NCHRP 20-44(13)
IMPLEMENTATION OF NCHRP RESEARCH REPORT 893: THE OREGON DOT STATEWIDE PEDESTRIAN AND BICYCLE PLAN

Prepared for:

American Association of State Highway and Transportation Officials (AASHTO)

Prepared by:

Nick Foster, Nick Gross, Matt Braughton, and Brian Ray
Kittelson & Associates, Inc., Portland, OR

Lacy Brown and Brian Chandler
DKS Associates, Salem, OR

Christopher Monsere
Independent Consultant, Portland, OR

November 2020

The information contained in this report was prepared as part of NCHRP Project 20-44(13), National Cooperative Highway Research Program.

Acknowledgements

This study was conducted with funding provided through the National Cooperative Highway Research Program (NCHRP) Project 20-44(13), *Implementation of NCHRP Research Report 893: The Oregon DOT Statewide Pedestrian and Bicycle Plan*. The NCHRP is supported by annual voluntary contributions from the state departments of transportation. Project 20-44 is intended to facilitate implementation of NCHRP research results. The report was prepared by Nick Foster, Nick Gross, Matt Braughton, and Brian Ray of Kittelson & Associates, Inc.; Lacy Brown and Brian Chandler of DKS Associates, Salem, OR; and Christopher Monsere, Independent Consultant, Portland, OR. The work was guided by a technical working group that included:

- Doug Bish, Oregon DOT
- Darren McDaniel, Texas DOT
- Christine McDaniel-Wilson, Oregon DOT
- Susan Peithman, Oregon DOT,
- Amanda Salyer, Oregon DOT
- Sid Mohan, TRB (Liaison)

The project was managed by Ann Hartell, NCHRP Senior Program Officer.

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Abstract

This report presents the results from NCHRP Project 20-44 (13), Implementation of *NCHRP Research Report 893*: The Oregon DOT Statewide Pedestrian and Bicycle Plan.

The project team performed a statewide systemic pedestrian and bicycle safety analysis on the Oregon Department of Transportation (ODOT) highway network. The analysis followed the seven-step systemic safety process outlined in *NCHRP Research Report 893: Systemic Pedestrian Safety Analysis*. While *NCHRP Research Report 893* provides a framework for evaluating systemic pedestrian safety, the approach was adapted to evaluate systemic bicycle safety in addition to pedestrian analysis.

Based on a crash data analysis, 50 sites (25 pedestrian sites and 25 bicycle sites) on state highways were identified as high-risk locations for pedestrian and bicycle crashes across ODOT's five regions to demonstrate a countermeasure selection process. The sites were selected based on a range of inputs, including urban and rural context, risk factor scores, crash history, and input from the ODOT project management team (PMT).

The results of this project provide lessons learned for other states and local agencies that wish to implement the *NCHRP Research Report 893* methods in their own jurisdictions. For ODOT, the results will be used to update the state's Highway Safety Improvement Program (HSIP) project selection process for systemic bicycle and pedestrian safety projects.

Executive Summary

Introduction

NCHRP Research Report 893 (Thomas et al. 2018) provides agencies guidance for applying a data-driven systemic approach to improving pedestrian safety. *NCHRP Research Report 893* describes a systemic safety analysis methodology using analytical techniques to identify activities, roadway features, and other contextual risk factors (e.g., land use) associated with crashes; identifying appropriate and cost-effective systemic safety improvements to address their associated risk factors; and enabling transportation agencies to prioritize candidate locations for selected safety improvements based on risk. *NCHRP Research Report 893* can be found at the following link: (http://www.trb.org/NCHRP/Blurbs/178087.aspx)

Pedestrian and bicycle crashes are less frequent than motor vehicle crashes and exposure information limited, making it difficult to apply crash-history based screening methods (e.g., potential for safety improvement, critical crash rate, crash frequency) to identify and treat locations for reducing pedestrian crashes. The systemic safety approach is a means to overcome this challenge.

This plan takes a data-driven approach in identifying risk factors for pedestrian and bicycle crashes, high-risk locations, and countermeasures to address these risks following the process outlined in *NCHRP Research Report 893.*

The *NCHRP Project 20-44 (13)* objective is to update the 2014 ODOT Pedestrian and Bicycle Safety Implementation Plan (ODOT, 2014) and inform future iterations of ODOT's All Roads Transportation Safety (ARTS) program, through which ODOT Regions and local agencies may apply for project funding to reduce crashes on public roads in Oregon. *NCHRP Project 20-44(13)* can also be used as a resource, in conjunction with *NCHRP Research Report 893*, by ODOT and local agency staff in completing their own systemic pedestrian safety analyses and program development efforts, updating the analysis documented in this memo, or developing a jurisdiction-specific program.

The process and approach of *NCHRP Project 20-44 (13)* provides value to other state DOTs and jurisdictions who may wish to apply the *NCHRP Research Report 893* methodology and process. *NCHRP Project 20-44 (13)* was developed considering the potential of transferability with documentation of suggested considerations for implementing agencies. While several considerations and lessons learned were identified, no barriers or significant impacts were documented precluding other agencies from following the process summarized in this report. Considerations and lessons learned for implementing agencies are summarized in Chapter 2 of this report.

Project Approach

The project team followed the seven steps outlined in *NCHRP Research Report 893*, as summarized below:

Steps 1–3 (Study Scope, Data Collection, and Risk Factors)—These steps were completed within the context of existing available data.

Step 4 (Identifying Potential Treatment Sites)—State highways were screened and prioritized using the risk factors identified in Step 3. The process followed in Step 4 can be replicated within local agency jurisdictions to identify locations for potential bicycle safety projects. The process can be tailored to the available data within the jurisdiction.

