ADDRESSING OREGON’S RISE IN DEATHS AND SERIOUS INJURIES FOR SENIOR DRIVERS AND PEDESTRIANS

Final Report

PROJECT SPR 828

Oregon Department of Transportation

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SPR 828

by

Christopher Monsere, Ph.D., P.E., Professor
Jason C. Anderson, Ph.D., Research Associate
Sirisha Kothuri, Ph.D., Senior Research Associate
Portland State University

David Hurwitz, Ph.D., Associate Professor
Cadell Chand, Graduate Research Assistant
Oregon State University

for

Oregon Department of Transportation
Research Section
555 13th Street NE
Salem OR 97301
and
Federal Highway Administration
1200 New Jersey Avenue SE
Washington, DC 20590

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16. Abstract: The research reviewed best practices, identified overrepresentations of serious crashes involving older drivers and pedestrians using Oregon crash data, and mapped the best practices and countermeasures. From 2013 to 2016, there were 884 older driver and 112 older pedestrian fatal and serious injury crashes. Older driver fatal and serious injury crashes most often occurred between 3 to 6 p.m., on Mondays, on rural principal arterials, at intersections, and within 20 miles of a driver's home. Fixed-object, turning-movement crashes were the most frequent crash types. Not at fault, not yielding the right-of-way, and speeding too fast for conditions were the most frequent driver-level causes. Older pedestrian fatal and serious injury crashes most often occurred between 3 to 6 p.m., on Friday, at intersections. Crossing between intersections and crossing at an intersection without a traffic signal was the most frequent pedestrian action. Crash proportions were statistically different for the time of day, day of the week, roadway classification, and various participant-level crash causes. A population-based crash rate analysis found county-level differences in older driver fatal and serious injury crashes in Oregon (Harney) and for pedestrians (Baker, Morrow, Curry, Hood River, Umatilla, and Washington). Using a comprehensive list of potential countermeasures and input from key stakeholders at a workshop, specific recommendations were generated to improve older driver and pedestrian safety. The priority focus areas were identified for older drivers as intersections, rural principal arterials, and licensing and education. For older pedestrians, treatments to improve pedestrian visibility and illumination, manage left turns, and to shorten crossing distances were recommended.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
~NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit	(F-32)/1.8	Celsius	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
m^2	meters squared	1.196	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius	1.8C+32	Fahrenheit	°F

*SI is the symbol for the International System of Measurement

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

In the U.S., older drivers accounted for 18% of all traffic fatalities in 2016, representing a 3% rise from 2015 (NHTSA, 2015; 2016). In Oregon, 19.8% of the fatalities involved older drivers in 2016 (NHTSA, 2016). In this report, drivers and pedestrians age 65 years and older are defined as "older drivers" or "older pedestrians." Despite lower per population crash involvement rates for older drivers relative to younger and middle-aged drivers, older drivers in Oregon have the highest fatal involvement of any other age group tracked by the Oregon Department of Transportation (ODOT). The rate of fatality and serious injury of older drivers has been increasing, triggering the Special Rule for Older Drivers and Pedestrians (SRODP) in the "Fixing America's Surface Transportation (FAST)" Act. According to the SRODP, Oregon must include strategies to address this issue in its State Strategic Highway Safety Plan (SHSP) update.

The objective of this research was to help ODOT satisfy the requirements set forth by the SRODP by developing strategies to address older driver and pedestrian safety issues. Oregon may include these strategies in the SHSP update. This research included:

1. Identifying where there is an overrepresentation of serious crashes involving older drivers and pedestrians using Oregon crash data,

2. Conducting a review of best practices locally and nationally, and

3. Mapping the best practices and countermeasures to Oregon such that significant improvements to older driver and pedestrian safety result both in the short and long term.

This *Final Report* summarizes the research and is organized into six chapters. Chapter 2 presents a brief literature review. Chapter 3 presents the analysis of crash data for older drivers and pedestrians, particularly focusing on fatal and serious injury crashes. Chapter 4 describes the list of potential countermeasures to improve the safety of older drivers and older pedestrians to the crash patterns. Chapter 5 presents the findings of a workshop that was conducted to identify policies and procedures that could be modified based on crash data analysis and review of best practices. Chapter 6 summarizes the findings of the major research tasks, synthesizes the results, and presents recommendations for improving older driver and pedestrian safety. Cited references are presented in Chapter 7.

2.0 LITERATURE REVIEW

The literature on older driver safety is complex and deep, covering topics from engineering, planning, psychology, and health fields. This review is not comprehensive but aims to highlight the most important topics for this research project. The research team reviewed design manuals, guidance documents, and published literature with a focus on older driver and pedestrian safety. The chapter is organized by topical area and concludes with a brief summary of findings.

2.1 LICENSING AND ASSESSMENT

One of the challenges with older driver safety is identifying when a person can no longer satisfactorily complete the driving task. As discussed in Lanford et al. (2006), some age-related impairments can be manifested in driving problems. Table 2.1 summarizes these potential issues.

Evidence, however, shows that older drivers are likely to self-regulate. Older drivers who feel they have reduced driving function will choose not to drive in unsafe conditions or conditions outside of their perceived abilities (Charlton et al., 2006). However, certain physical performance measures may not be an accurate indicator of driver safety and often need further evaluation. For example, older drivers with better visual performance were less likely to self-regulate, decreasing their level of caution and increasing their crash risk (Keay et al., 2009).

Table 2.1: Age-Related Impairments and Associated Driving Problems (Adapted from Langford et al., 2006; Adapted from Suen and Mitchell, 1998)

Age-related impairments	Driving problems
Increased reaction time; Difficulty dividing attention between tasks	Difficulty driving in unfamiliar or congested areas
Deteriorating vision, particularly at night	Difficulty seeing pedestrians and other objects at night; Difficulty reading signs; Difficulty with wet weather driving
Difficulty judging speed and distance	Failure to perceive conflicting vehicles; Accidents at intersections
Difficulty perceiving and analyzing situations	Failure to comply with Give Way signs, traffic signals, and railway crossing signals; Slow to appreciate hazards
Difficulty turning head and reduced peripheral vision	Failure to notice obstacles while maneuvering; Failure to observe traffic behind when merging and changing lanes
More prone to fatigue	Get tired on long journeys; Run-off-road single vehicle crashes
General effects of aging	Worries over the inability to cope with a breakdown, driving to unfamiliar places, at night, in heavy traffic
Some impairments vary in severity from day to day; Tiredness, symptoms of dementia	Concern over fitness to drive

Despite this self-regulation, older drivers are often not aware of all of the changes that are happening to their bodies (Levi et al., 2013) and it is critical that physicians evaluate these changes for them. Oregon is one of the states that already requires physicians to report those with cognitive or functional impairments to the Driver and Motor Vehicle Services Division (Potts et al., 2004). There is no work done on the association between this requirement and fatal crash involvement rates. In general, this responsibility can be challenging for medical professionals who are often reluctant to be the primary judge of an older person's ability to drive safely. An additional challenge with age-based licensing is that age alone may not be an accurate indicator of crash risk. One study showed that amongst older drivers, those between 70-79 years of age were more likely to make gap acceptance errors while those over 80 years of age were less likely to make gap acceptance errors and more likely to be unaware of oncoming vehicles (Sifrit et al., 2011).

Still, the research suggests that any older driver assessment has proven to be better than no program. States with a valid and reliable system for assessing the competency of older drivers have seen an average reduction of 31% in the fatal crash involvement rates of drivers 85 and older (Tefft, 2014). Changes in renewal period frequency do not seem to have an association with fatal crash involvement rates for older drivers (Tefft, 2014). A summary of key provisions of state laws about older driver licensure and screening is located in Appendix B.

2.2 EDUCATION, AWARENESS, AND SELF-REGULATION

A critical and often overlooked element to improving older driver safety as identified by the National Cooperative Highway Research Program (NCHRP) is to improve older driver competency regarding local driving laws (Potts et al., 2004). For example, the majority of resources in Florida for improving older driver safety are allocated to education and awareness programs (FDOT, 2017). Another study also suggests that education is a more sustainable solution to increasing older driver safety than older driver licensure testing and screening (Keskinen, 2014). This study suggests a five-level hierarchy (Figure 2.1) to guide the development of older driver education programs. Partnerships with insurance companies may also yield opportunities to improve education and awareness of older driver safety. For example, Arizona has collaborated with insurance agencies to offer discounts to older drivers who complete defensive driver courses (ADOT, 2014).

Improvements in vehicle technology have improved safety for all roadway users. Still, there has been limited access to training on the proper use of vehicle safety technology, specifically for older drivers (Hewitt and Evans 1999). Specific technologies may even increase older driver crash risk when older drivers are unsure of how to use the technology, such as in-vehicle voice-activated phone systems (Young and Regan, 2007). The potential safety benefits of vehicle technology likely outweigh the disadvantages. Arizona is encouraging the use of existing technologies, such as in-vehicle lane-departure warning systems, with its older driver population (ADOT, 2014). Arizona is also allocating resources to promoting the research and development of autonomous vehicles as a strategy to increase older driver safety (ADOT, 2014). A data collection program in partnership with insurance companies in Arizona is identifying the ways older drivers use in-vehicle safety features through insurance installed in-vehicle monitoring devices (ADOT, 2014).

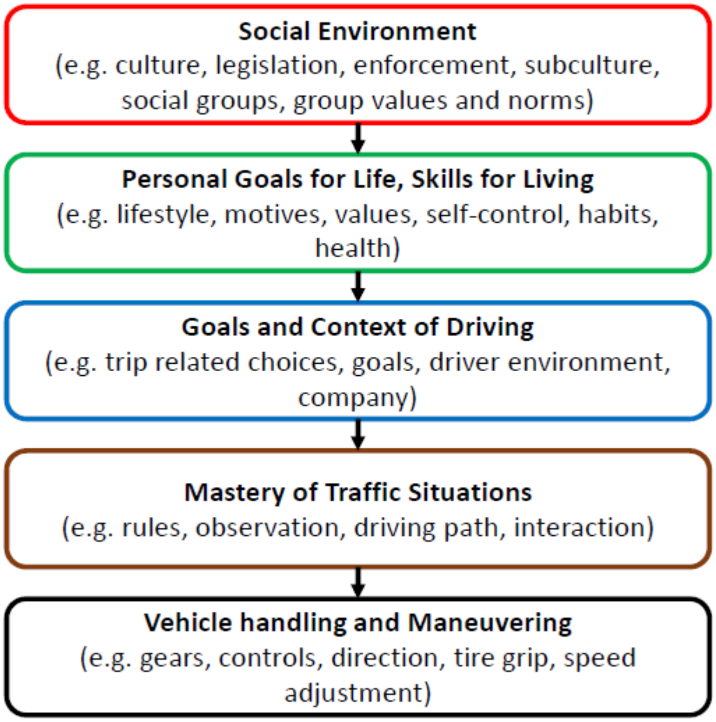

Figure 2.1: Five-level hierarchy for older driver education (Keskinen, 2014)

Driver beliefs and perceptions s about driving influence driving behaviors. Due to these influences, some older drivers choose to cease driving. Neal and colleagues in 2018 conducted a cross-sectional study that surveyed both existing drivers and those who stopped driving to identify influences that would lead to driving cessation. The study results revealed that older and female drivers 10 years over the average age of surveyed drivers (84 years old) were more likely to voluntarily cease driving (Neal, M, 2008). Additionally, the study found that individuals who claimed to have ceased driving, reported that they would still drive if they felt they needed to (Neal, M, 2008). This finding has significant implications as these populations face unique challenges due to physiological or pathological age-related changes which may not have been considered in prior policy changes to effectively operate a vehicle safely. If older populations are choosing to drive post driving cessation, much of their common skills could be in decline and this could lead to dangerous driving conditions for both the older driver and other road users.

The American Automobile Association (AAA) (2019) evaluated self-reported driving patterns of older adults using questionnaires and GPS/datalogger with the aim of understanding both exposure, patterns and self-regulation. The results showed that those aged 75 to 79 years had the lowest exposure of driving, were likely to have the shortest trips (i.e., within 25 miles of home), and the lowest percentage of trips during evening and PM rush hour (Molnar, 2019). This study also identified that women had lower driving exposure with regards to trips, miles, and minutes per month (Molnar, 2019). Understanding exposure and travel patterns of this population will help improve driving instruction, and implementation of future infrastructure and roadway design that will not only accommodate but also improve the safety of older adult drivers.

2.3 INTERSECTIONS

Intersections, due to their complexity and crossing traffic streams, are typically a crash potential for all road users. For older road users, however, navigating the challenges at intersections can be more difficult. Studies have shown that older drivers are more than 10 times as likely to be involved in a fatal multiple-vehicle crash at an intersection as middle-aged drivers and are over-represented in fatal crashes while performing a left-turn maneuver (Potts et al., 2004). Oxley et al. (2006) identified some issues at intersections that contribute to older driver crashes. In their research, they reviewed crashes at 62 sites in Australia involving older drivers (aged 65 years and above) with crashes per site ranging from 11 to 89. Their study identified the lack of separate traffic signal heads, limited or restricted sight distance at left turns, and use of less than 2.5 seconds for perception-reaction time (PRT) in design as the top three factors contributing to older driver crash risk at these locations. The same study summarized each factor into eight categories and ranked each category by cumulative percentage effect on older driver crash risk (Figure 2.3).

In 2004, the Institute of Transportation Engineers (ITE) and FHWA jointly published *"Older Drivers at Intersections,"* which described the engineering solutions that could be applied at intersections to improve older road user safety (ITE, 2004). Table 2.2 summarizes these recommendations. In the following subsections, additional details and discussion are provided about many of these recommendations.

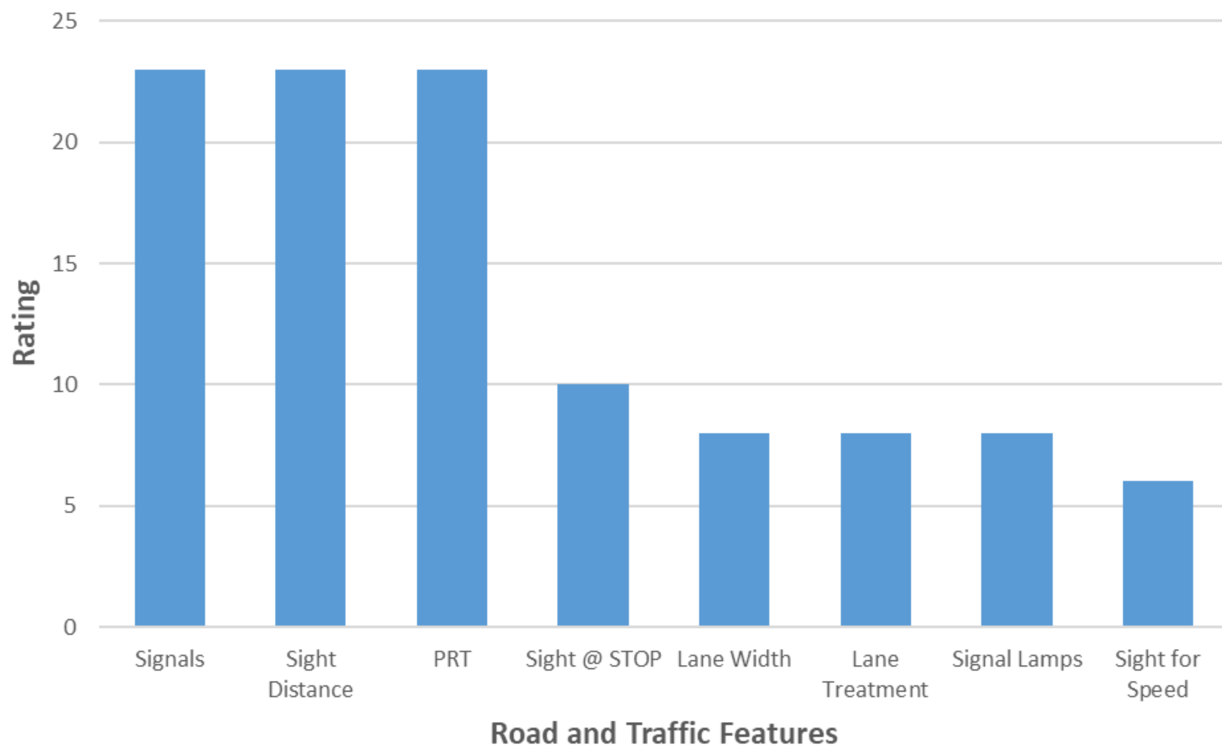

Figure 2.2: Top contributing factors to older driver crashes (Oxley et al., 2006)

Table 2.2: Engineering Solutions at Intersections for Older Drivers (ITE, 2004)

Characteristic	Solution
Geometric Design	• Minimum receiving lane of 12 ft. with 4-ft shoulder • Positive offset of left-turn lanes • 90-degree angle approaches • Raised channelization with sloped curbs for exclusive turn lanes
Signage	• Larger and more reflective regulatory signs • Redundancy and larger lettering size for street-name signage • More overhead-lighted signage
Pavement Markings	• Treat raised medians with reflective markings • More visible and durable pavement markings • Transverse pavement striping or rumble strips at stop-controlled intersections • Arrow pavement markings in advance of exclusive turn lanes
Traffic Signal Operations	• Increase use of protected left-turns and use separate signal face • Use leading left turns as opposed to lagging • Use red arrow for left-turn signals • Use yellow and all red formulas in ITE Traffic Engineering Handbook (more conservative) • Assume slower walking speeds for pedestrian intervals
Traffic Signal Hardware	• Use 12-in. signal lenses • Use backplates on signal heads for roads with speeds 40 mph or greater • More signal heads and overhead traffic signals • Consider post-mounted signals
Right-Turns-on-Red	• Use more than one NO TURN ON RED sign • Prohibit right-turn-on-red at skewed intersections

2.3.1 Left-Turn Movements

Left-turn maneuvers become problematic for older drivers in permitted left-turn scenarios, where the driver must decide when there is a safe gap in opposing traffic to complete the turn. Compared to younger and middle-aged drivers, studies have shown that older drivers have a reduced ability to estimate available gaps when making permitted left-turn maneuvers because of declining visual and cognitive function (Chandraratna and Stamatiadis, 2003). In a driving simulator study, older drivers tended to accept gaps in oncoming traffic for left turns that are one-half to one full second longer than other age groups, and have slower left-turn speeds (Boot et al., 2014).

At some intersections with sufficient right-of-way, one solution to improving safety for older drivers at left turns is offsetting the left-turn bay to increase forward sight-distance for the left-turning driver (Figure 2.3). Studies show that positive left-turn offsets have a high success rate at reducing the crash risk for older drivers, though this benefit is quickly reduced on higher-volume and higher-speed facilities (Boot et al., 2013). Of 92 installations of positive left-turn offsets in

Nebraska, a 34% reduction in all crash types were seen (Persaud et al., 2009). Furthermore, left-turn offsets require additional road space, and if the offset is not positive, there is no guarantee for improved sight distances and reduced crash risk for older drivers.

