✓	✓	✓
Other Measures	Automated Traffic Safety Cameras		✓	

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