Step 5 (Selecting Potential Countermeasures)—Fifty sites (25 pedestrian sites and 25 bicycle sites) on state highways were selected and examined for potential countermeasures to address the identified risk factors. To illustrate a range of applications, the sites selected for this analysis are a mix of urban, suburban, and rural locations and each one includes segment- and intersection-related risk factors. They include locations with multiple crashes per year and locations without any documented crash history in the study period (i.e., the last 11 years). The countermeasures shown in this step are examples ODOT could consider at each location based on the identified risk factors and roadway and intersection characteristics. They are illustrative examples for how an agency could start this step. ODOT may wish to further evaluate these locations to select the final set of countermeasures and possibly apply for safety funding.

Steps 6–7 (Implementation and Evaluation)—These steps were not completed for this project, since countermeasures are not intended to be implemented from Step 5 (although if funding is obtained and measures are implemented, these steps could be followed). The plan describes how these steps could be completed within the context of ODOT's ARTS program and *NCHRP Research Report 893* guidance.

Each step is described further, including lessons learned, success, and challenges, in Chapter 2 of this report. The completed Pedestrian Systemic Safety Analysis and Bicycle Systemic Safety Analysis Memorandums are included in Appendix A and Appendix B, respectively.

Transferability of Approach to other States/Jurisdictions

Chapter 2 of this report discusses transferability of the approach taken for this project to other states or local agencies.

With attention to the transferability considerations summarized in Chapter 2, the approach taken as part of the *NCHRP Project 20-44 (13)* appears appropriate for other state DOTs to replicate on their respective statewide highway systems. While the approach of implementing *NCHRP Research Report 893* relies on comprehensive datasets to conduct the analysis, the process can be customized to the level of data available.

Chapter 1. Background

Overview

This final report documents the work conducted by the project team as part of *NCHRP Project 20-44(13)*. It consists of the following chapters and appendices:

Chapter 1: Background

Provides the research problem statement that led to this project and summarizes the project's work scope.

Chapter 2: Project Approach, Findings, and Application

Describes the project process as well as key successes, challenges, and lessons learned.

Chapter 3: Conclusions

Describes the conclusions as part of *NCHRP Project 20-44 (13)* and suggests additional research related to the project objectives.

Chapter 4: References

Lists the source material referenced in this report.

Appendix A: Pedestrian Systemic Safety Analysis Memorandum

Appendix B: Bicycle Systemic Safety Analysis Memorandum.

NCHRP Project 20-44 (13) also produced the following stand-alone deliverables not included in this final report:

- Meeting summaries for each meeting and presentation slides with speaker notes

Background

NCHRP Research Report 893 describes a safety analysis method for: (1) conducting systemic safety analyses for pedestrians using analytical techniques to identify pedestrian activities (including behavior), roadway features, and other contextual risk factors (e.g., land use) associated with pedestrian crashes; (2) identifying appropriate and cost-effective systemic pedestrian safety improvements to address their associated risk factors; and (3) enabling transportation agencies to prioritize candidate locations for selected safety improvements based on crash risk.

Oregon Department of Transportation was selected to use NCHRP implementation funds to demonstrate the methodology developed in *NCHRP Research Report 893* to develop a plan for pedestrian crashes and bicycle crashes. The results of the analysis will be used by the State of Oregon's Highway Safety Improvement Program (HSIP) to select and develop projects to reduce crash frequency and severity for pedestrians and bicyclists. To date, ODOT has used a systemic approach to prioritize the selection of projects during two previous rounds of HSIP funding.

ODOT was the lead agency in the development of *NCHRP Project 20-44(13)*. Stakeholders from local agencies also provided input. ODOT aims to incorporate diverse perspectives from urban and rural areas, small and large communities, and individuals in engineering, education, and enforcement in its safety planning processes.

Objective

The objective of this project was to develop a pedestrian and bicycle plan for Oregon using the systemic safety analysis method described in *NCHRP Research Report 893*.

Work Scope

Addressing the research objectives through a work program involved the following tasks:

Task 1: Project Kickoff

Confirming project objectives with NCHRP, ODOT revised and finalized the project work plan

Task 2: Pedestrian Systemic Safety Analysis and Proposed Bicycle Methodology

Completing the pedestrian systemic safety analysis using the *NCHRP Research Report 893* process; proposing a methodology for applying the *NCHRP Research Report 893* process to bicycle safety

Task 3: Bicycle Systemic Safety Analysis

Completing the bicyclist systemic safety analysis according to the methodology described in Task 2

Task 4: Present Results

Engaging stakeholders and presenting results of Tasks 2 and 3 to ODOT and local agency stakeholders

- Stakeholder Meeting #1—July 30, 2020
    - *Purpose*: Review and solicit feedback on the Pedestrian Systemic Safety process from ODOT staff and local agencies from around the state
- Stakeholder Meeting #2—October 6, 2020
    - *Purpose*: Review and solicit feedback on the Bicycle Systemic Safety process from ODOT staff and local agencies from around the state
- Results Meeting with ODOT management—October 29, 2020
    - *Purpose*: Present the results of the project, including feedback from ODOT and local agency staff from the stakeholder meetings, to ODOT management

Task 5: Performance Measures

Developing potential performance measures that can be used to monitor the effectiveness of the bicycle and pedestrian safety implementation plan

Task 6: Project Report

Developing a project report for NCHRP documenting the work completed to implement the *NCHRP Research Report 893* process and describing the successes, challenges, and lessons learned

Chapter 2. Project Approach, Findings, and Application

Introduction

This chapter documents each step performed as part of *NCHRP Project 20-44 (13)* following the steps of *NCHRP Research Report 893* for ODOT. Within each step, it describes the project approach, as well as successes, challenges, and lessons learned. The full text of *NCHRP Research Report 893* can be found at the following link: (http://www.trb.org/NCHRP/Blurbs/178087.aspx)

Project Process

NCHRP Research Report 893 provides a methodology to address pedestrian safety performance. It describes a systemic approach, as opposed to a traditional crash history or "hot spot" approach, to proactively identify sites for potential safety improvements based on specific risk factors for pedestrians. Figure 1 presents seven key steps in a systemic pedestrian safety analysis process. The steps are depicted in linear sequence, but some steps may occur simultaneously, in different orders, or iteratively.