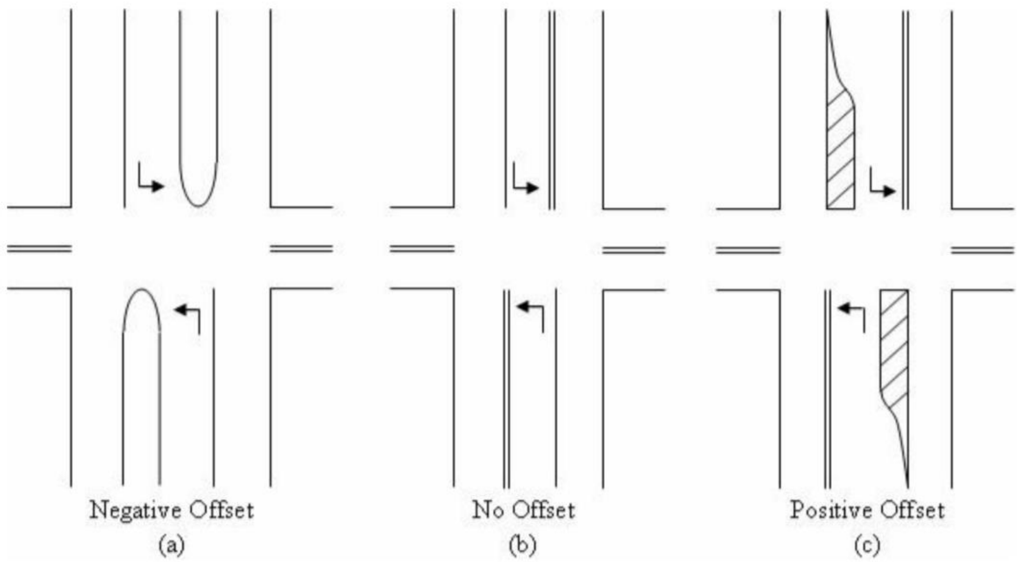

Figure 2.3: Schematic layout of intersections with negative (a), no (b), and positive (c) left-turn offsets (Boot et al., 2013)

The effect of flashing signal indicators for permitted left turns on older driver crash risk remains unclear. One study of empirical crash data found that intersections with flashing signals tend to pose an increased crash risk for older drivers. However, sample sizes were too small to isolate the effect on the left-turn movements specifically (Stutts et al., 2009). A study completed by the FHWA surveyed older drivers in Maryland, New York, and Virginia to find comprehension rates of various signalized intersection configurations. The study concluded that older drivers were confused or had low comprehension of the meaning of flashing red signals (primarily used in Michigan) to indicate a permitted left-turn phase (Hewitt and Evans, 1999). A similar study in Florida surveyed older drivers to find comprehension rates of the flashing yellow arrow indication and found no association with the indication and critical safety errors for older adults (Boot et al., 2014).

2.3.2 Signal Timing

Older drivers take almost two seconds longer to perceive and react to the onset of yellow signals (Boot et al., 2014). The PRT of 1.0 second used in the majority of signal phasing designs may not adequately account for age-related changes to PRT at signalized intersections. The Michigan Department of Transportation (MDOT) has identified its standard yellow time, which is based on a 2.0 second PRT, as not appropriate for an elderly driver (Hewitt and Evans, 1999), while the Wisconsin Department of Transportation has implemented a 4-5 second red clearance interval to accommodate drivers of all abilities and ages (Potts et al., 2004). Iowa has also implemented more protected left-turn phases at intersections near older populations and communities (Iowa DOT, 2017).

2.3.3 Pavement Markings and Signage

States with higher proportions of older drivers have adopted pavement marking and signage methods approaching and inside intersections specifically to improve older driver safety. Arizona has increased advance signage approaching intersections and lane markings inside intersections (ADOT, 2014). Iowa has found that brighter pavement markings and larger or brighter signs can help improve driver reaction times, especially for older drivers (Iowa DOT, 2017). Orlando has placed more raised reflective pavement markers spaced at 40 feet (versus the standard spacing of 80 feet) and advance signage approaching intersections to improve visibility and expectancy for older drivers, which is a strategy Michigan is looking to emulate (Hewitt and Evans, 1999). Michigan has also found that the upgrading of their older signal design (where signals are suspended from a span wire that runs diagonal across the intersection) to a "box span" design that has signal heads positioned on each approach reduced older driver crashes at intersections, with a benefit to cost ratio of 13:1 (MDOT, 2015).

2.3.4 Turning Restrictions

Right-turns-on-red (RTOR) can be especially problematic for older pedestrians because they take longer to cross the intersection. Studies have shown that 40% of the drivers do not entirely come to a stop before making an RTOR (ITE, 1992). Additionally, some drivers stop beyond the stop line and block the crosswalk while waiting to turn, which obstructs pedestrian movements (Campbell et al., 2012). Pedestrians may also cede the right-of-way to such drivers and subsequently may not have enough time to cross the intersection, which can be especially problematic for older pedestrians (Campbell et al., 2012). The MUTCD provides six situations when RTOR should be restricted, and three of these include pedestrians – locations where an exclusive phase exists, locations where significant pedestrian conflicts result from RTOR, and locations where there is significant crossing activity by children, elderly or disabled pedestrians (FHWA, 2009). The countermeasures to increase pedestrian safety at intersections with RTOR include vehicular time-based restrictions and pedestrian restrictions (Campbell et al., 2012). Retting et al. found that the time-based restriction led to a greater reduction in RTOR (77% vs. 19%), increased the number of drivers that stopped before making an RTOR, and significantly reduced the number of pedestrians that yielded to drivers as compared to a pedestrian-restricted implementation (Retting et al., 2002). Zegeer and Cynecki also evaluated different sign alternatives and found that the NO TURN ON RED (NTOR) sign with a red ball was more effective than the standard black and white NTOR sign (Zegeer and Cynecki, 1986). Additionally, a NO TURN ON RED WHEN PEDESTRIANS ARE PRESENT sign was effective at sites with moderate to low volume of right-turning vehicles (Zegeer and Cynecki, 1986). Zegeer and Zegeer also stated that confusing partial prohibitions, far side or hidden NTOR signs, long cycle lengths, confusing multileg intersections, and NTOR that are not justified based on traffic conditions might reduce the effectiveness of RTOR restrictions on driver compliance (Zegeer and Zegeer, 1988).

2.4 ROADWAY DESIGN AND SIGNING

Situations that require older drivers to complete complex visual searches, such as processing information from multiple sources or processing information under divided attention conditions, induce greater crash risk for those older drivers (Stutts et al., 2009). Additionally, older drivers have physical limitations that change their visual search patterns. A study, which compared neck flexibility to driver eye movement and head rotation data, found that older drivers have different visual search behaviors than other age groups primarily because of greater neck stiffness (Dukic and Broberg, 2012). Therefore, states are changing certain roadway characteristics to account for the older driver such as limiting intersection skew to no more than 60-70 degrees (Campbell et al., 2012).

NCHRP 600: Human Factors Guidelines for Road Systems also discusses issues with older drivers' limitations at unsignalized skewed intersections. Specifically, the manual outlines the viewing limitations of older drivers for both left-skewed and right-skewed intersections. For left-skewed intersections, a typical person requires approximately 13.5 degrees of rotation in an intermediate "leaning forward" position to adequately view oncoming traffic back over their right shoulder (NCHRP, 2012). However, due to limitations in older driver neck and trunk flexibility, it may be difficult for this population to conduct the intermediate "learning forward" position (i.e., 13.5-degree rotation) to safely determine oncoming vehicles. Therefore, the guideline recommends using the desirable vision angle (i.e., 4.5-degree rotation to design left-skewed intersection to accommodate older drivers. Additionally, when considering right-skewed intersections, limitations are based on how far the drivers can rotate or turn their body to look over their shoulder. Older drivers are known to have restricted neck and head rotational abilities, which limits their visual capacity of oncoming vehicles. Therefore, while the guideline provides both the other-driver (i.e., 115 degrees) and older driver (i.e., 95 degrees) vision angles, the recommendation is to design right-skewed intersections based on the older driver vision angle (NCHRP, 2012).

Arizona plans to fully integrate design standards and policies from the FHWA "*Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians*" into their state design standards (ADOT, 2014). Additionally, Arizona has committed to improving roadway delineation, striping, and lighting. In or near communities with high older driver densities, Arizona plans to reduce speed limits to accommodate older drivers' longer PRT (ADOT, 2014). Michigan identified the detection, legibility, and comprehension level of regulatory, warning and guide signs to be low for older drivers nearly two decades ago (Hewitt and Evans, 1999). Today, signs in Michigan use Clearview font (left panel of Figure 2.4), fluorescent yellow sheeting on warning signs, and arrow-per-lane signs (left panel of Figure 2.5) (MDOT, 2015). Michigan found that arrow-per-lane signs reduced crashes by up to 68% for older drivers, with a benefit-to-cost ratio of 1440:1. The benefit-to-cost ratio per segment mile for upgrading signs to Clearview font was found to be 2716:1, while the benefit-to-cost ratio for fluorescent yellow sheeting ranged from 581:1 to 4107:1 depending on the roadway classification which the solution was applied. Fluorescent yellow sheeting had the highest benefits on high-speed roads with high volumes during nighttime and inclement weather conditions. These strategies have improved safety for older drivers as well as drivers of all ages, and the benefits have outweighed the costs significantly (MDOT, 2015).

In 2016, FHWA revoked the interim approval for the use of Clearview font, citing the differences in the detection distances of signs with positive contrast (as shown in the figures below) and those with negative contrast (e.g., black letters on white backgrounds). After re-consideration, FHWA reissued an interim approval (IA-5) in 2018 after additional research and public comments were provided.

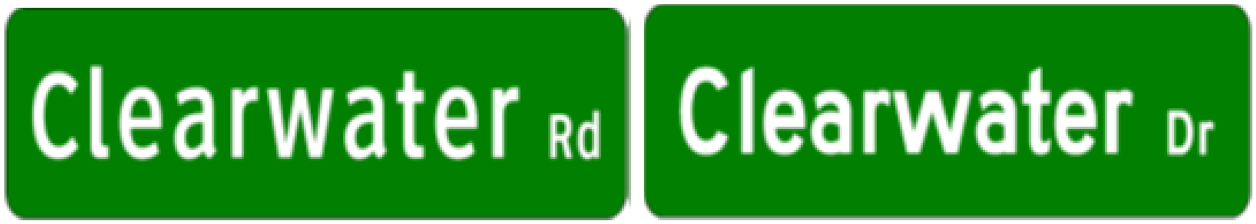

Figure 2.4: A comparison of Clearview font (left) and Standard font (right) (MDOT 2015)

Figure 2.5: A comparison of arrow-per-lane guidance sign (left) and standard diagrammatic guidance sign (right) (MDOT, 2015)

Older drivers in rural areas are likely to display behavioral differences and face different driving challenges than older drivers in urban areas (Stutts et al., 2009). Overall, crash and fatality rates for older drivers are twice as high for older drivers in rural areas than in urban areas (Thompson et al., 2010). Higher crash rates were attributed to higher roadway speeds, delayed or reduced availability to medical care, and more frequent instances of impaired driving-related crashes in rural areas (Thompson et al., 2010). In the rural driving environment, older drivers may use less search time to prepare for maneuvers when traveling on a rural highway versus other roadway types (Bao and Boyle, 2007).

In general, movements at stop-controlled intersections are more cognitively demanding and problematic for older drivers. In rural areas, older drivers are more likely to comply with stop signs, which may be attributed to lower traffic volumes, greater visibility, and higher perceived risk with rural intersections (Keay et al., 2009). Conversely, older drivers are more likely to run red lights at signalized intersections in rural areas (though this matches general trends with red light compliance in rural areas for all age groups) (Keay et al., 2009).

2.5 EDGE LINES

Difficulty visually perceiving or identifying roadway features by older drivers can place this population in danger as well as surrounding road users. Older drivers' vision may be impaired due to physiological and pathological age-related changes. To address these challenges, safety measures such as edge lines have been implemented as a strategy to assist drivers in lane identification and positioning. Pavement edge lines are the most consistently implemented form of traffic control measure on the roadway. The older driver population, specifically, may benefit from increasing edge line width (i.e., from four to six/eight inches) due to age-related changes in vision, providing a safer driving experience for roadway users. While the MUTCD currently states an edge line standard width of four inches, studies have looked to determine the effect of wider edge lines and found a positive driver response and increased crash reduction due to edge line width increases (e.g., six-inch to eight-inch widths vs. four-inch) (FHWA, 2009).

Recently, a study was done at Texas Transportation Institute (TTI) that analyzed a large set of data to evaluate the impact of wider edge lines on crash types in three states (Kansas, Missouri and Illinois). The results indicated that the three states showed a range of 15 to 30 percent in total crash reduction, with Illinois showing a 24.1 percent (24.1%) crash reduction for older drivers (Park et al., 2012). Furthermore, a follow-up study was conducted using the data collected from TTI to determine the cost-benefit ratio of edge lines and results showed that wide edge lines had a $33 to $55 benefit to $1 cost ratio (TTI, 2012). In 2019, before-and-after studies (e.g., group comparison and Empirical Bayes) were conducted to determine the safety effectiveness of wider pavement markings on crashes at 38 two-lane highway locations in Idaho. The results of the study indicated that both the group comparison and Empirical Bayes showed a decrease in average crash rates for total, night, fatal and severe injury day, and fatal and severe injury night crashes; however, the crashes were not statistically significant at 95% confidence, except for fatal and severe injury crashes (Abdel-Rahim et al., 2018).

In contrast, there is evidence to suggest that there could be variability in outcomes due to the increase in edge line width. Specifically, in 2012 Carlson and colleagues summarized several studies over a 30-year period, and many found that the increase in edge line width had no statistically significant difference in crashes (TTI, 2012). Therefore, while an increase in edge lines can have a positive influence on overall driver safety, some studies have shown inconclusive results with the subtle increase in edge line width.

2.6 ROADWAY LIGHTING AND VISIBILITY

Low illumination impacts the ability to detect objects in older drivers; however, older eyes are also slower to adjust to glare from bright illumination (Khan and Kline, 2011). Lighting design and analysis for facilities serving older drivers should consider these factors, specifically with respect to average illuminance and illuminance uniformity factors. Reduced visibility in rural environments can be especially challenging for older drivers. Fixed illumination can improve visibility, reduce speed and improve safety in rural areas (Isebrands et al., 2006; Hallmark et al., 2008).

Reduced visibility can occur when the intensity of the light source within the visual field is greater than the visual adaptation level leading to glare (Campbell et al., 2012). Reducing the glare from oncoming headlamps can be achieved by increasing the lateral separation of the opposing vehicles using wide medians and independent alignments (Mace et al., 2001), fixed roadway lighting or glare screens (TRB, 1979). Other treatments can be used to enhance nighttime safety include advance warning signs, flashing beacons, reflective strips on stop sign posts, and raised pavement markers (Anderson et al., 1984; Brewer and Fitzpatrick, 2004; Isebrands et al., 2006; Hallmark et al., 2008).

Treatments to improve pedestrian visibility at crosswalks include the use of in-pavement flashing lights, sign-mounted flashing beacons, and flashing LEDs mounted in “Pedestrian Crossing” warning signs (Van Derlofske et al., 2003; Ullman et al., 2004; FHWA, 2009). These treatments, when used in conjunction with signs and markings, have reduced the number of evasive conflicts between drivers and pedestrians (Van Houten et al., 2008); increased the rate of motorist yielding to pedestrians (Van Houten et al., 2008; Godfrey and Mazella, 1999); increased the distance at which drivers applied their brakes (Godfrey and Mazella, 1999); reduced motorists approach speed (Prevedouros, 2001); and increased pedestrians’ perception of safety during day and night (Ullman et al., 2004).

2.7 PEDESTRIANS

Older pedestrian collisions with motor vehicles are more likely to result in a fatality when compared to other age groups due to increased physical frailty (Cottrell and Pal, 2003). Furthermore, older pedestrians are particularly susceptible to collisions with motor vehicles due to slower walking speeds, difficulty meeting situational demands, and are at increased risk for falling while walking (Levi et al., 2013). Older pedestrians may also have an inhibited ability to make safe road crossing judgments and decisions due to visual and hearing degradation combined with cognitive decline (Levi et al., 2013). Studies show that when crossing a street, older pedestrians accept shorter time gaps in oncoming traffic as vehicle speeds increase (Lobjois et al., 2012). This particular study suggests lowering speed limits on roadways with high older-pedestrian volumes can increase the likelihood of older pedestrians correctly determining a safe time gap before crossing (Lobjois et al., 2012). In the context of speed, however, lower operating speeds are the overall objective and reducing regulatory or advisory speed limits may not lower speeds depending on the context.

Separating pedestrians by time and space (for example, utilizing protected or leading pedestrian intervals at signalized intersections), increasing the visibility of pedestrians to drivers, and reducing vehicle speeds on roadways with high pedestrian volumes, are all highly effective ways to increase safety for older pedestrians (Levi et al., 2013; Kothuri et al., 2018). However, if there is a significant proportion of older drivers in the population, these strategies may be less effective. One study showed that older driver fixations do not change with high-emphasis crosswalks, shown in Figure 2.6, intended to increase the visibility of pedestrians (Boot et al., 2013). The same study found that age was not a factor in brake reaction time or the probability of a collision with a pedestrian, nor did age impact the yield expectancy pedestrians have of drivers (Boot et al., 2013). Installing pedestrian countdown signals in Michigan improved safety for older pedestrians and pedestrians of all ages (Hewitt and Evans, 1999). Pedestrian countdown signals increase the likelihood of an older pedestrian to be clear of the crossing area at the onset of steady DON’T WALK (MDOT, 2015).

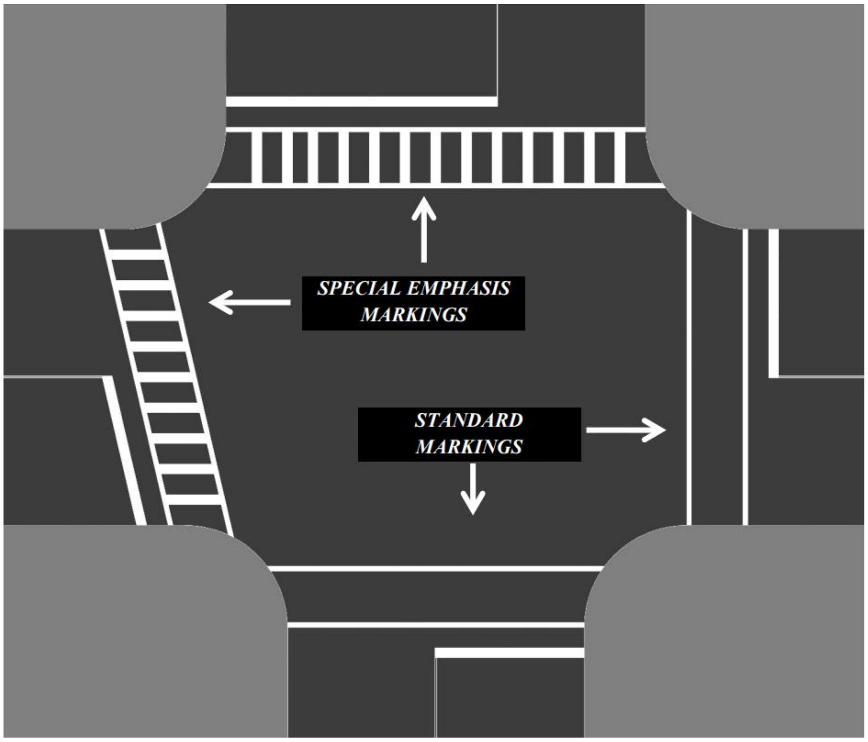

Figure 2.6: Comparison of crosswalk marking types evaluated in both driving simulator and real-world experiments (Boot et al., 2013)

Identifying where infrastructure improvements need to be made to accommodate older pedestrians is a challenge for many agencies. Successful pedestrian programs in Sacramento, CA, rely on older pedestrians to self-report problems with pedestrian infrastructure in their respective communities (Levi et al., 2013). In addition to pedestrian infrastructure improvements, providing information to older pedestrians on the ways functional decline with age impacts the importance of health checks, and strategies to avoid high-risk situations when walking are critical to improving older pedestrian safety (Levi et al., 2013).

2.8 AGING IN PLACE

Effective planning for the needs of an older driving population is critical to reducing the crash risk for older drivers and requires cooperation across multiple departments and agencies within a state. Arizona, California, Florida, Iowa, Maryland, and Michigan began this coordinated effort by first developing a task force specifically for older driver safety (Potts et al., 2004). These task forces were effectively used to develop action plans for their respective states and remained active after the development of these action plans to help guide and oversee subsequent older driver safety programs (Potts et al., 2004). Action plans and subsequent programs often center on the idea of “aging in place.” “Aging in place” can be defined as “the ability to live in one’s own home and community safely, independently, and comfortably, regardless of age, income, or ability level,” according to the U.S. Centers for Disease Control and Prevention (CDC, 2009). After age 55, only approximately 5% of U.S. residents change residences (Frey, 2007), which creates “naturally occurring retirement communities” defined as communities with high densities of older residents outside of designated older resident zones (Ormand et al., 2007). These types of communities are problematic for older drivers if they have not been planned to accommodate older residents. Transportation is a key issue for aging in place. Michigan has found that many older drivers do not use public transportation because they do not know how and because there are no door-to-door services offered (Hewitt and Evans, 1999).

The research team found a few existing practices to improving communities for "aging in place," outside of the development of new communities. New York has developed a self-help network for older drivers wanting to explore all modal options available to them (Potts et al., 2004). New York City's *Safe Routes for Seniors* campaign to accommodate aging communities is summarized in Table 2.3 (Frey, 2007). The table organizes the recommendations by approximate cost. Risks associated with "aging in place" increase for older drivers in rural communities, where correlations between reliance on driving and fatal crash risk for older drivers are prevalent (Thompson et al., 2010).

Another program to help older drivers is a result of a collaboration between the American Society on Aging, AAA, AARP, and AOTA. CarFit helps older drivers learn about the safety features of their car and individualized adjustments, and also fosters a discussion on their driving safety and mobility options without concern of losing their driver's license (AOTA, n.d.). According to a national survey of more than 7,000 seniors, the top challenges for older drivers included improper distance from the steering wheel, adequate and safe views from side mirrors, improper seat height and improper head restraint. CarFit events are held in communities across the country and volunteers, including occupational therapists, go over a 12-point checklist that ensures that each driver's settings in the car are adjusted for the best fit and improved safety (AOTA, n.d.).

Table 2.3: Summary of Safe Routes for Seniors Recommendations (Frey, 2007)

Cost	Recommendation
Low	Bus shelters and benches near older communities Protected pedestrian phases near older communities Move stop bars to 15-ft. before the intersection at busy intersections
High	Pedestrian islands in the median of wide and busy streets Bus bulbs on wide and busy streets Raised crosswalks and road diets near older communities Curb extensions on commercial streets and bus routes

2.9 REVIEW OF STATE POLICIES

Many states have undertaken efforts to improve older driver safety. The authors of NCHRP synthesis study 348 classified these efforts into one of four categories – improving the roadway, driver licensing initiatives, educational approaches, and law enforcement and other judicial programs. NCHRP synthesis study 348 contains detailed information regarding various states' efforts in each of these categories (Stutts et al., 2005).

With respect to improving the roadway, states have focused their efforts mostly on improvements in the following categories – traffic signs, traffic signals, pavement markings, geometric design, work zones, and railroad grade crossings. For traffic signs, the focus was on larger signs and lettering, making signs more conspicuous and easier to read, providing advance road name signs, supplemental signs and improved diagrammatic signs (Stutts et al., 2005). Improvements to traffic signals included increasing the visibility of signal heads by motorists through better placement, making signal heads more conspicuous, using multiple signal heads, and modifying signal operations to incorporate left-turn phases and red clearance intervals (NCHRP, 2005). Improvements to pavement markings included more conspicuous road markings, especially for nighttime and wet weather conditions; use of edge lines to guide the motorist; improved island delineation; and provision of advance notice pavement markings. Road and intersection design improvements included better facilitating turning movements (especially left turns by realigning skewed intersections), converting four-lane roadways to three-lane roadways, installing roundabouts, improving sight distance, and adding shoulder and centerline rumble strips (Stutts et al., 2005).

A number of states impose additional requirements for older drivers who are renewing their driver's licenses, including more frequent renewals, vision screening, and in-person renewals (Stutts et al., 2005). Eighteen states enforce shorter renewal periods for older adults (IIHS, 2018). Eighteen states require more frequent vision screening for older drivers. Sixteen states do not allow online or mail renewal for older drivers even though accepted for the general population. Oregon requires all drivers to respond to a series of medical questions on the driver's license renewal application. In Oregon, license renewal occurs every eight years for both the general population and older drivers. However, in Oregon, drivers 50 years or older are required to present proof of adequate vision every renewal (IIHS, 2018). Oregon also implements an At-Risk Driver Program that requires most medical professionals to report drivers who can no longer drive due to impairment (Oregon DMV, 2018).

2.10 SUMMARY

Older driver safety is complex and deep, covering topics from engineering, planning, psychology, and health fields. A review of the literature found that left turns at intersections, situations that require complex visual searches, and rural roadways pose a higher crash risk for older drivers. Improving safety and mobility for older road users includes land use policies to promote aging in place, providing access to alternate transportation options, and improving the safety of vehicles, roadways, and users. Many states have adopted policies and programs that impose additional requirements on older drivers in the form of more frequent driver's license renewals and mandatory vision checks.

3.0 ANALYSIS OF CRASH DATA

For the descriptive analysis, older driver and pedestrian crash characteristics are summarized based on records in the Oregon crash data. In the current study, an older driver or pedestrian is defined as a person aged 65 years or greater. For this analysis, driver crashes are those involving a crash when a driver of one of the involved vehicles was aged 65 years or older. A pedestrian crash was defined when the pedestrian was 65 years or older. After providing a summary of older driver and pedestrian crashes, driver records are matched to each pedestrian crash. By matching driver records to each pedestrian crash, statistics on vehicle movements and driver age in older pedestrian crashes can be provided. Following the summary of older driver and pedestrian crashes, a z-test of proportions is conducted to determine if factors related to fatal and incapacitating crashes (K+A crashes) by age group are statistically different. To conclude the descriptive analysis, a random forest model was constructed to identify variable importance in older driver and pedestrian crashes. Following several recent publications from the National Highway Transportation Safety Administration (National Highway Traffic Safety Administration, 2019a, 2019b, 2019c), age groups compared to older driver and pedestrian crashes are as follows:

- 16 years to 24 years
- 25 years to 44 years
- 45 years to 64 years

3.1 OLDER DRIVER FATAL AND SERIOUS INJURY CRASHES

Considering four years of crash data (2013 to 2016), as stated previously, Oregon crash data records indicate that 884 older driver fatal and serious injury crashes (K+A) occurred. To help explain these crashes, the following crash characteristics are summarized:

Time of Day

- Day of the Week
- Roadway Classification
- Roadway Character
- Weather Condition
- Road Surface Condition
- Lighting Condition
- Crash Type

- Number of Vehicles Involved
- Driver Age
- Residence of Driver
- Gender
- Crash Cause (Driver-Level)

The following subsections will summarize older driver fatal and serious injury crashes based on the listed crash characteristics.

3.1.1 Time of Day

Figure 3.1 shows that the majority of older driver fatal and serious injury crashes occurred during daytime hours, where 27% happened from 3:00 p.m. to 5:59 p.m., 26.1% took place from 12:00 p.m. to 2:59 p.m., and 19% occurred from 9:00 a.m. to 11:59 a.m. Representing small proportions of older driver fatal and serious injury crashes are nighttime hours and early morning hours, specifically, 9:00 p.m. to 11:59 p.m. (4%), 3:00 a.m. to 5:59 a.m. (1.9%), and 12:00 a.m. to 2:59 a.m. (0.3%).

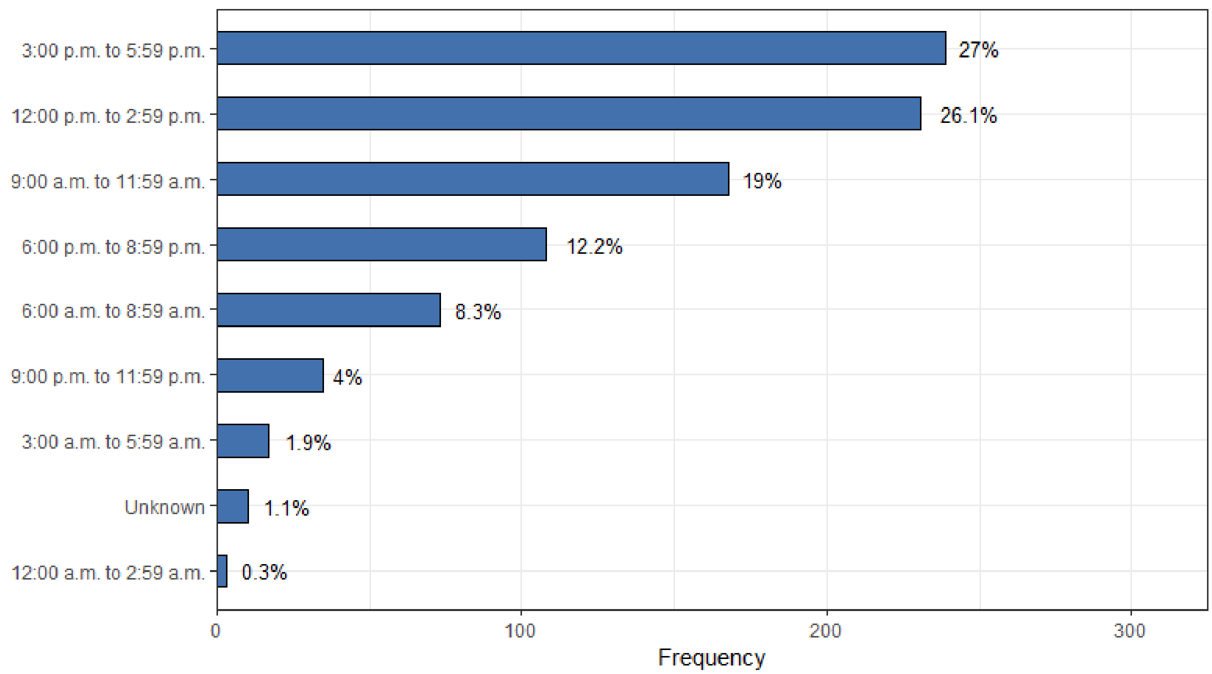

Figure 3.1: Older driver fatal and serious injury crashes and time of day

3.1.2 Day of the Week

As shown in Figure 3.2, just under 80% of older driver fatal and serious injury crashes occurred on a weekday, with the most occurring on Monday (17.9%). The remaining days of the week accounted for similar proportions of older driver fatal and serious injury crashes, ranging from 14% to 16%. Based on the crash records, the smallest proportion of older driver fatal and serious injury crashes took place on weekends.

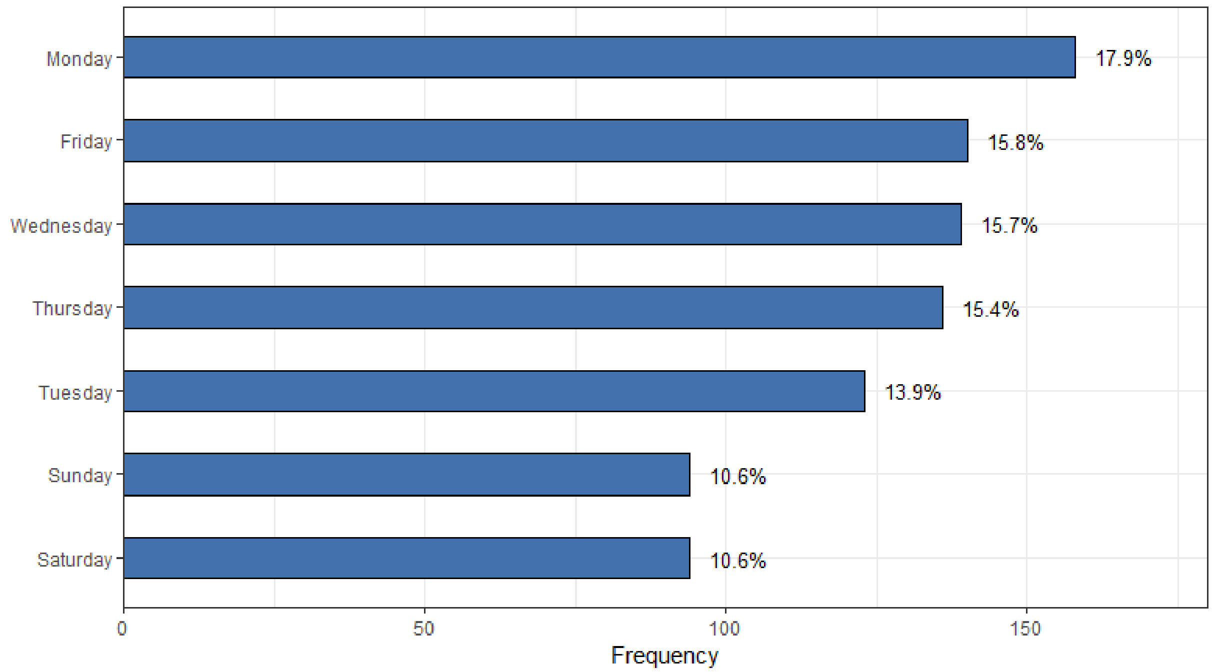

Figure 3.2: Older driver fatal and serious injury crashes and day of the week

3.1.3 Roadway Classification

Figure 3.3 shows the proportion of older driver fatal and serious injury crashes by roadway classification. Principal arterials account for the largest proportion, with rural and urban principal arterials having similar crash proportions at 21.4% and 20.4%, respectively. Roadway classifications with smaller proportions of older driver fatal and serious injury crashes include rural minor collectors, rural local streets, urban freeways or expressways, and urban minor collectors. Further, as shown in Figure 3.4, roughly half of older fatal and serious injury crashes occurred on rural classifications and half on urban classifications.

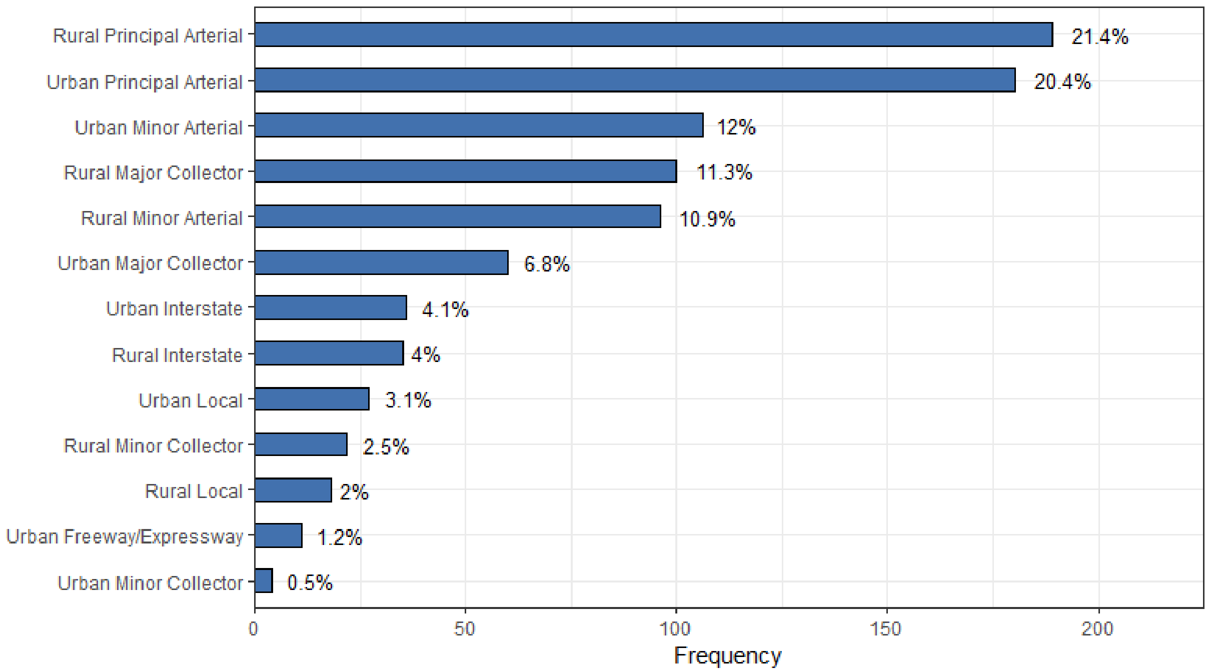

Figure 3.3: Older driver fatal and serious injury crashes and roadway classification

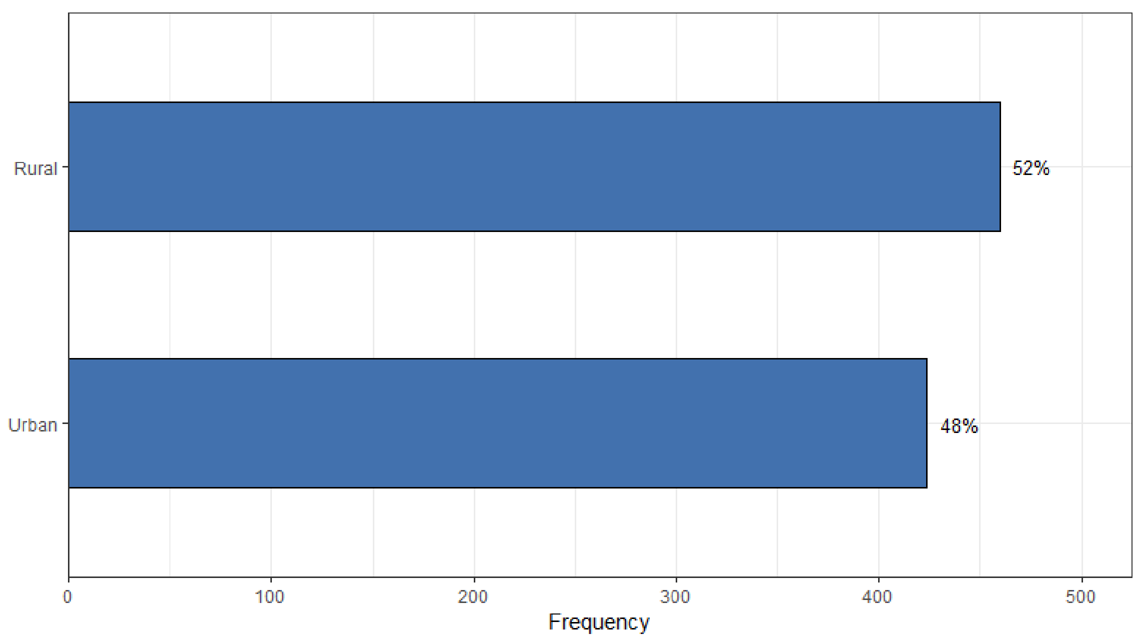

Figure 3.4: Older driver fatal and serious injury crashes and urban/rural classifications

3.1.4 Roadway Character

Figure 3.5 shows that larger proportions of older driver fatal and serious injury crashes occurred at intersections (39.5%), on straight roadway segments (28.7%), or on horizontal curves (19.1%). Roadway characters that account for small proportions of older driver fatal and serious injury crashes include bridge structures, open access or turnout locations, and locations where there is a transition in the number of lanes.