Figure 1: Steps in a Systemic Pedestrian and Bicycle Safety Analysis Process

The project has taken ODOT through the first five steps of the process outlined in *NCHRP Research Report 893*. Per ODOT direction, the countermeasures identified in Step 5 are intended to serve as illustrative examples for ODOT staff and local agencies to follow in the future when nominating safety projects. As a result, Steps 6 and Step 7 were not carried out as part of this project, since they require selecting, implementing, and then evaluating treatments.

The following section describes the approach for each step followed by a summary of the successes, challenges, and lessons learned.

Step 1 – Define the Study Scope

> "The first step of the systemic process is to define the study scope. This step sets the stage for all subsequent steps." – *NCHRP Research Report 893*

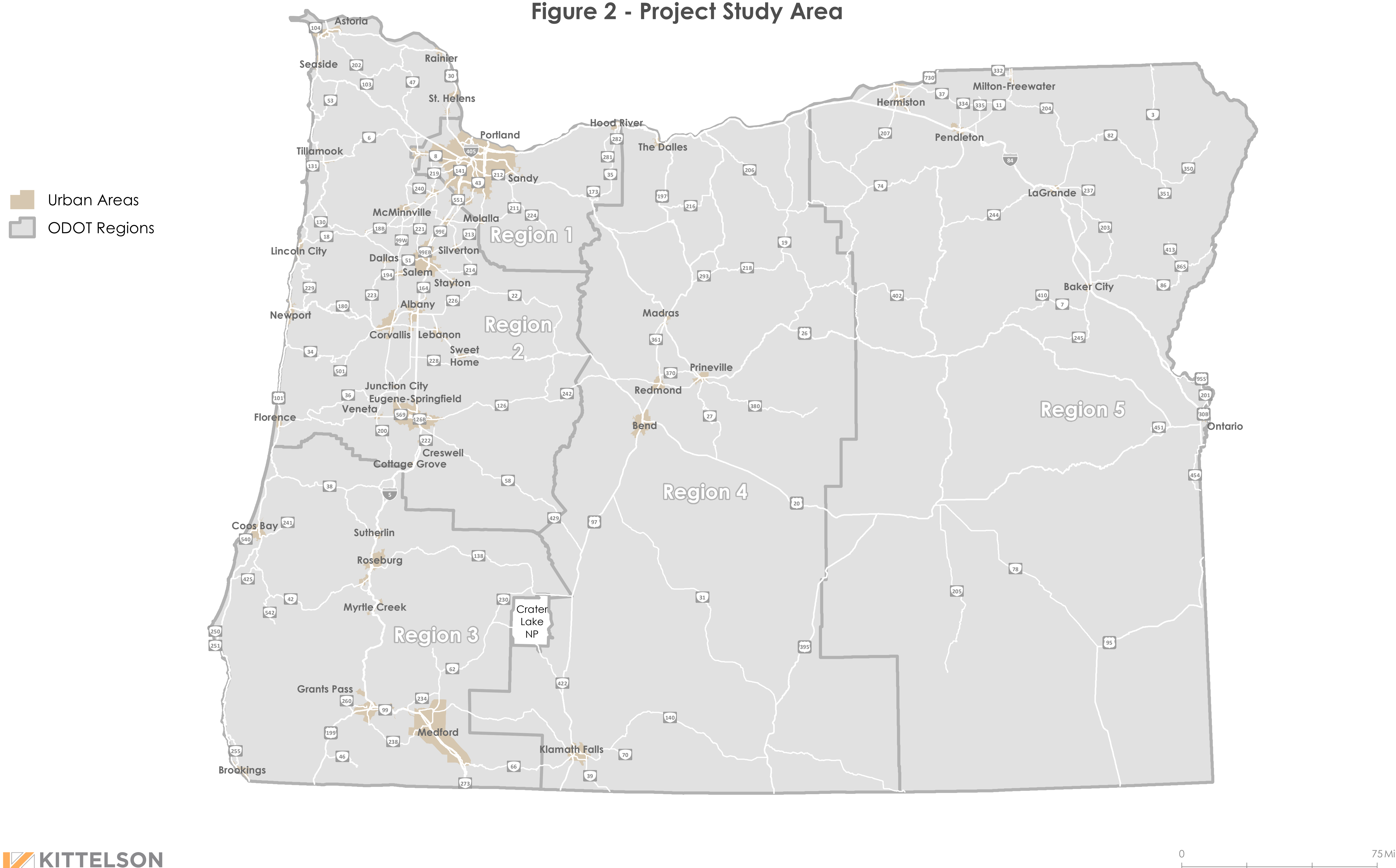
Project Approach

Step 1 involves defining the analysis area and identifying the focus facility type or location types. It sets the stage for subsequent steps.

Defining the Study Area

ODOT's goal was to create a statewide plan, therefore, the study area encompassed all public roadways in Oregon for which data are available from ODOT. Figure 2 illustrates the study area.

Figure 2 - Project Study Area



H:\23\23900 - NCHRP 20-44 - ODOT Ped Bike Safety Plan\gis\site selection\Final Report\02 - Project Study Area.mxd Date: 10/21/2020

KITTELSON & ASSOCIATES

Identifying One or More Target Facility or Location Type(s)

To determine whether any areas should receive increased attention, the project team developed pedestrian and bicycle crash trees. The crash trees use crash data provided by ODOT for the most recent 11 years for which data were available, 2007 to 2017. The pedestrian and bicycle crash tree analyses are shown in Figure 3 and Figure 4, respectively.