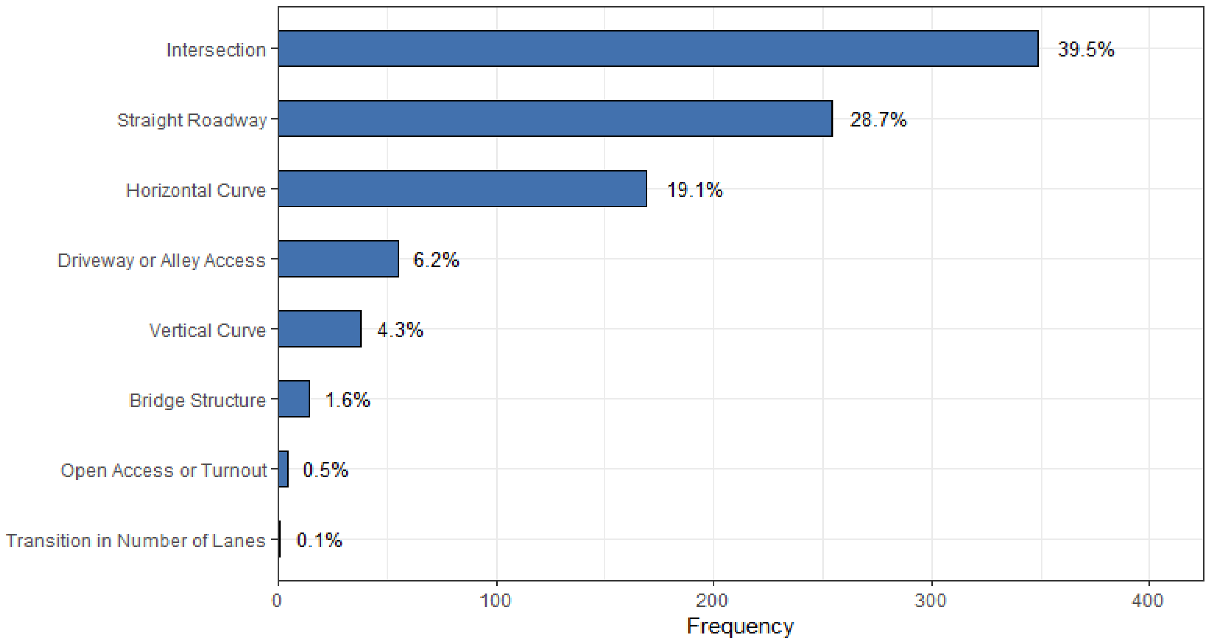

Figure 3.5: Older driver fatal and serious injury crashes and roadway character

3.1.5 Weather Condition

Referring to Figure 3.6, 66.6% of older driver fatal and serious injury crashes occurred during clear weather, 16.5% took place during cloudy weather, and 11.7% happened under rainy conditions. Of the remaining weather conditions, each accounted for less 2% of older driver fatal and serious injury crashes.

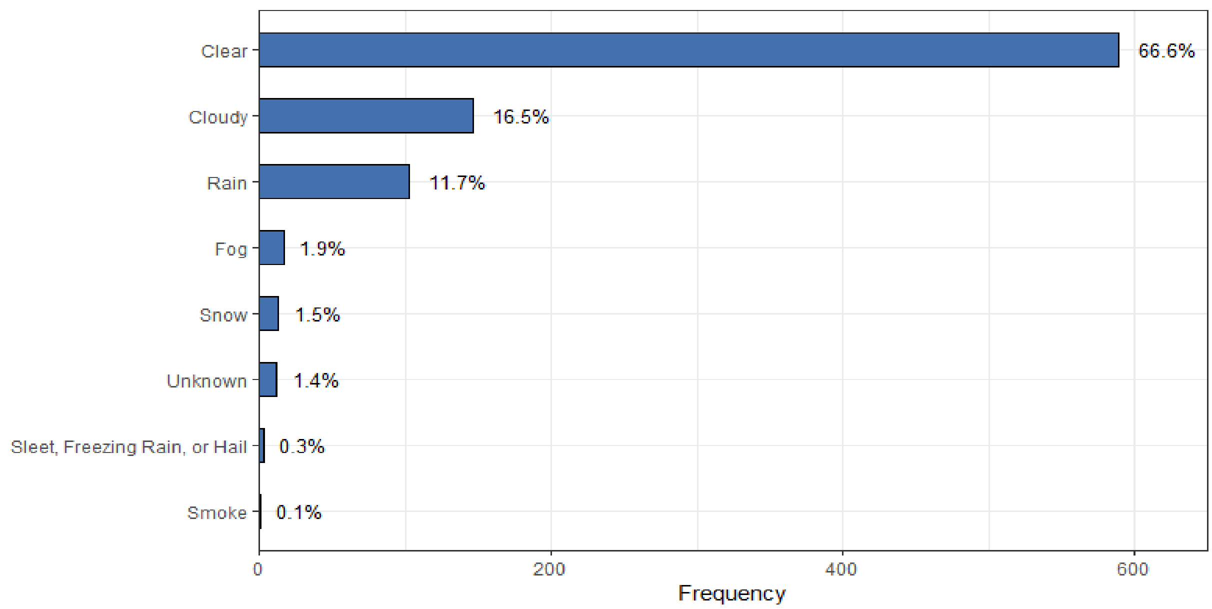

Figure 3.6: Older driver fatal and serious injury crashes and weather condition

3.1.6 Road Surface Condition

In terms of road surface conditions, Figure 3.7 shows that greater than 90% of older driver fatal and serious injury crashes occurred on dry surface conditions (75.8%) or on wet surface conditions (18.8%). As for icy surface conditions or snowy surface conditions, substantially smaller proportions occurred on these conditions at 3.2% and 1%, respectively.

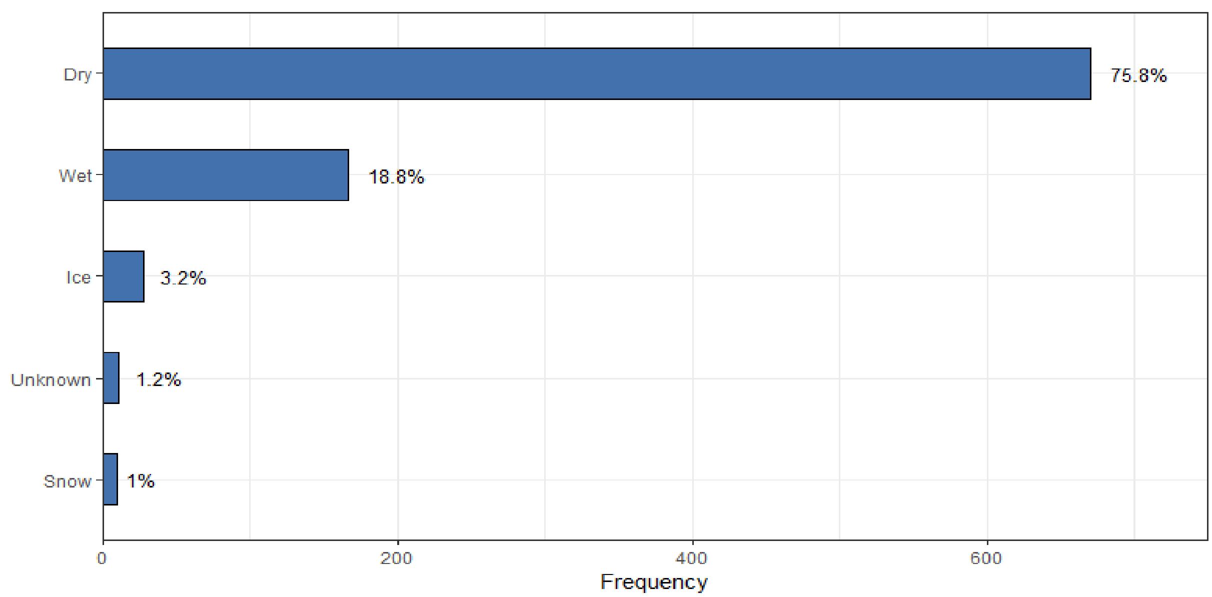

Figure 3.7: Older driver fatal and serious injury crashes and road surface condition

3.1.7 Lighting Condition

The majority of older driver fatal and serious injury crashes occurred under one lighting condition, daylight. In regards to other lighting conditions, 9.3% of crashes happened in the dark with no street lights, 5.3% took place in the dark with street lights, 4.1% occurred at dusk, and 1.7% happened at dawn. The distribution of older driver fatal and serious injury crashes can be observed in Figure 3.8.

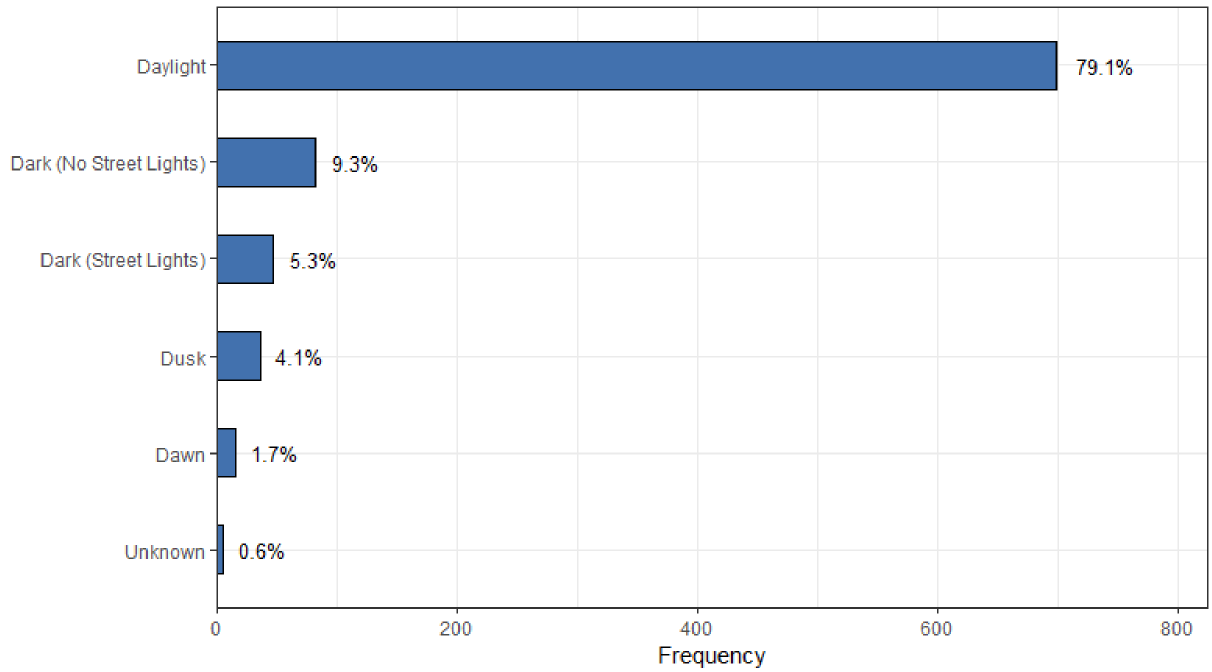

Figure 3.8: Older driver fatal and serious injury crashes and lighting condition

3.1.8 Collision Type

Figure 3.9 shows the distribution of collision types for older driver fatal and serious injury crashes. The largest proportion of crashes were fixed-object crashes, followed by turning-movement crashes, rear-end crashes, head-on crashes, and angle crashes. As for turning movement crashes, this is consistent with the number of crashes that occurred at intersections. Sideswipe crashes (both meeting and overtaking), as well as backing and parking maneuver crashes, account for significantly smaller proportions of older driver fatal and serious injury crashes.

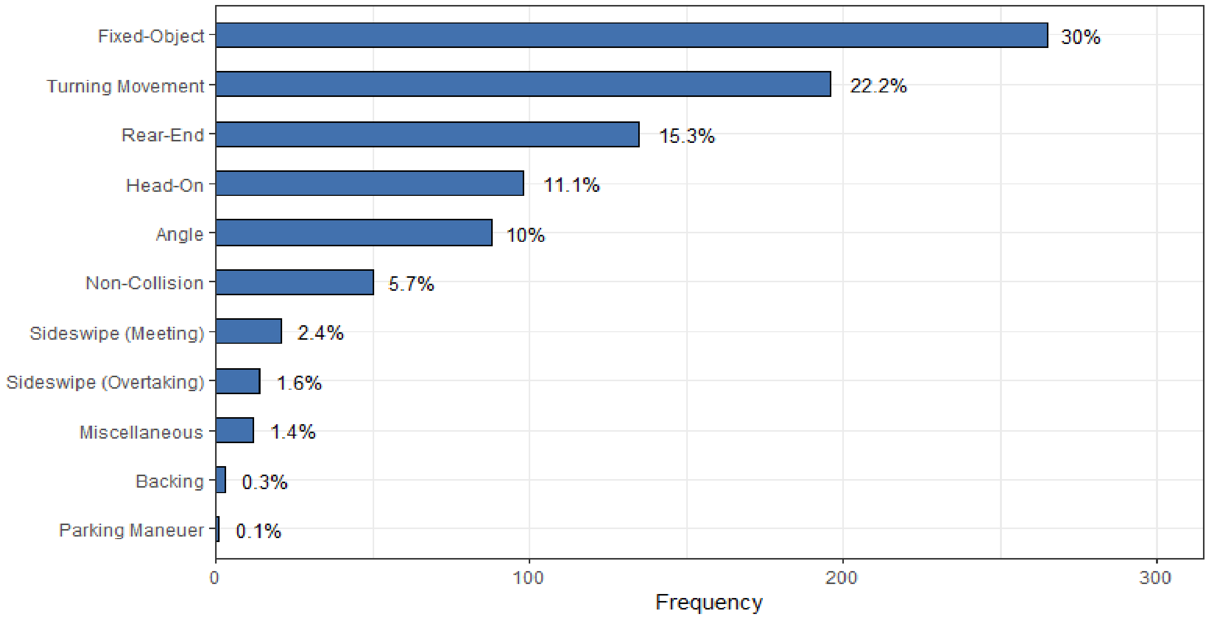

Figure 3.9: Older driver fatal and serious injury crashes and collision type

3.1.9 Number of Vehicles Involved in Crash

Referring to Figure 3.10, approximately 65% of older driver fatal and serious injury crashes involved more than one vehicle. On the other hand, about 35% of older driver fatal and serious injury crashes were reported as single-vehicle crashes. The number of single-vehicle crashes is also consistent with the number of fixed-object crashes.

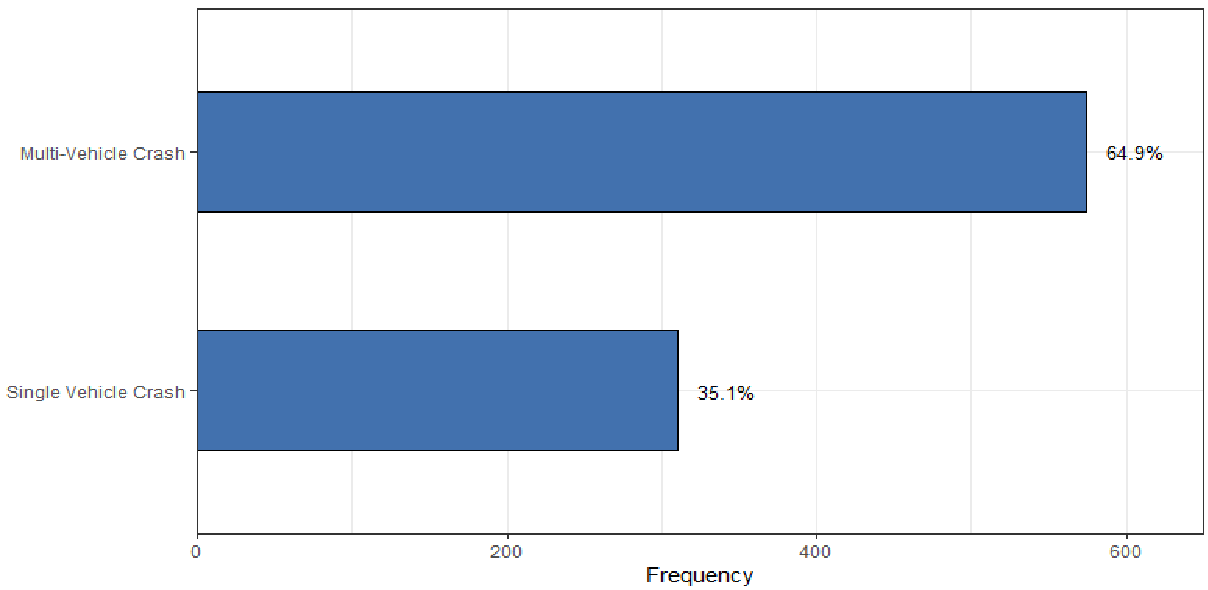

Figure 3.10: Older driver fatal and serious injury crashes and number of vehicles involved

3.1.10 Driver Residence

As observed in Figure 3.11, nearly 75% of older driver fatal and serious injury crashes were Oregon residents within 20 miles from home. Roughly 15% were Oregon residents more than 20 miles from home, and about 10% were reported as non-residents.

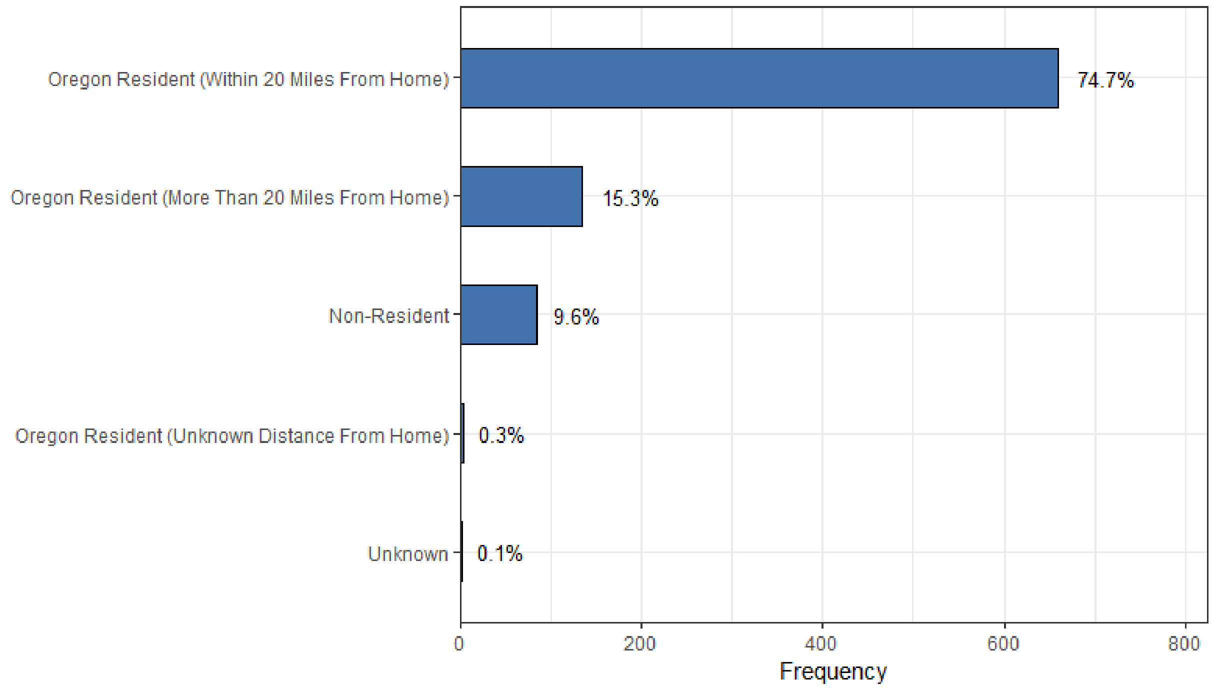

Figure 3.11: Older driver fatal and serious injury crashes and driver residency

3.1.11 Driver Gender

Figure 3.12 shows that approximately 63% of older driver fatal and serious injury crashes involved a male driver, and roughly 37% involved a female driver.

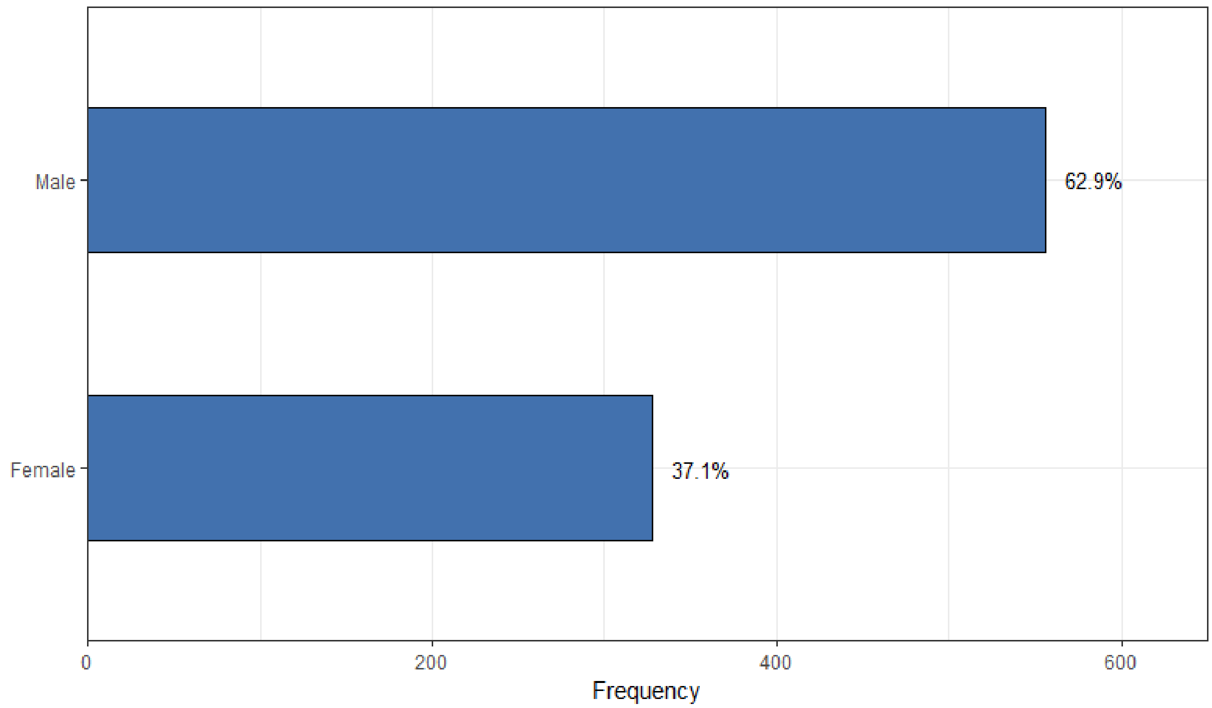

Figure 3.12: Older driver fatal and serious injury crashes and driver gender

3.1.12 Driver-Level Crash Cause

The final crash characteristic summarized for older driver fatal and serious injury crashes is the crash cause at the driver level. Referring to Figure 3.13, 29.3% of older driver fatal crashes have no associated driver-level crash cause. In other words, for 29.3% of older driver fatal crashes from 2013 to 2016, crash cause was not attributed to the driver. The cause with the highest proportion of older drivers is other improper driving (15%), while not yielding the right-of-way (11.8%), speed being too fast for conditions (9.4%), and physical illness (5.8%) also account for larger proportions compared to other driver-level crash causes. In regard to other improper driving, the Oregon Crash Data Manual states that this cause is used when a driver error was a factor in the crash, but no other cause code used by Oregon applies (Oregon Transportation Data Section & Oregon Crash Analysis and Reporting Unit, 2018). Of the causes associated with an Oregon cause code, 11.8% of crashes happened as a result of not yielding the right-of-way, 9.4% occurred due to speed too fast for conditions, and 5.8% happened due to physical illness. Although these are the driver-level crash causes as recorded in the crash data, it is likely that there are other contributing factors that were not recorded in the crash data.

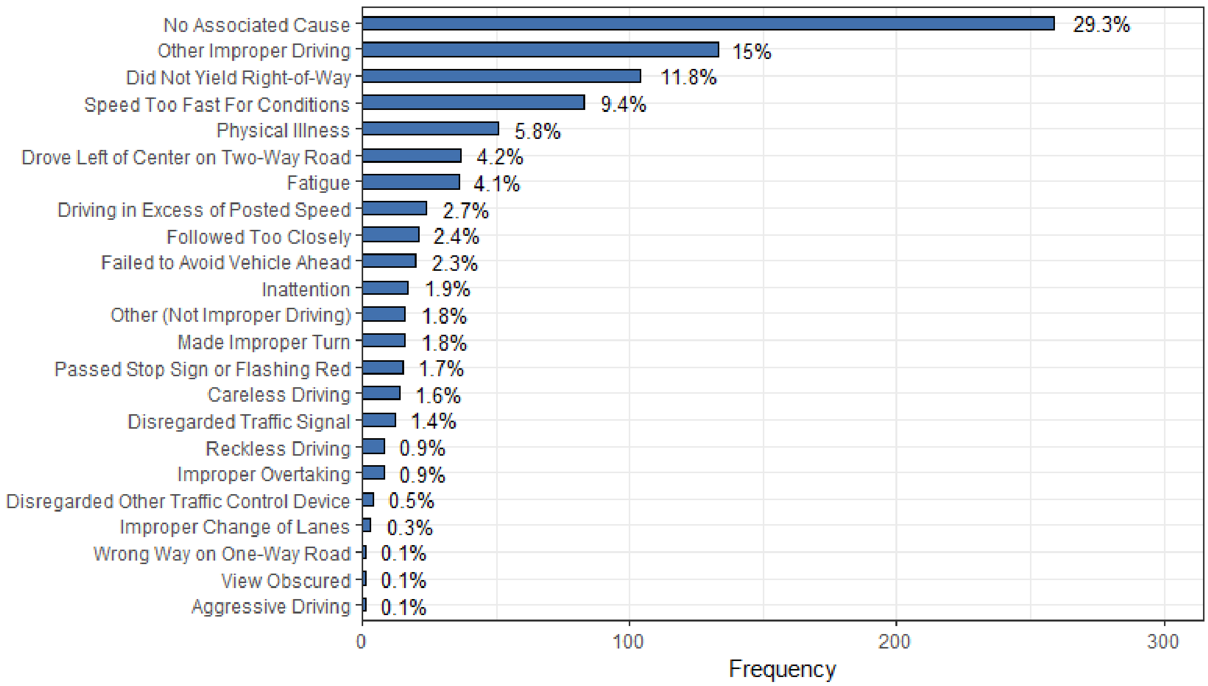

Figure 3.13: Older driver fatal and serious injury crashes and driver-level crash cause

3.2 OLDER PEDESTRIAN FATAL AND SERIOUS INJURY CRASHES

During the same four years, 2013 to 2016, Oregon crash data records indicate that 112 older pedestrian fatal and serious injury crashes occurred. In addition to most of the crash characteristics summarized for older driver crashes, the following were included for older pedestrian crashes:

- Pedestrian Action
- Pedestrian Location
- Vehicle Movement
- Driver Age

3.2.1 Time of Day

Referring to Figure 3.14, the majority of older pedestrian fatal and serious injury crashes occurred from 3:00 p.m. to 5:59 p.m. (26.8%) or 6:00 p.m. to 8:59 p.m. (21.4%). Few older pedestrian fatal and serious injury crashes, compared to other time periods, happened during late night hours (12:00 a.m. to 2:59 a.m.) or early mornings (3:00 a.m. to 5:59 a.m.).

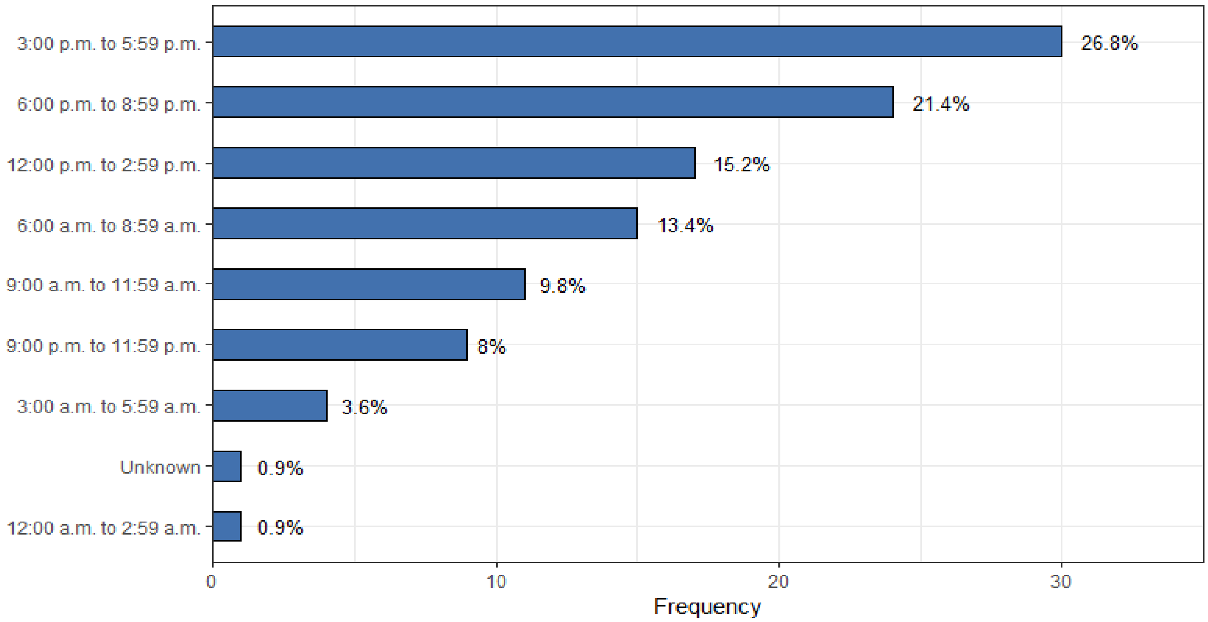

Figure 3.14: Older pedestrian fatal and serious injury crashes and time of day

3.2.2 Day of the Week

As shown in Figure 3.15, older pedestrian fatal and serious injury crashes took place on a Friday at roughly 24%. Of the remaining days, 16.1% happened on a Monday, 14.3% occurred on a Thursday, 12.5% took place on a Tuesday, 11.6% happened on a Wednesday, 11.6% happened on a Saturday, and 9.8% occurred on a Sunday.

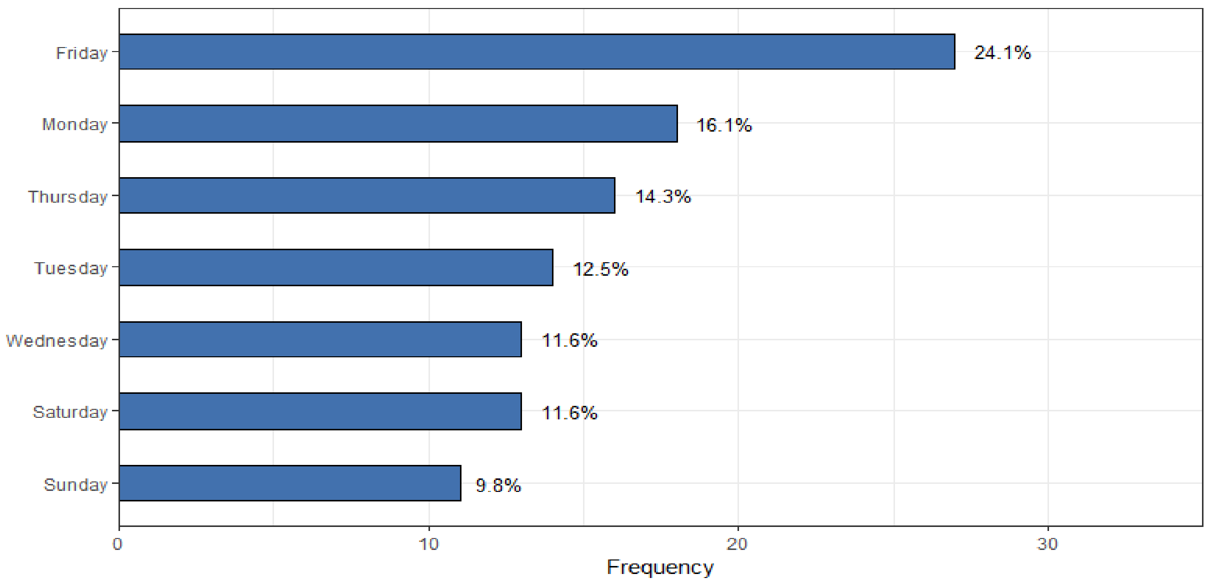

Figure 3.15: Older pedestrian fatal and serious injury crashes and day of the week

3.2.3 Roadway Classification

Figure 3.16 shows that the majority of older pedestrian fatal and serious injury crashes happened on urban roadway classifications. Specifically, about 34% occurred on urban principal arterials, 25% on urban minor arterials, and 15% on urban major collectors. For rural classifications, the highest percentage observed is approximately 6% on rural principal arterials and approximately 6% on rural major collectors. In addition, Figure 3.17 shows that greater than 80% of older pedestrian fatal and serious injury crashes happened on roadways classified as urban.

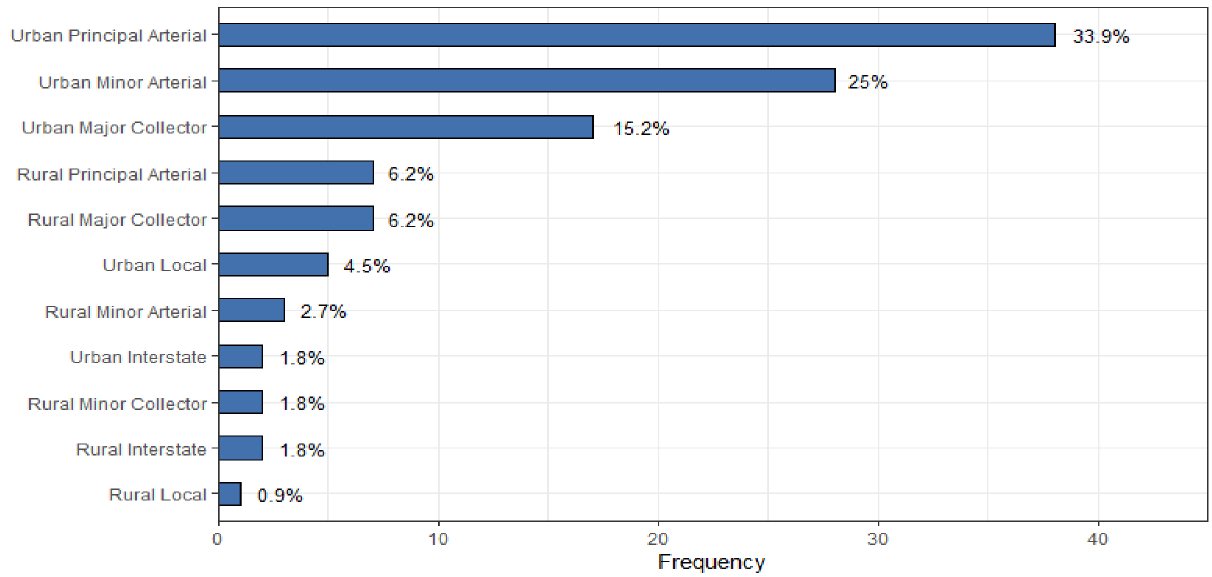

Figure 3.16: Older pedestrian fatal and serious injury crashes and roadway classification

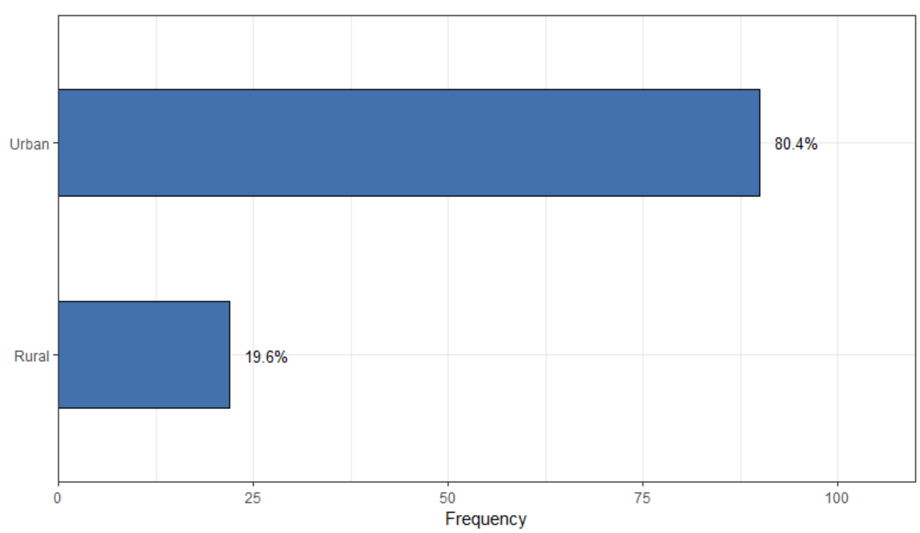

Figure 3.17: Older pedestrian fatal and serious injury crashes and urban/rural classifications

3.2.4 Roadway Character

As it pertains to roadway character and older pedestrian crashes, nearly 55% occurred at an intersection (refer to Figure 3.18). Also representing a larger proportion of older pedestrian fatal and serious injury crashes, straight roadway segments constituted roughly 32%. Of the remaining roadway characters, approximately 9% happened at driveway or alley access locations, and fewer than 3% occurred on horizontal curves, vertical curves, or open access/turnout locations.