Figure 3: Pedestrian Crash Tree Analysis

8,877 PEDESTRIAN CRASHES IN OREGON (2007-2017)

	Urban 92.7%			Rural 7.3%		
	Intersection 62.9%	Driveway 8.1%	Segment 29.0%	Intersection 25.3%	Driveway 6.8%	Segment 67.9%
K	3.3%	2.2%	11.0%	6.7%	8.8%	22.9%
A	10.4%	8.2%	18.5%	12.1%	23.1%	16.8%
B	46.2%	43.1%	44.6%	53.5%	40.6%	40.9%
C	39.5%	45.6%	25.4%	27.7%	27.5%	19.0%
O	0.6%	0.9%	0.5%	0.0%	0.0%	0.4%

The pedestrian crash tree analysis shows approximately 93% of reported pedestrian crashes occurred in urban areas, which are defined by the Federal Highway Administration (FHWA) and include locations with populations of 5,000 or more. Similarly, the bicycle crash tree analysis shows approximately 95% of reported bicycle crashes across all severities, and approximately 88% of fatal and serious crashes, occurred in urban areas. Based on this finding from the pedestrian and bicycle crash tree analyses, ODOT staff recommended that *NCHRP Project 20-44 (13)* focus on urban areas, though rural areas should still be considered.

Figure 4: Bicycle Crash Tree Analysis

9,652 BICYCLE CRASHES IN OREGON (2007-2017)

	Urban 9,166 95%			Rural 486 5%		
	Intersection 6,264 68%	Driveway 1,842 20%	Segment 1,060 12%	Intersection 213 44%	Driveway 75 15%	Segment 198 41%
K	0.5%	0.3%	2.3%	4.0%	4.7%	11.1%
A	6.5%	5.4%	9.8%	10.3%	2.5%	18.9%
B	56.5%	56.3%	59.6%	60.4%	63.4%	50.5%
C	33.8%	35.2%	26.3%	23.9%	29.4%	18.6%
O	2.7%	2.8%	2.0%	1.4%	0%	0.9%

Successes

- The crash data were available in a format that allowed for quickly developing crash trees to help focus the analysis.
- Crash trees allowed high-level focus areas to be identified based on characteristics contained within the crash data.

Challenges

- ODOT was interested in focusing on fatal and serious injuries. However, this would have resulted in a smaller sample size for determining crash risk factors, even at the statewide level, for some risk categories. Careful consideration of crash severity should be given based on project scope, context, and jurisdiction priorities.
- At a statewide level, crash trees may group various contexts into larger categories that may obscure variations in crash patterns. For example, large cities, like Portland (population: 654,741), and small cities, like Scappoose or Madras (population: 7,564 and 7,051), are categorized as urban. Clearly the roadway, land use, and user contexts vary significantly between these communities. This is also true of the initial location types (i.e., intersection, roadway, and driveway) used in the analysis, with significant potential variation for crashes classified in these high-level groupings.
- Balancing urban and rural pedestrian and bicycle safety is a challenge when establishing focus areas for the systemic analysis. With the great majority of pedestrian and bicycle crashes occurring in urban areas, there is the potential that rural safety programs may be less competitive for funding opportunities. Determining the appropriate level of emphasis for urban versus rural areas requires assessing the trade-offs between reducing investments in urban areas and prioritizing funding to rural areas with fewer crashes than urban areas.

Lessons Learned

- To draw conclusions from the systemic analysis, practitioners must recognize the potential for bias based on low-frequency, but high-severity crash locations or trends.
  - This potential bias was noticeable in the crash analysis results when considering rural and urban trends against each other. Areas with fewer, but relatively more severe crashes may stand out compared to locations with a higher number of crashes, but a lower average severity (even though they may have more fatal or serious injury crashes than other locations), if only considering average severity as a metric.
  - Locations defined as "urban" vary in context. Safety countermeasures should only be recommended after reviewing the roadway characteristics, adjacent land uses, and urban contexts to ensure appropriate application.
  - Average severity of rural crashes is higher; however, rural crashes are fewer and more dispersed. Overall, prioritizing urban crashes may be more cost-effective on a per location/mile basis.

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[0] Population data provided by US Census: https://www.census.gov/data.html

Step 2 – Compile Available Data

> "A systemic approach is inherently data driven, as data are used to identify pedestrian safety risks, locate sites with high risk features, and evaluate the cost-effectiveness of various treatment alternatives. The purpose of this step is to provide guidance on how to compile the data that will be needed to support all future steps in the process." *– NCHRP Research Report 893*

Project Approach

Step 2 involved compiling data to support future steps. The project team obtained infrastructure, crash, sociodemographic, land use, and volume data from multiple agencies. ODOT provided most data. The project team also obtained data from Metro (the regional government for the Portland, Oregon, metropolitan area) and the cities of Portland, Eugene, and Bend. These agencies were identified based on their historical count programs. The team compiled only data made readily available in a geographic information system (GIS) form as part of Step 2. Table 1 illustrates a summary of the compiled dataset.

Table 1: Dataset

Data Type	Eugene	Portland	Bend	ODOT
Ped Counts				X
Vehicle Counts		X		X
Zoning	X	X	X	X
Parks	X	X	X	X
Schools	X	X	X	X
Transit Stops				X
Functional Class	X	X	X	X
Ped Facility	X	X	X	X
Bike Facility	X	X		X
Trails/Shared-Use Paths	X	X		X
Road Centerlines	X	X	X	X
Road Lanes			X	X
Road Shoulders				X
Road Speed	X	X		X
Marked Crossings				
Traffic Signals	X	X	X	X
Enhanced Crossings	X			X
Crashes 2007 - 2017				X
SPIS[1] Data 2009 – 2015				X

1. Safety Priority Index System (SPIS) – the system used by ODOT to rank high crash locations

Crash Data

ODOT provided the 11 most recent years of available pedestrian and bicycle crash data (2007-2017), including crashes where a pedestrian or bicyclist was struck. The project team filtered the dataset to exclude crashes on interstates or other fully access-controlled facilities. The resulting dataset includes 18,529 crashes.

The crash data themselves contain useful information for identifying risk factors. They contain infrastructure- and user-action-related items, including, for example, whether the crash occurred at an intersection or involved a turning movement; and whether or not the pedestrian or bicyclist was crossing the road or walking/biking along the shoulder/sidewalk.

Land Use and Demographic Data

Eugene, Bend, and Metro (the Portland area metropolitan planning organization) provided land use data including zoning and parks. ODOT also provided zoning data through the Oregon Spatial Data Library (OSDL). The project team obtained statewide school location data through Longitudinal Employer-Household Dynamics (LEHD, 2017). American Community Survey 2017 estimates (ACS, 2017) provided population, employment, and walk-to-work data by block group.

The project team used these data to identify potential risk factors and treatment sites as described in Steps 3 and 4.

Exposure (Count) Data

ODOT provided the 10 most recent years (2009-2018) of pedestrian count data for state and local facilities.[*] The data included 510 unique sites and identified pedestrian peak hour volumes as well as daily crossing volumes. The locations of pedestrian count data represent a broad range of facility types and contexts throughout Oregon. The project team collected additional pedestrian count data from Metro, City of Portland, City of Bend, and City of Eugene.

The project team explored estimating pedestrian volumes by using models developed for Caltrans (Griswold, 2019). These models estimate the number of crossing pedestrians at California highway intersections. The project team applied these models to ODOT highways and compared the results to the pedestrian crossing count data provided by ODOT. While the model produced count estimates that varied from the actual counts, it was generally able to predict the highest-count locations (i.e., the actual count ranking compared to the model estimate ranking was within 10% of the same percentile for 72% of the site and within 5% for about 60% of the site).

The project team used the models to estimate pedestrian crossing volumes on state highway segments. The segments were divided into high, medium, and low volume estimate categories. The project team compared these categories to the crash data but found no meaningful correlation between estimated activity level and crash frequency. Therefore, the count estimates produced by the models were ultimately not used as part of this project.

In this project, exposure is likely accounted for in the principal arterial, number of lanes, transit stops, mixed-use zoning, and schools risk factors.

Successes

- ODOT had a number of datasets available to include in a systemic analysis of the state highway system. Building and maintaining these datasets has been a focus of the agency’s over the last several years and it allowed the project team to complete a more robust analysis than was possible when ODOT completed its 2014 systemic bicycle and pedestrian safety plan.

[*]ODOT also provide the 10 most recent years of bicycle count data for state and local facilities; however, analysis was conducted utilizing the bicycle count data due to the pedestrian exposure model providing no meaningful correlation.

Challenges

- While many of the data were available in GIS formats, not all data elements were easily linked together. The data needed to be processed and cleaned further to generate a comprehensive database.
- Supplemental data for roadways not on the state highway system were not consistently available, only available as partial coverage of a jurisdiction's network, coded differently from jurisdiction to jurisdiction, or available only in a tabular or document format. As a result, the local agency data were not included in the analysis.
- Intersection-level data were limited to an understanding of the characteristics of the roadways approaching an intersection as well as the locations of signalized intersections. Detailed data on the intersection characteristics most strongly associated with pedestrian or bicycle crash risk in the literature (e.g., number of turn lanes, volume of left-turning movements, pedestrian crossing treatments, etc.) were not available for intersections along the Oregon statewide highway system, creating the project-specific challenge of understanding the factors impacting walking or biking crash risk at intersections.
- Available pedestrian and bicycle exposure data was limited in its geographic and location-type coverage.
- Bicycle and pedestrian crash research shows that crashes involving people walking or biking are often underreported. The degree to which such crashes are underreported in the ODOT data is unknown, but this could introduce some uncertainty in the analysis.

Lessons Learned

- Step 2 directly informs the work that can be completed in Steps 1 and 3. Therefore, Step 2 will likely begin with Step 1 and may be revisited while Step 3 is being carried out.
- Pedestrian exposure models developed in other states may not be directly applicable in a different context. It may be possible that they could be calibrated or re-fit to data in the state they are being transferred to. Conducting initial exploratory analysis of candidate models may provide further insights into their potential applicability.
- Crash data can contain multiple fields that presumably address the same characteristic but are coded differently. For example, in Oregon, crashes are coded as involving a bicyclist or pedestrian at the crash (summary) level and at the participant level. There was variation in when crashes were coded as pedestrian- or bicyclist-involved at the crash level and when a pedestrian or bicycle was coded as a participant in the crash. For example, approximately 4.5% of pedestrian involved crashes are not coded as "PED" crash types (~36 crashes per year). For bicycles, it is only 0.5% (~4 crashes per year). Due to this potential ambiguity in how a pedestrian or bicyclist crash is defined, it is essential that practitioners take a detailed approach in reviewing and analyzing crash datasets and clearly define analysis parameters to maintain consistency and accuracy in the subsequent steps.

Step 3 – Determine Risk Factors

> "The purpose of this step is to identify treatable crash risk factors that can be used to identify locations across the network for potential systemic treatments." – *NCHRP Research Report 893*

Project Approach

Step 3 involved analyzing the data collected as part of Step 2 to determine risk factors associated with pedestrian and bicycle crashes. Table 2 summarizes the variables investigated as part of the pedestrian risk process.

Table 2: Data Variables

Data Element	Source
Functional Classification	Crash Data Roadway Inventory and Classification Unit Services (RICS)
Number of Lanes	Crash Data (RICS), ODOT, Metro, Bend
Median Type	Crash Data (RICS)
Posted Speed	Crash Data (RICS), Portland, Metro, Eugene
Sidewalk Presence	ODOT, Metro, Bend, Eugene
Shoulder Width	ODOT
Schools Nearby	OSDL, Eugene, Bend, Metro
Transit Stops Nearby	ODOT
SPIS Locations	ODOT
Land Use/Zoning	OSDL, Eugene, Bend, Metro
Driveway Density	ODOT
Annual Average Daily Traffic (AADT)	ODOT

Risk Factors

The project team identified and categorized risk factors from this analysis based on roadway characteristics and context factors (i.e., proximity to transit and schools). The project team reviewed the initial list of potential risk factors against the factors identified in *NCHRP Research Report 893*, the list of potential countermeasures to be used in Step 5, and each other (for possible overlap). Based on this review, the project team identified the pedestrian and bicycle risk factors shown in Table 3 and Table 4. Most of these factors were used in the site selection process in Step 4. Some could not be used because of their lack of availability across the state highway system.