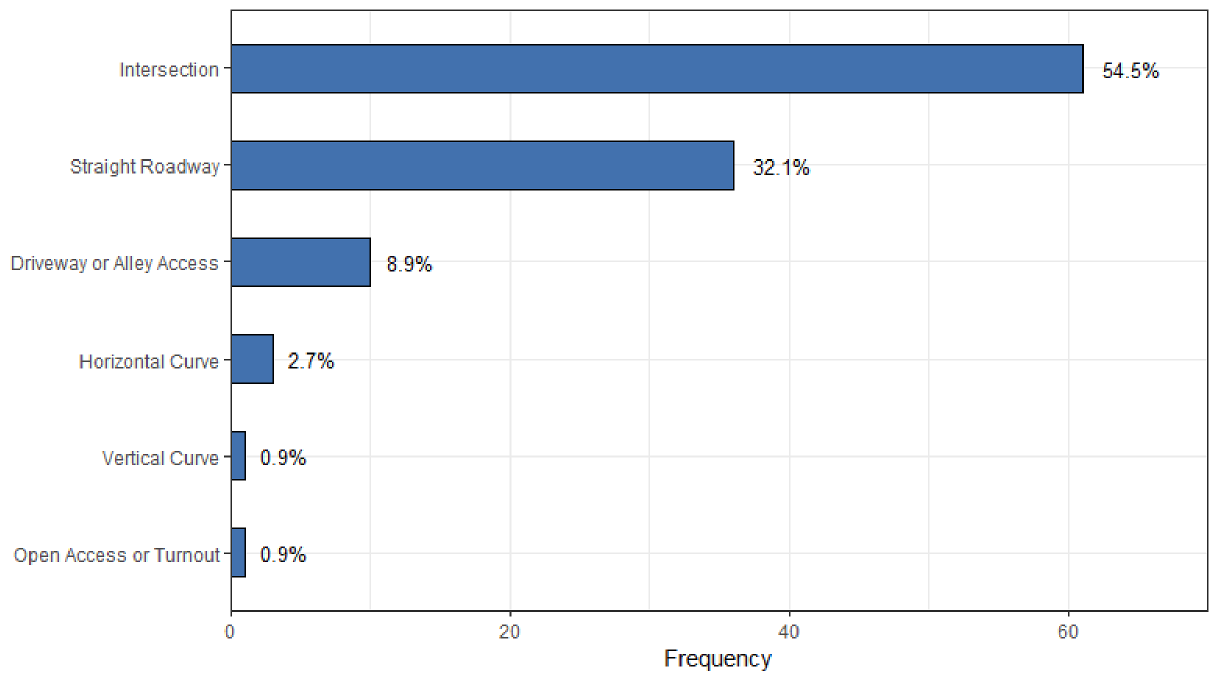

Figure 3.18: Older pedestrian fatal and serious injury crashes and roadway character

3.2.5 Weather Condition

Of the 112 older pedestrian fatal and serious injury crashes, Figure 3.19 shows that nearly 52% occurred during clear conditions, about 29% happened during cloudy conditions, approximately 14% took place under rainy conditions, and roughly 5% occurred during foggy conditions.

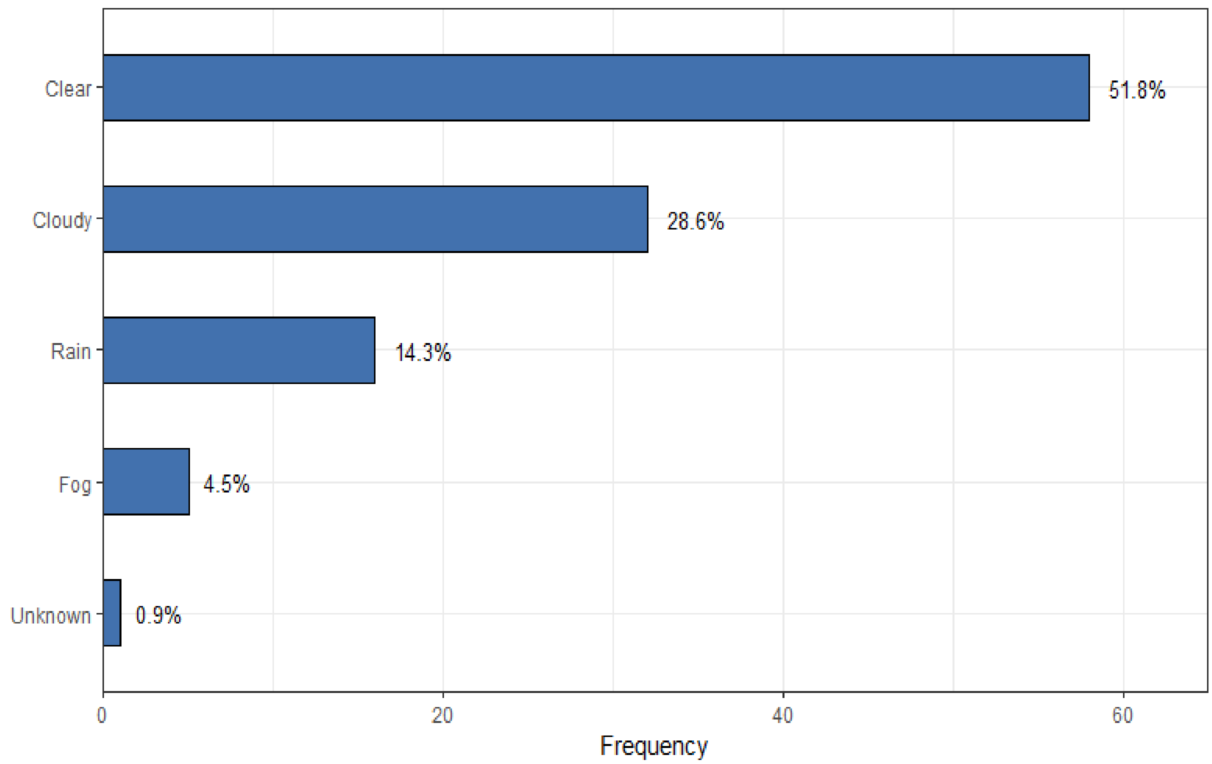

Figure 3.19: Older pedestrian fatal and serious injury crashes and weather condition

3.2.6 Road Surface Condition

Equivalent to older driver fatal and serious injury crashes, Figure 3.20 shows that the majority of older pedestrian fatal and serious injury crashes happened on dry surface conditions (approximately 66%). Also, of note, about 29% occurred on wet surface conditions, while less than 3% happened on snowy surface conditions, and less than 2% took place on icy surface conditions.

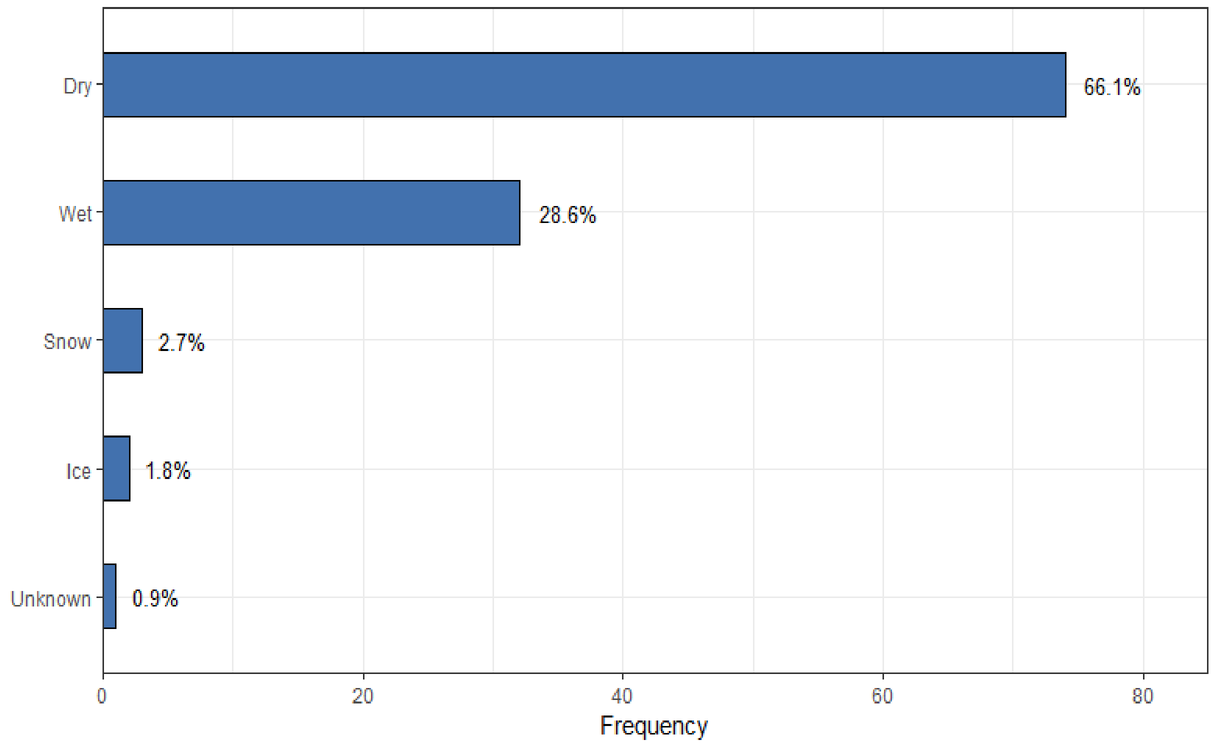

Figure 3.20: Older pedestrian fatal and serious injury crashes and road surface condition

3.2.7 Lighting Condition

Referring to Figure 3.21, roughly 47% of older pedestrian fatal and serious injury crashes happened during daylight conditions. In regards to dark conditions, the same proportion of crashes occurred under dark conditions with street lights and without street lights, both at approximately 20%. Dawn lighting conditions accounted for 8% of older pedestrian fatal and serious injury crashes, and dusk accounted for roughly 5% of older pedestrian fatal and serious injury crashes.

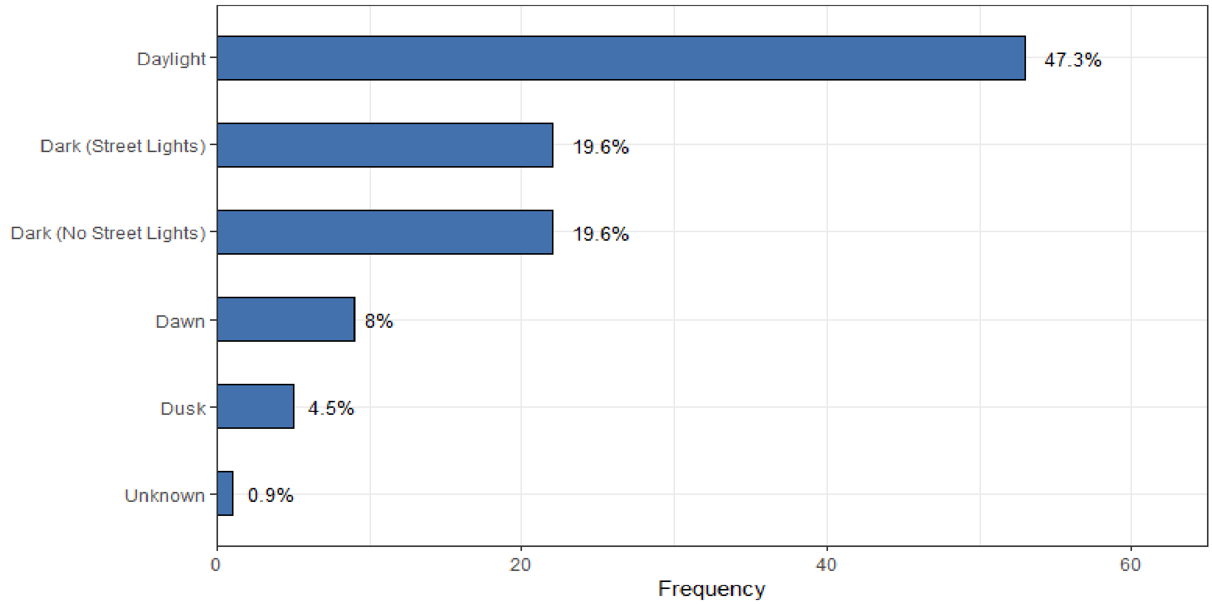

Figure 3.21: Older pedestrian fatal and serious injury crashes and lighting condition

3.2.8 Pedestrian Gender

As observed in Figure 3.22, approximately 62% of older pedestrian fatal and serious injury crashes involved a male, and roughly 38% involved a female.

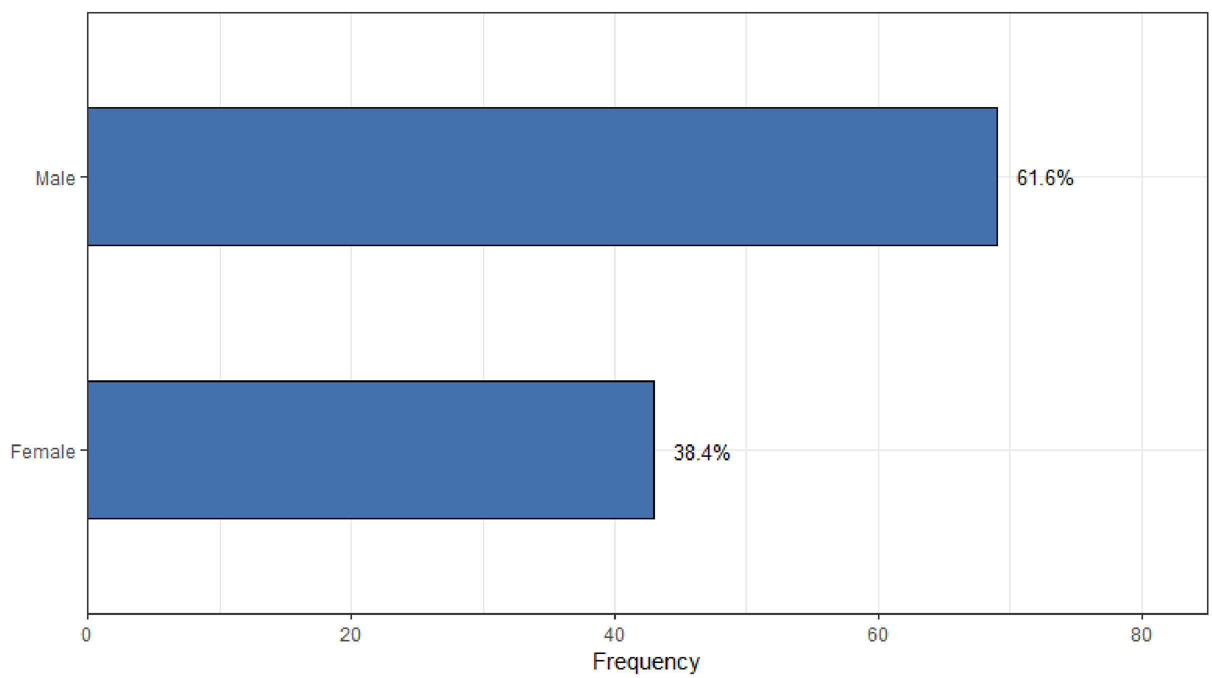

Figure 3.22: Older pedestrian fatal and serious injury crashes and pedestrian gender

3.2.9 Pedestrian Action

Pedestrian action describes what the pedestrian was doing, their condition, or other factors affecting the individual at the time of the crash (ODOT Crash Analysis and Reporting Unit, 2018). As shown in Figure 3.23, the majority of pedestrian actions correspond to intersections, the roadway character with the highest proportion of older pedestrian fatal and serious injury crashes (see Figure 3.18). From Figure 3.23, about 24% of older pedestrians were crossing between intersections when the crash occurred, about 23% were crossing at an intersection with no traffic signal, and roughly 21% were crossing at an intersection with a traffic signal. Approximately 21% of older pedestrian fatal and serious injury crashes had no recorded action, or it was non-warranted. Of the remaining pedestrian actions at the time, each account for less than 5% of the total number of crashes.

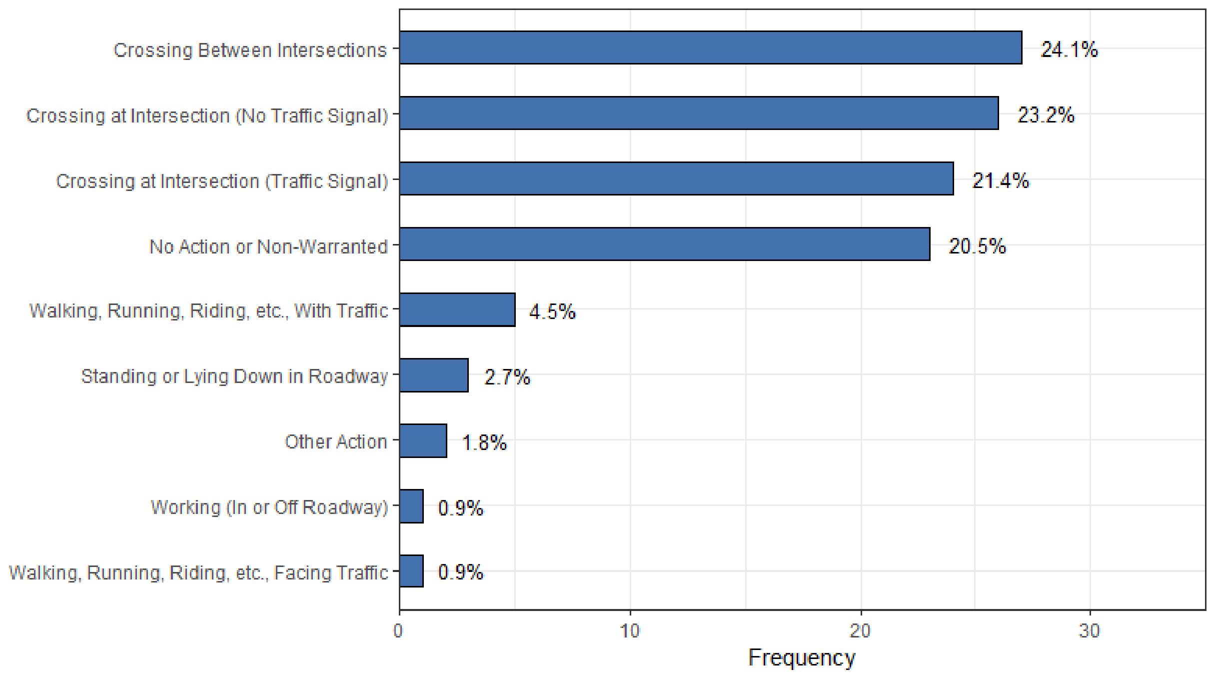

Figure 3.23: Older pedestrian fatal and serious injury crashes and pedestrian action

3.2.10 Pedestrian Location

Referring to Figure 3.24, the majority of older pedestrian locations at the time of the crash are split among three locations. Specifically, about 36% of older pedestrians were located at an intersection inside a crosswalk, approximately 31% were located in the roadway (not at an intersection), and roughly 15% were located at an intersection while in the roadway. Although at smaller proportions, about 5% of older pedestrians were located at an intersection while outside the crosswalk, roughly 5% were located on the roadway shoulder (not at an intersection), and nearly 4% were located on a sidewalk (not at an intersection).