Demographic Risk Factor

After the initial list of risk factors was developed by the project team, ODOT asked that the project team evaluate older and younger populations, as these are both emphasis areas in ODOT's Strategic Highway Safety Plan. The analysis found a correlation between populations 65 years and older and crash risk. The "High" Population over the Age of 64 risk factor includes the top 40% of Census block groups in the state based on the proportion of people above the age of 64 living in the block group.

Table 3: Pedestrian Risk Factors

Risk Factor	Facility Type	Urban	Rural
Roadway Characteristics			
Principal Arterial	General	X	X
Number of Lanes (>= 4 Lanes)	Segment	X	X
High-Access Density	Segment	X	
No Sidewalks (or Only One Side)	Segment	X	
Posted Speed (>=35 mph)	Segment	X	X
Context			
Mixed Use Zoning	General	X	
Other Zoning	General		X
Proximity to Schools (1 Mile)	General	X	X
Proximity to Transit Stops (1/4 Mile)	General	X	X
Demographics			
High Population over the Age of 64	General	X	X
Other Risk Factors (Not Used in Screening Due to Data Availability)			

Risk Factor	Facility Type	Urban	Rural
High-turning Volumes at Intersections	Intersection	X	X
Left-turn Signal Phasing	Intersection	X	X
Lighting	Intersection	X	X
Propensity for Mid-block Crossings	Intersection/Mid-block	X	X
Exposure	Intersection	X	X

Table 4: Bicycle Risk Factors

Risk Factor	Facility Type	Urban	Rural
Roadway Characteristics			
Principal Arterial	General	X	X
Minor Arterial	General	X	
Number of Lanes (>= 4 Lanes)	Segment	X	X
Posted Speed (>=35 mph)	Segment	X	X
No Bike Lanes	Segment	X	
Context			
Mixed Use Zoning	General	X	
High Density Access (>80 driveways per mile)	Segment	X	
Proximity to Schools (1 Mile)	General	X	X
Proximity to Transit Stops (1/4 Mile)	General	X	X
Demographics			
High Population over the Age of 64	General	X	X
Other Risk Factors (Not Used in Screening Due to Data Availability)			
Scenic Bikeways	General	X	X
Time of Day	General	X	X
Lighting	Intersection	X	X

Successes

- The risk analysis correlated some roadway characteristics to the bicycle and pedestrian crash data to establish relationships between the roadway characteristics and potential crash risk.
- The risk factors identified in the analysis were supported by the research literature, indicating consistency with the project team analysis and established practices.
- The ODOT crash dataset was comprehensive enough to evaluate some risk factors without any supplemental data. The crash database includes geolocated crash event information, as well as some roadway characteristics (i.e., functional classification, number of lanes, intersection traffic control, and median type) for all reported crashes.
- Three larger urban agencies in Oregon (the Cities of Portland, Bend, and Eugene) were able to provide additional pedestrian and bicycle infrastructure data (like sidewalks and bike facilities) and land use information to supplement the statewide crash analysis.
- There were sufficient data to identify risk factors in urban and rural areas, though rural areas had a much smaller sample size for the analysis.

- The project team successfully used the equivalent property damage only (EPDO) safety performance metric to aid in prioritizing risk factors and establish the relative severity of each crash risk factor.

Challenges

- Pedestrian exposure models imported from Caltrans did not produce results that were useful in correlating pedestrian exposure with crash risk.
- There were significantly more data variables available in urban areas and on state highways. This may have introduced some bias when identifying risk factors.
- Not all desired data elements were available for the entire state.
- Many risk factors are related (e.g., speed and functional class) and it was not possible to accurately account for that within the scope of this project's approach.
- Piecing together a statewide dataset from individual agencies required a significant amount of data processing and cleaning, as each dataset was coded differently. Future analyses would be more efficient if there was a state-maintained database of local roadway and land use characteristics.

Lessons Learned

- Some risk factors could not be analyzed because of limited data. The project team overcame this limitation in some cases by relying on the literature to establish the relationship between the risk factor and crash risk.
- Pedestrian exposure models developed in one state may not be readily transferable to another state. The Caltrans models were able to generally predict activity levels across broad tiers but were not accurate enough in the Oregon context to be useful to this project. Possible future approaches could include refitting existing models from other states using Oregon data or developing Oregon-specific models. As part of piloting the pedestrian exposure modeling for Oregon, the project team identified the following for further exploration and refinement in future efforts:
    - Tourist areas and destinations were outliers when estimating exposure using the Caltrans methodology and given the large variety of contexts across the state (urban areas, small towns, tourism-oriented cities, rural communities, recreational land)—statewide volume estimates will likely require more place-type specific calibration or estimation processes.
    - Segment pedestrian volume data is limited, and most estimation models are based on intersection pedestrian volumes. The project team calculated segment volumes by inferring relative volumes from intersections but this approach will require refinement if it is to be used as a reliable measure of pedestrian (or bicyclist) exposure.
    - When calculating parameters for volume estimation at a statewide level, providing quality control over the entire state is infeasible without a significant investment of time and consistent quality control practices. Assumptions and limited verification were required to complete the analysis within budget for this project. Future efforts should account for this need to confirm accurate data inputs and results.
    - Local count data formats are often created and stored using different approaches that can make synthesizing them into a statewide database for calibration difficult. Additionally, while local agency data can help supplement and deepen available analysis parameters, integrating these in a statewide effort is difficult given the variety of data formats,

collection methods, collection periods, and consistency. Utilizing a consistent data format across datasets is vital to performing an accurate analysis.