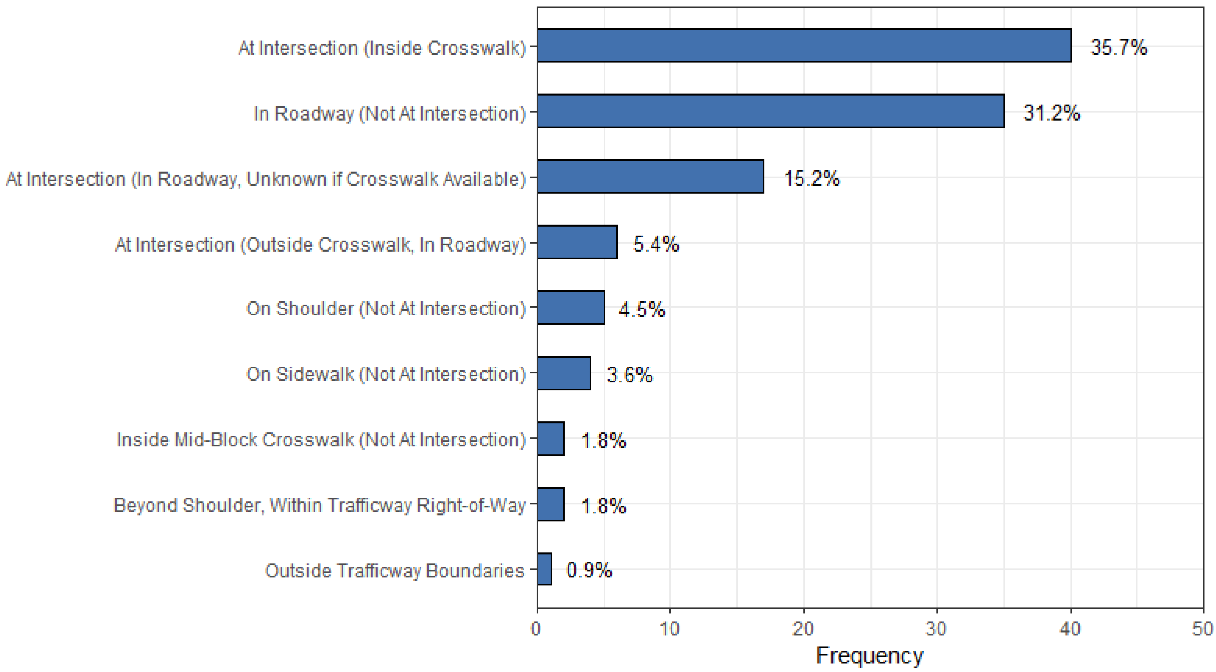

Figure 3.24: Older pedestrian fatal and serious injury crashes and pedestrian location

3.2.11 Pedestrian-Level Crash Cause

Of the pedestrian-level crash causes shown in Figure 3.25, the majority of older pedestrian fatal and serious injury crashes had no associated cause at the pedestrian level (about 46%). Of the crashes that did have an associated cause, roughly 30% were attributed to the pedestrian being illegally in the roadway, about 9% were attributed to the pedestrian not being visible, 8% were attributed to the pedestrian disregarding the traffic signal, and approximately 7% were attributed to the pedestrian not yielding the right-of-way.

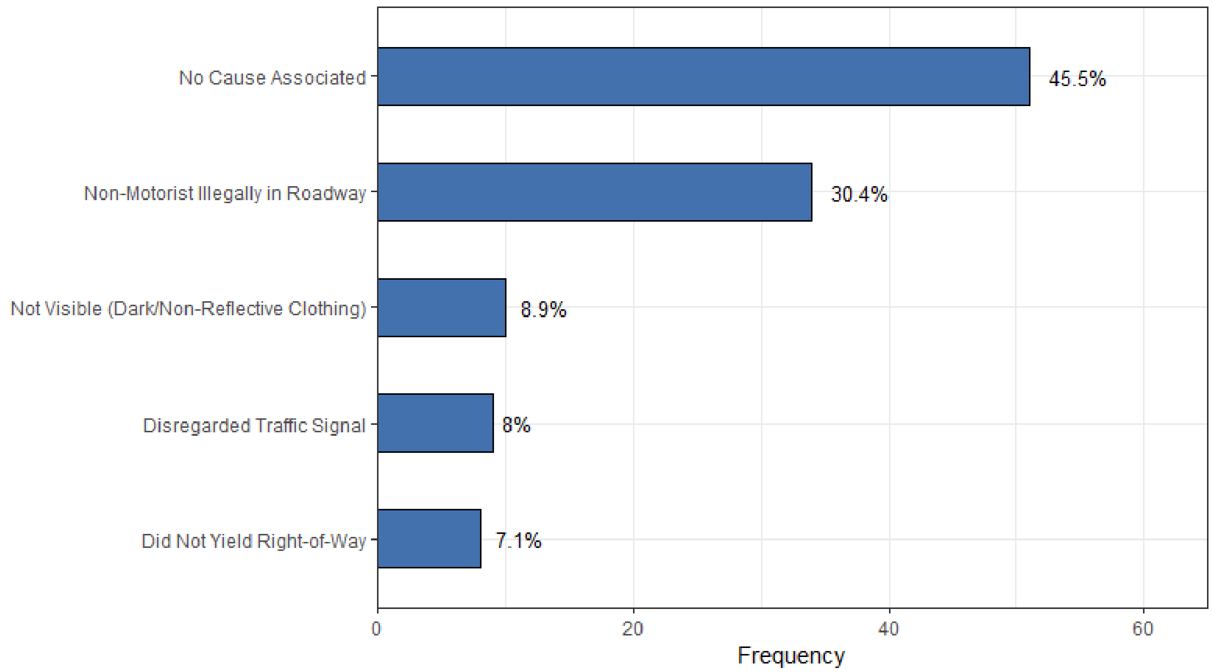

Figure 3.25: Older pedestrian fatal and serious injury crashes and pedestrian-level crash cause

3.2.12 Older Pedestrian Crashes, Vehicle Movements, and Driver Gender

For each of the older pedestrian fatal and serious injury crashes, the corresponding records for the vehicle involved were matched to the pedestrian record. Therefore, vehicle movements and driver gender of the vehicle involved are summarized here. As seen in Figure 3.26, approximately 67% of vehicles were moving straight ahead at the time of the older pedestrian crash, roughly 19% were turning left, about 11% were turning right, nearly 2% were backing up, and less than 1% were stopped in traffic.

Figure 3.27 shows that about 56% of drivers involved in an older pedestrian fatal and serious injury crash were male, and about 44% of drivers were female. Of the gender characteristics presented thus far, this is the narrowest split among males and females involved.

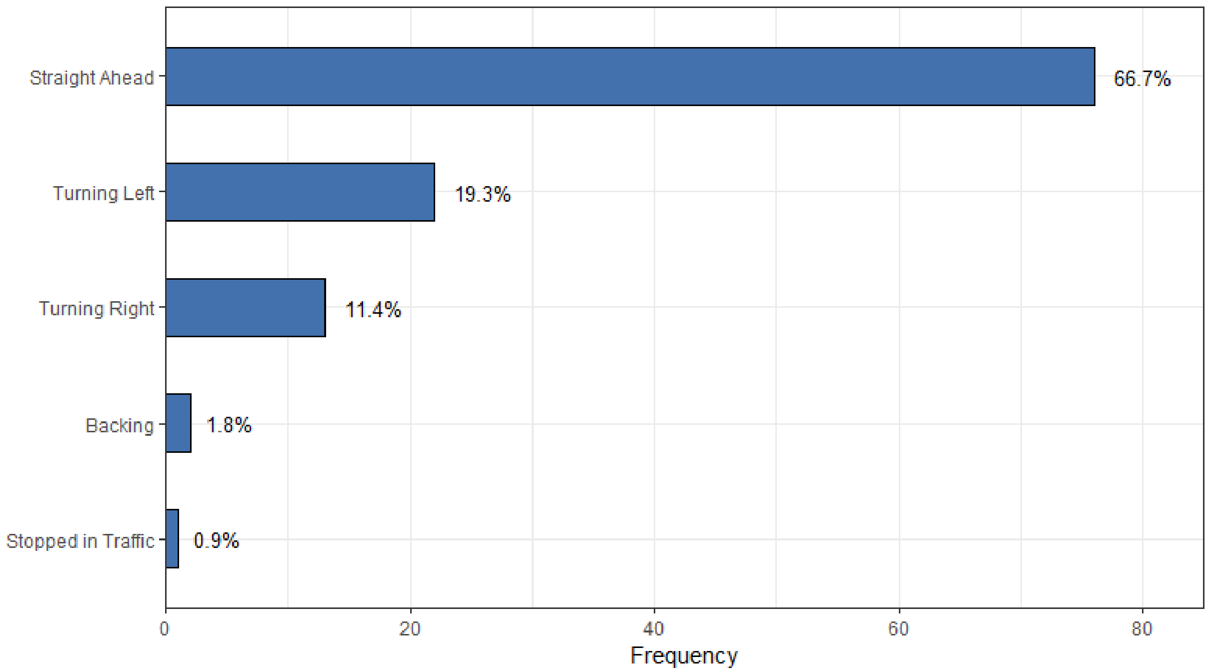

Figure 3.26: Older pedestrian fatal and serious injury crashes and vehicle movements

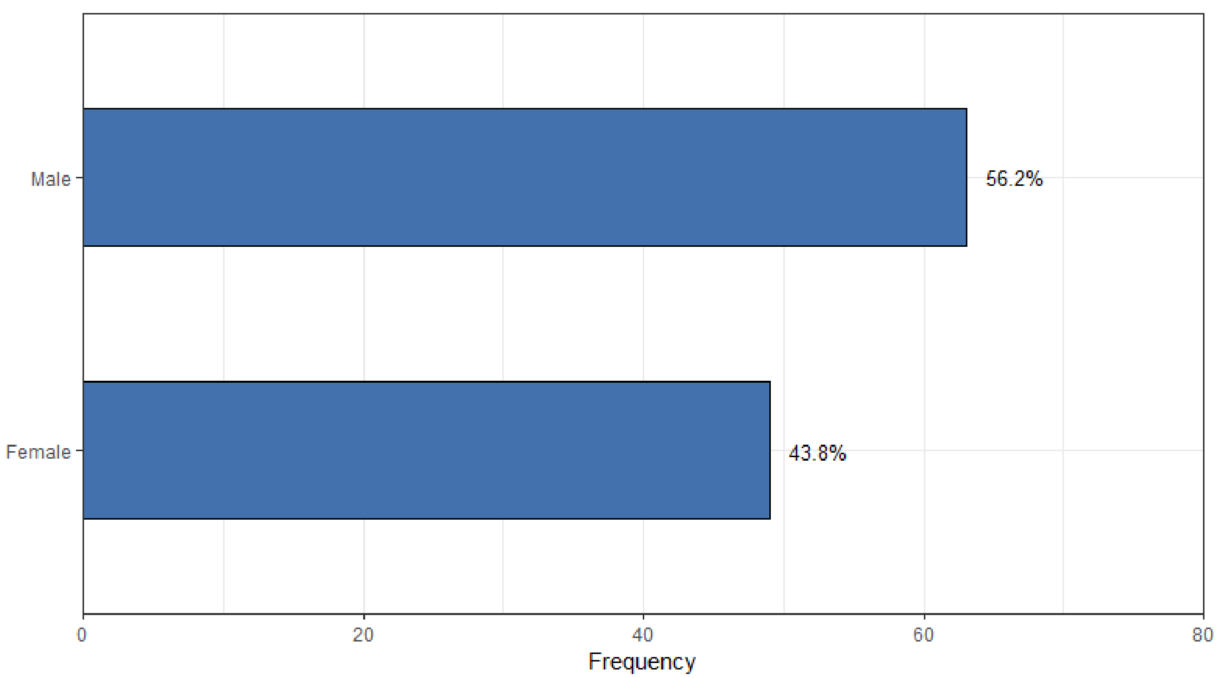

Figure 3.27: Older pedestrian fatal and serious injury crashes and driver gender

3.3 COMPARISON OF OLDER DRIVER FATAL AND SERIOUS INJURY CRASHES BY AGE GROUP

As stated previously, older driver fatal and serious injury crashes are compared to fatal and serious injury crashes of other age groups, namely:

- 16 years to 24 years
- 25 years to 44 years
- 45 years to 64 years

The number of fatal and serious injury crashes for drivers of the different age groups is shown in Table 3.1, and the trend in fatal and serious injury crashes by age group is shown in Figure 3.28.

Table 3.1: Number of Driver Fatal and Serious Injury Crashes by Age Group

Age Group	Number of Fatal and serious injury Crashes (Fatal and Incapacitating)
16 years to 24 years	943
25 years to 44 years	1,830
45 years to 64 years	1,827
65 years or greater	884

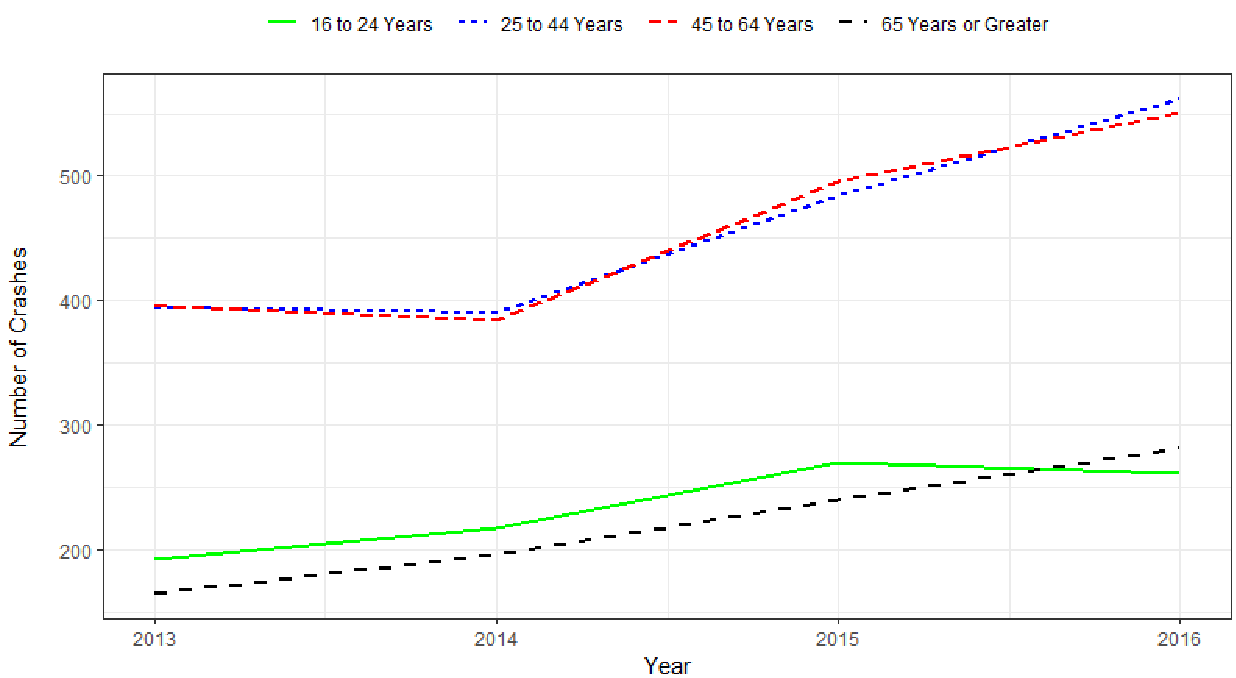

Figure 3.28: Driver fatal and serious injury crashes by year and age group

To present the comparison, stacked bar charts are used with a brief description of the corresponding bar chart. The comparisons are made based on the characteristics summarized in Section 3.1.

3.3.1 Driver Fatal and Serious Injury Crashes by Time of Day

As shown in Figure 3.29, all age groups had the most fatal and serious injury crashes during the same time periods: 12:00 p.m. to 2:59 p.m. and 3:00 p.m. to 5:59 p.m. For time of day, the one period in which a higher number of crashes occurred for older drivers compared to another age group is 9:00 a.m. to 11:59 a.m. In this case, older driver fatal and serious injury crashes occurred compared to fatal and serious injury crashes of young drivers (drivers age 16 years to 24 years).

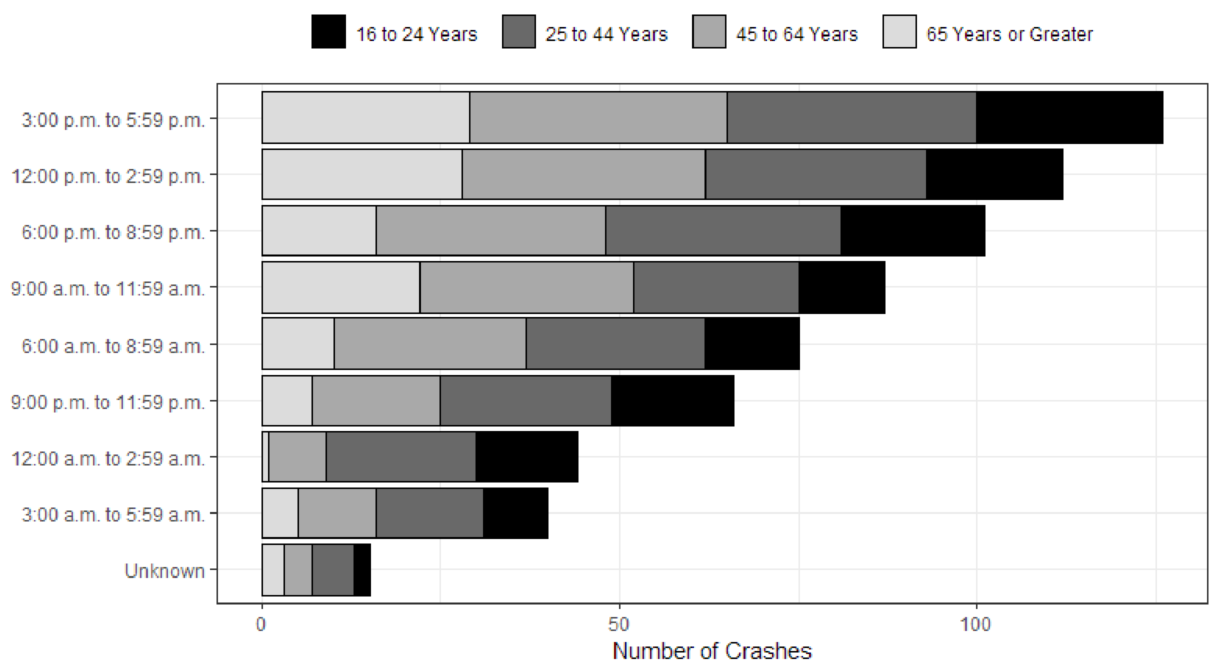

Figure 3.29: Driver fatal and serious injury crashes by time of day and age group

3.3.2 Driver Fatal and Serious Injury Crashes by Day of the Week

In general, Figure 3.30 shows no overrepresentation of older driver fatal and serious injury crashes by day of the week. Fewer older driver crashes occurred on weekends compared to other age groups. On most days, similar proportions of older drivers and younger drivers (drivers aged 16 years to 24 years) are observed. However, as Figure 3.30 shows, older driver fatal and serious injury crashes occurred on Mondays compared to younger drivers.