- Establishing early consensus with the project team and stakeholders on the project's analysis approach, including the parameters to be evaluated, and compiling a master dataset of all bicycle and pedestrian related data (crashes, infrastructure, volume, etc.) was useful. This process clearly defined the scope of the risk analysis and reduced the potential for having to redo or update analyses.
- The overall process employed in this project is transferrable to other state and local jurisdictions. However, the time and budget necessary to complete a similar analysis will vary significantly based on the accuracy and completeness of the data available for any given jurisdiction.
- If comprehensive data is sparse at the statewide level, orientating the analysis around a subset of urban and rural areas with more complete data sets could help focus the analysis and allow for generalized statewide risk factors to be developed from each subset and confirmed through future analyses as data becomes available.

Step 4 – Identify Potential Treatment sites

> "In this step, the goal is to identify candidate sites across the entire roadway network with the greatest potential for future crashes that an agency would want to address. These should bear relation to the crash types or locations of interest (from Step 1) and have key risk factors present (identified in Step 3)." – *NCHRP Research Report 893*

Project Approach

Step 4 identified candidate sites with the greatest crash potential. This was accomplished using the risk factors identified in Table 3 and Table 4 through the following steps:

1. **Weighting the risk factors based on their EPDO scores.**

To capture both frequency and severity of crashes, EPDO scores were calculated. The EPDO method is a useful way to consider both crash frequency and crash severity in a single metric. Each crash was assigned a score based on severity. Property Damage Only (PDO) crashes were assigned a score of 1, non-serious injury crashes were assigned a score of 10, and severe injury and fatal crashes were assigned a score of 100 (these relative weighting factors are consistent with the ODOT Safety Priority Index System calculations). These scores were then aggregated for different risk factors as part of the evaluation process, thereby ensuring that the risk factor identification process was not driven solely by crash frequency. The results of the risk factor weights for pedestrian and bicycles are summarized in Table 5 and Table 6.

Table 5: Pedestrian Risk Factors Screening Weights

Risk Factor	Risk Factor Weights	
	Urban	Rural
Principal Arterial	1.24	1.46
Number of Lanes (>= 4 Lanes)	1.55	1.73
High-Access Density	1.64	--
No Sidewalks (or Only One Side)	1.38	--
Posted Speed (>=35 mph)	1.83	1.63
Mixed-Use Zoning	1.00	--
Other Zoning	--	1.45

Risk Factor	Risk Factor Weights	
	Urban	**Rural**
Proximity to Schools (1 Mile)	1.03	1.17
Proximity to Transit Stops (1/4 Mile)	1.08	1.00
High Population over the Age of 64	1.00	--

Table 6: Bicycle Risk Factors Screening Weights

Risk Factor	Risk Factor Weights	
	Urban	**Rural**
Principal Arterial	1.13	1.39
Minor Arterials	1.07	--
Number of Lanes (>= 4 Lanes)	1.08	--
Posted Speed (>=35 mph)	1.11	1.09
No Bike Lane	1.06	--
High-Access Density	1.02	--
Mixed-Use Zoning	1.00	--
Proximity to Schools (1 Mile)	1.01	1.00
Proximity to Transit Stops (1/4 Mile)	1.03	1.03
High Population over the Age of 64	1.00	1.00

2. **Using these weighted values to score state highway segments.**

3. **Dividing the scored segments into quintiles (i.e., 20% bins) based on urban/rural contexts.**

The project team worked with ODOT's staff to identify 25 pedestrian and 25 bicycle high-risk sites for further evaluation. These sites were typically selected from the two highest risk categories with the following objectives in mind: (1) The sites represent a range of land-use contexts; and (2) They include sites with no, or limited, crash history. Preference was given to sites in the top 20% of risk factor scoring, but sites from lower tiers were also needed to meet these criteria.

Successes

- The analysis used EPDO scores to weight risk factors to assist ODOT in prioritizing locations to evaluate for systemic improvements.
- The GIS-based screening analysis conducted in this step was relatively efficient and comprehensive for the state highway system. The analysis approach benefits from economies of scale—where consistent data are available over a larger area, the relative increase in analysis time is minimal once crash risk factor associations are established.

Challenges

- There were crash risk factors established in the literature that could not be evaluated (see Step 3). Continuing to expand the collected data, particularly for walking and biking facilities and intersections, will allow for more detailed crash risk analysis and screening in the future.

Lessons Learned

- When evaluating locations based on risk factors, very small segments may result. This is caused by the variation in the presence of a given risk factor (e.g., sidewalk presence varying along a corridor). This can result in a series of short, high-scoring segments that are discontinuous or minimally separated by lower-scoring segments. Additionally, similar scoring segments may also remain separate when summarizing based on risk factor presence due to a difference in the risk factors present (even if the total score is the same).
    - Simplifying the roadway network based on total risk score or scoring values into quantile groups for aggregation could provide a streamlined process.
- Additionally, the network could be segmented into a consistent unit and a weighted average score calculated for each pre-defined segment based on a risk factor's presence/absence over the segment. This approach may help a jurisdiction develop high-priority improvement locations versus the more detailed, but more segmented approach, used in this analysis.

Step 5 – Select Potential Countermeasures

> "Now that the risk factors have been determined (Step 3) and locations having these risk factors have been identified (Step 4), the next step is to identify appropriate countermeasures or combinations of measures that could potentially address risks identified." – *NCHRP Research Report 893*

Project Approach

Step 5 included identifying countermeasures that could potentially address identified risks at each of the sites selected in Step 4.

The project team identified potential countermeasures based on the ODOT ARTS list, the FHWA Proven Safety Countermeasures and Crash Modification Factors (CMF) Clearinghouse, and other relevant literature. Potential countermeasures were only included if a crash reduction factor (CRF) was identified.

The process for selecting potential countermeasures at each of the 50 sites (25 pedestrian- and 25 bicycle-related) identified in Step 4 included the following steps:

1. Reviewing existing conditions at the potential treatment site, including traffic and roadway data, land use context, crash history, and risk factors present.

2. Based on this review, determining potentially relevant countermeasures.

3. Assessing the feasibility of countermeasure implementation based on review of aerial and street-level imagery.

The project team's recommended countermeasures were not programmed for implementation at the direction of ODOT. Instead, the countermeasures are intended to serve as illustrative examples for ODOT staff and local agencies to follow in the future when nominating safety projects.

Successes

- ODOT has established an effective list of pre-defined approved countermeasures and CRFs for addressing pedestrian and bicycle crashes.

- ODOT now has flexibility in its countermeasure selection process to efficiently add in new countermeasures and to allow for the creation of interim CRFs based on the best knowledge available at the time.
- The project team used the literature to identify risk factors that could not be accounted for in the Step 4 screening process (e.g., permissive left-turn signal phasing) and identify countermeasures to address them.

Challenges

- While the risk analysis was able to identify sites that would most benefit from systemic bicycle and pedestrian treatments, some of the evaluated sites would require expensive and intensive improvements (e.g., widening a corridor for sidewalks or bike lanes) and may not be fundable through a systemic program focused only on low-cost countermeasures.

Lessons Learned

- The risk factors present at some sites may not be candidates for lower cost systemic countermeasures (e.g., a built-out urban arterial without a sidewalk or bike lanes may require a more extensive capital project to address those particular risk factors). Balancing the more extensive needs of these high-priority sites with lower-cost improvements at multiple other locations will involve judgment of how best to address systemic crash risk.

Transferability and Other Considerations

NCHRP Project 20-44 (13) was carried out with an understanding that other state DOTs will likely have an interest in conducting a similar systemic safety process for their respective statewide networks. For that reason, the project team prepared documentation with a lens towards transferability throughout the project development. The following section summarizes key transferability and other considerations for replicating the *NCHRP Research Report 893 process.*

- Data availability and consistency is critical—ODOT has a robust dataset that is consistent statewide (for state highways) and relatively straightforward to combine and connect to crash data. States with less consistent datasets or data gaps may need to focus on data collection or improving datasets to effectively evaluate pedestrian or bicyclist crash risk. Additionally, these jurisdictions may consider supplementing their analysis based on risk factors established in the literature as an interim measure while data needs are addressed. This may limit the ability to screen a network based on the presence of crash risk factors but would allow the agency to select effective countermeasures for a range of situations and integrate systemic improvements into other project development processes.
- For local jurisdictions, many agencies will not have as much data available as ODOT or other state DOTs. Available data should be used to develop risk factors and screen networks, as possible, while using statewide or research-based risk-factors to supplement where data are not yet available. Data collection efforts should focus on first completing partially available datasets and supplementing with additional and more detailed datasets for future analyses.
- Exposure models would be useful to account for the relative crash risk per person walking or biking. The ODOT analysis was not able to develop a reliable exposure model. As a result, some crash risk factors may have been over- or under-prioritized if exposure was accounted for. Developing a reliable exposure model will require collecting walking and biking activity data at a wide variety of location types and geographies.

- Syncing all data sources so they naturally connect with one another would create a more efficient analysis and reduce the time and effort necessary to compile datasets into a consistent database.
- States could engage local agencies in the process of completing a systemic plan that will affect safety project and program funding. This includes helping local agencies understand how they can use the data they have to implement the process and how they can work through situations where their data may be lacking (e.g., using literature or a statewide analysis to supplement their work).
- Data availability and collection is critical for improving systemic risk analyses. Exposure data will be particularly helpful to understand how crash risk varies per person walking or biking rather than relying solely on crash frequencies. Datasets should be updated on an ongoing basis and new datasets or data fields added as time allows and the safety practice continues to evolve.
- Do not let perfect get in the way of good. Developing analysis methods and approaches based on the best available data and staff time will help an agency address bicycle and pedestrian crash risk in its jurisdiction. Getting the approaches started is a valuable first step to support safety goals. Program improvements to the evaluations and datasets used as part of a first effort at systemic safety screening can always be made in updates to the plan while actively working to address systemic crash risk.

Chapter 3. Conclusion

Conclusions

NCHRP Project 20-44 (13) successfully documented the *NCHRP Research Report 893* process and applied the methods to Oregon's statewide highway system to identify high risk locations for pedestrian and bicycle crashes statewide. While the *NCHRP Research Report 893* process is intended to serve as a systemic safety approach for pedestrians, *NCHRP Project 20-44 (13)* successfully transferred the methods and approach to bicycles.

Suggested Research

This section lists suggested future research to build upon and improve the results of *NCHRP Project 20-44 (13)* when carried out by state DOTs and other agencies.

Follow-Up Research

The following research activities would build upon this project's work:

- **Conducting a detailed systemic crash risk analysis for pedestrians and bicyclists at intersections.** Intersection risk analysis was limited by the available data for this study. Further research could help agencies proactively address bicycle and pedestrian intersection safety and identify intersection crash risk factors.
- **Developing flexible approaches to estimating pedestrian and bicycle exposure.** The statewide exposure model adapted from Caltrans was not transferable and did not account for the wide variety of contexts for Oregon's communities. Continuing to develop approaches to reliably estimate pedestrian and bicycle exposure, especially for large areas without the need for extensive calibration, will be an important step for improving systemic crash risk analysis. Developing methodologies to reliably extrapolate short-term intersection counts to segment exposure estimates would improve crash risk evaluation efforts.
- **Continuing to expand understanding of bicycle and pedestrian treatments' safety effects.** Bicycle and pedestrian safety treatments and infrastructure are continuing to evolve at a rapid pace. Additional research is needed to keep pace with these innovations and changes to the walking and biking environment while deepening our understanding of current treatments as they are more widely adopted by agencies over time.

Chapter 4. References

References

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