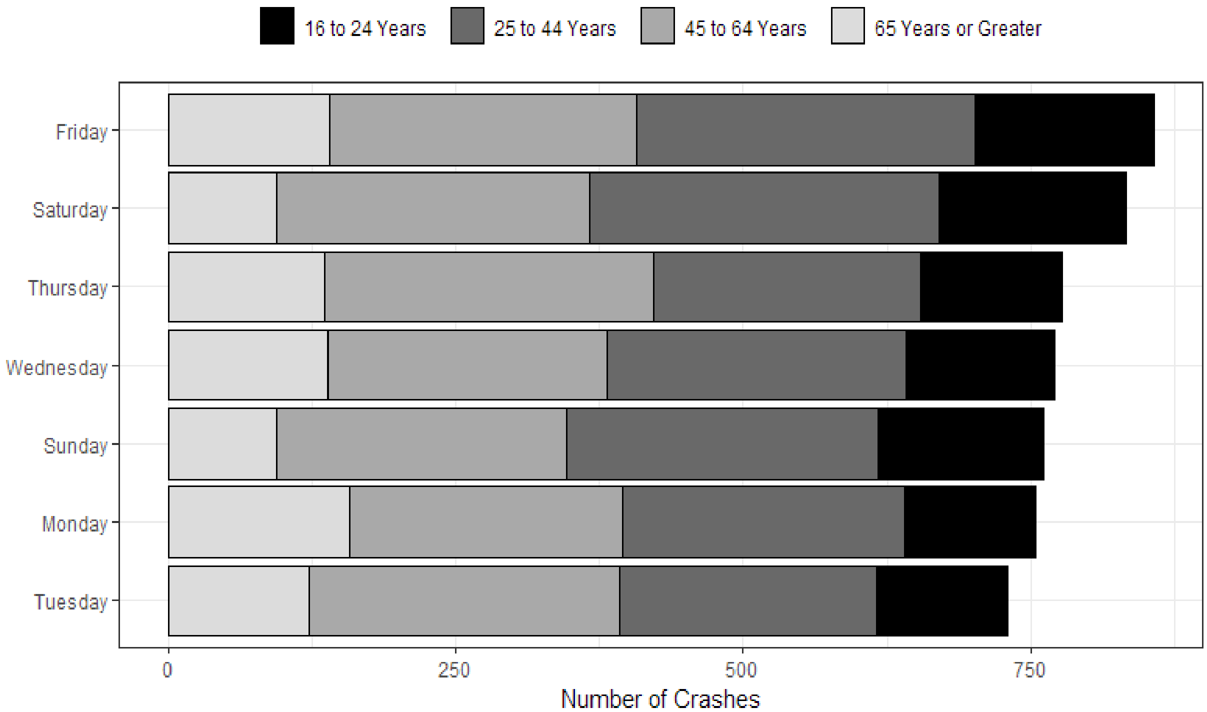

Figure 3.30: Driver fatal and serious injury crashes by day of the week and age group

3.3.3 Driver Fatal and Serious Injury Crashes by Roadway Classification

For roadway classification comparisons, Figure 3.31 shows similar trends at it pertains to older drivers and younger drivers (drivers aged 16 years to 24 years). In most cases, the proportions are similar. However, fewer older driver crashes, compared to younger drivers, happened on specific rural classifications (major collectors, minor collectors, and local streets) and specific urban classifications (minor arterials and major collectors). Two classifications show an overrepresentation of older driver fatal and serious injury crashes when compared to younger drivers: rural principal arterials and urban principal arterials.

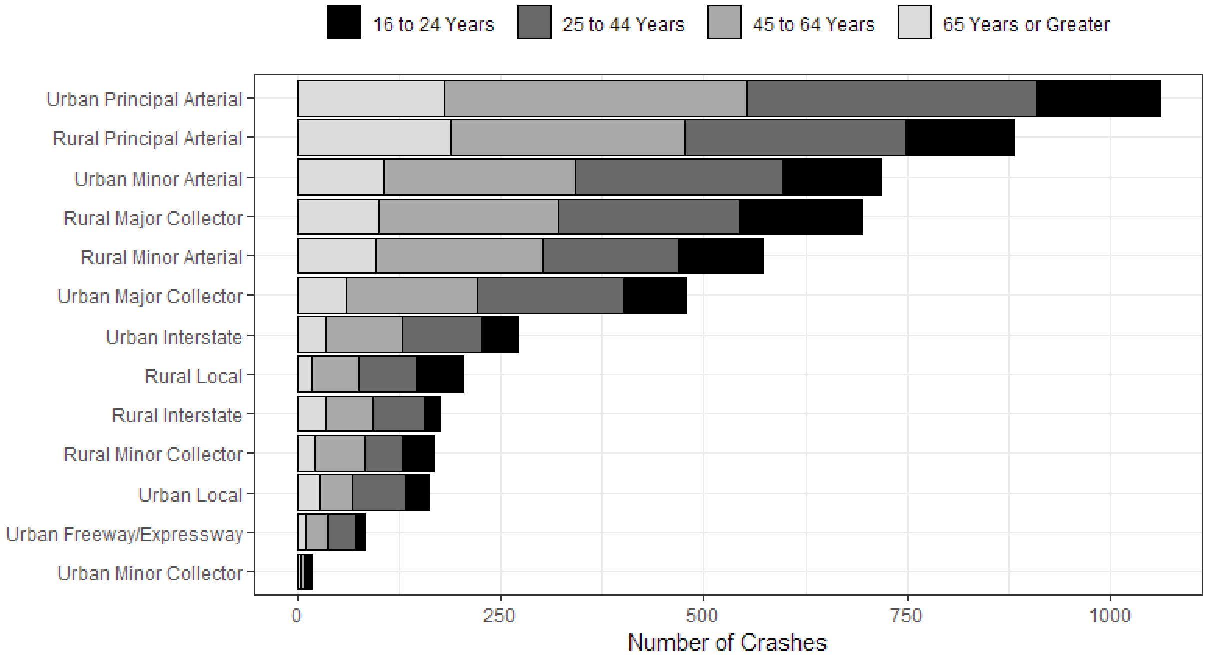

Figure 3.31: Driver fatal and serious injury crashes by roadway classification and age group

3.3.4 Driver Fatal and Serious Injury Crashes by Roadway Character

Referring to Figure 3.32, a larger proportion of older driver fatal and serious injury crashes occurred at intersections and driveways or alley access locations when compared to younger drivers (drivers aged 16 years to 24 years). Also of note, fewer older driver fatal and serious injury crashes occurred on straight roadway segments and horizontal curves compared to younger drivers. Similar proportions among all age groups are observed for fatal and serious injury crashes on vertical curves.

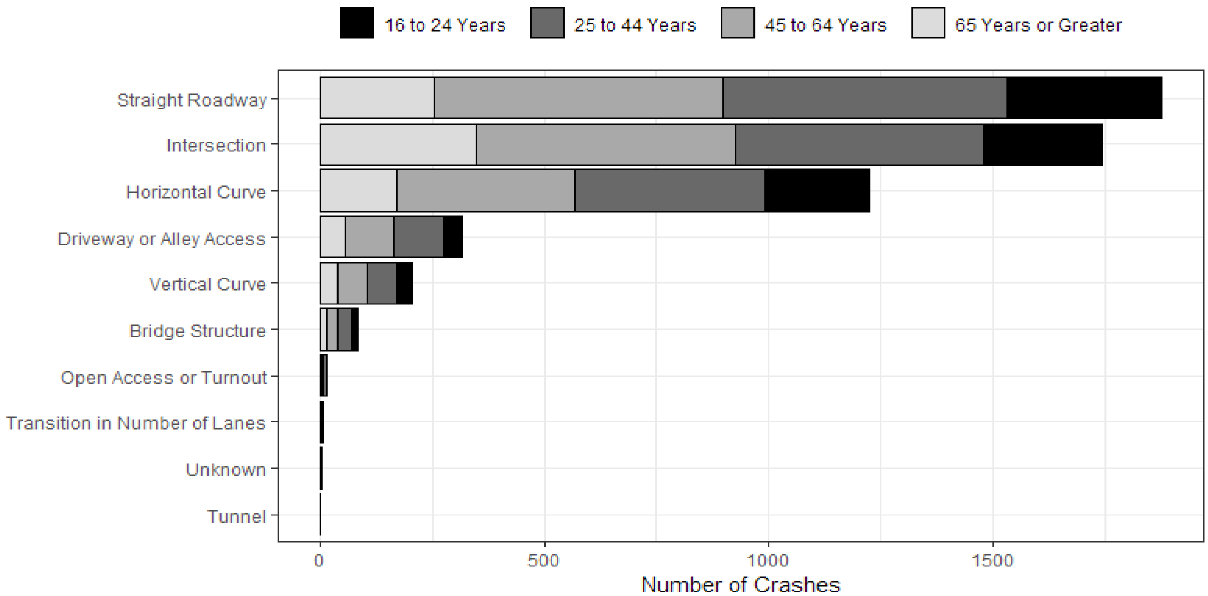

Figure 3.32: Driver fatal and serious injury crashes by roadway character and age group

3.3.5 Driver Fatal and Serious Injury Crashes by Weather Condition

Figure 3.33 shows that for all age groups, the majority of crashes occurred during clear conditions. For cloudy conditions and rainy conditions, Figure 3.33 shows that fewer older driver fatal and serious injury crashes occurred compared to younger drivers.

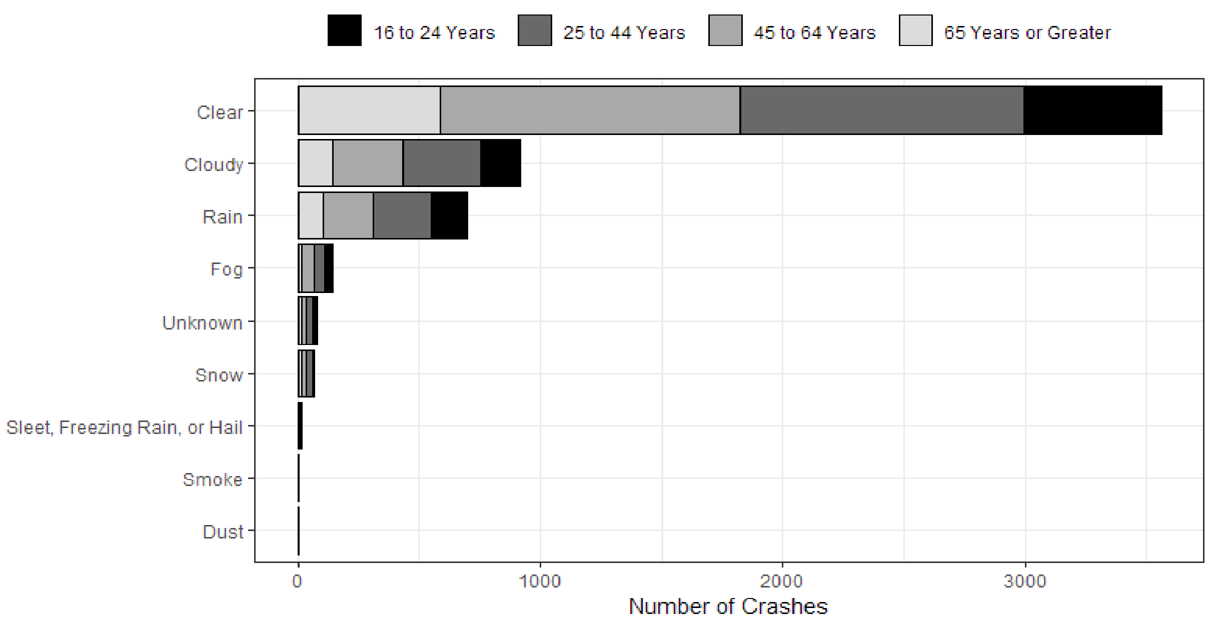

Figure 3.33: Driver fatal and serious injury crashes by weather condition and age group

3.3.6 Driver Fatal and Serious Injury Crashes by Road Surface Condition

Figure 3.34 shows that for all groups, the majority of crashes happened on dry surface conditions, with older drivers and younger drivers representing similar proportions. For wet surface conditions, the other notable condition, similar proportions are observed; however, older drivers do represent the smallest proportion.

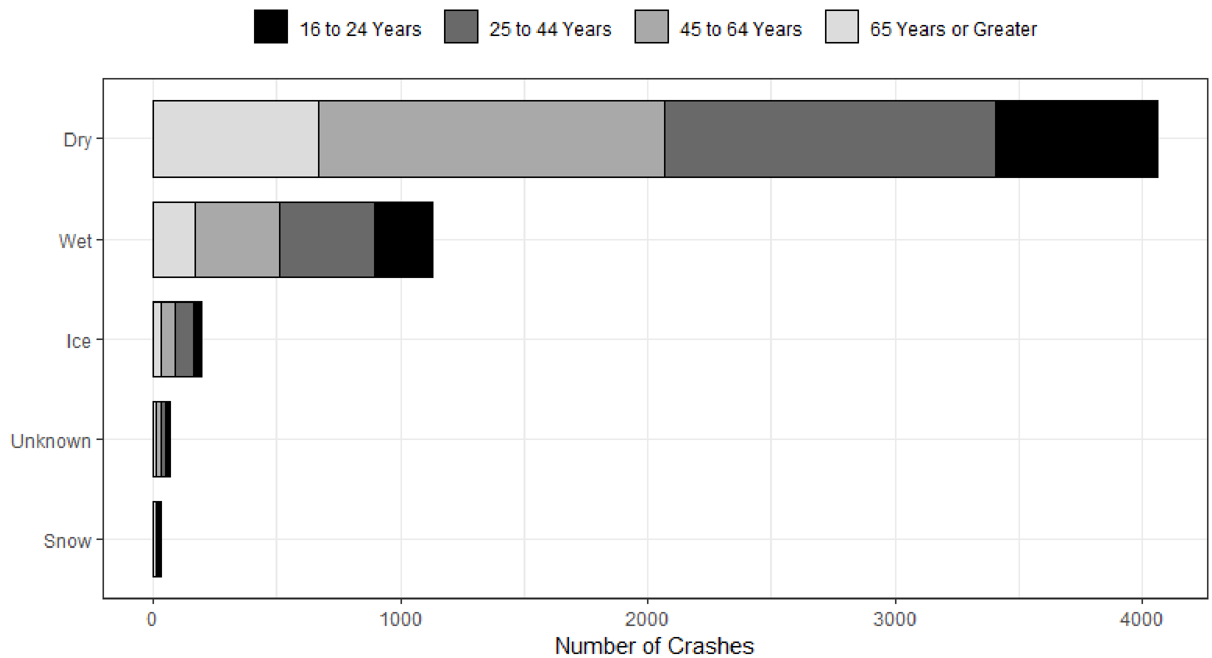

Figure 3.34: Driver fatal and serious injury crashes by road surface condition and age group

3.3.7 Driver Fatal and Serious Injury Crashes by Lighting Condition

Once more, as with the previous two crash characteristics, Figure 3.35 shows that the majority of fatal and serious injury crashes for all age groups happened during daylight conditions, with older driver crashes compared to younger drivers (drivers aged 16 years to 24 years). In addition, fewer older driver fatal and serious injury crashes occurred during dark conditions (both with and without street lights) and dawn or dusk conditions compared to the other age groups.

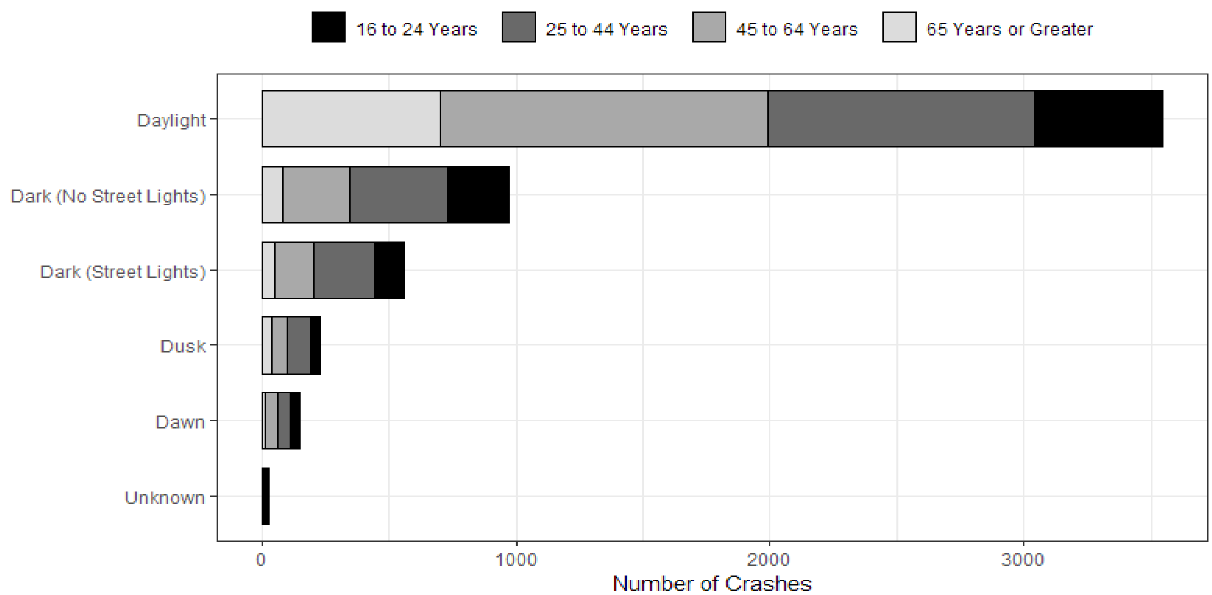

Figure 3.35: Driver fatal and serious injury crashes by lighting condition and age group

3.3.8 Driver Fatal and Serious Injury Crashes by Collision Type

As shown in Figure 3.36, the most occurring crash type for all age groups is fixed object. Compared to younger drivers (drivers aged 16 years to 24 years), fewer older driver fatal and serious injury crashes were head-on crashes. On the other hand, rear-end crashes, turning movement crashes, and angle crashes are represented more by older drivers compared to younger drivers.

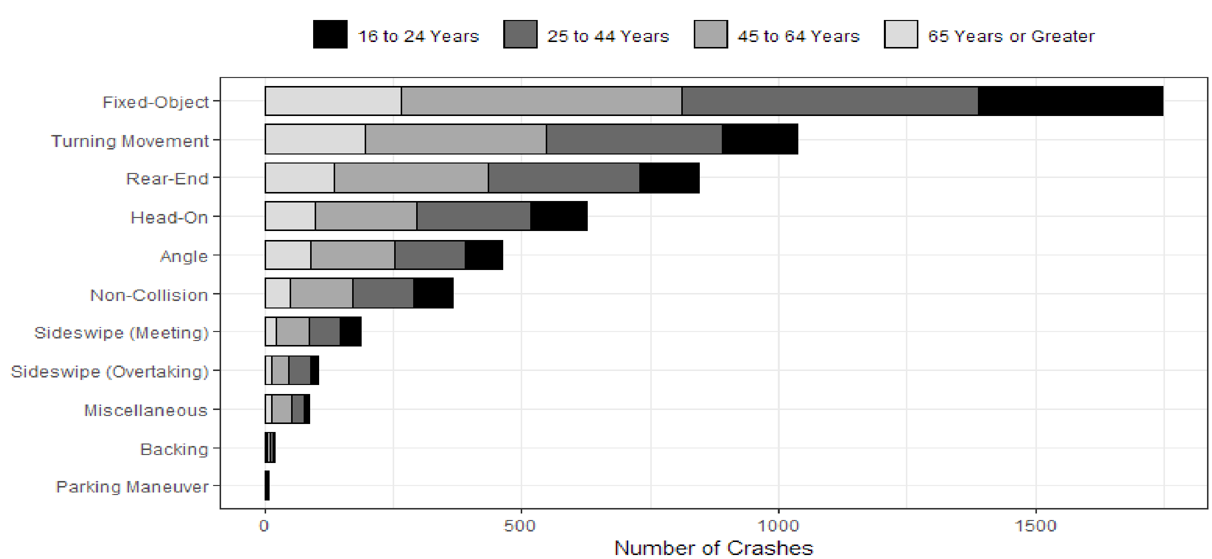

Figure 3.36: Driver fatal and serious injury crashes by collision type and age group

3.3.9 Driver Fatal and Serious Injury Crashes by Number of Vehicles Involved

Referring to Figure 3.37, multivehicle crashes account for the majority of crashes for all age groups. In terms of fewer fatal and serious injury crashes for older drivers, older drivers represent the smallest proportion of single-vehicle crashes. However, for multivehicle crashes, older drivers represent a larger proportion when compared to younger drivers (drivers aged 16 years to 24 years).

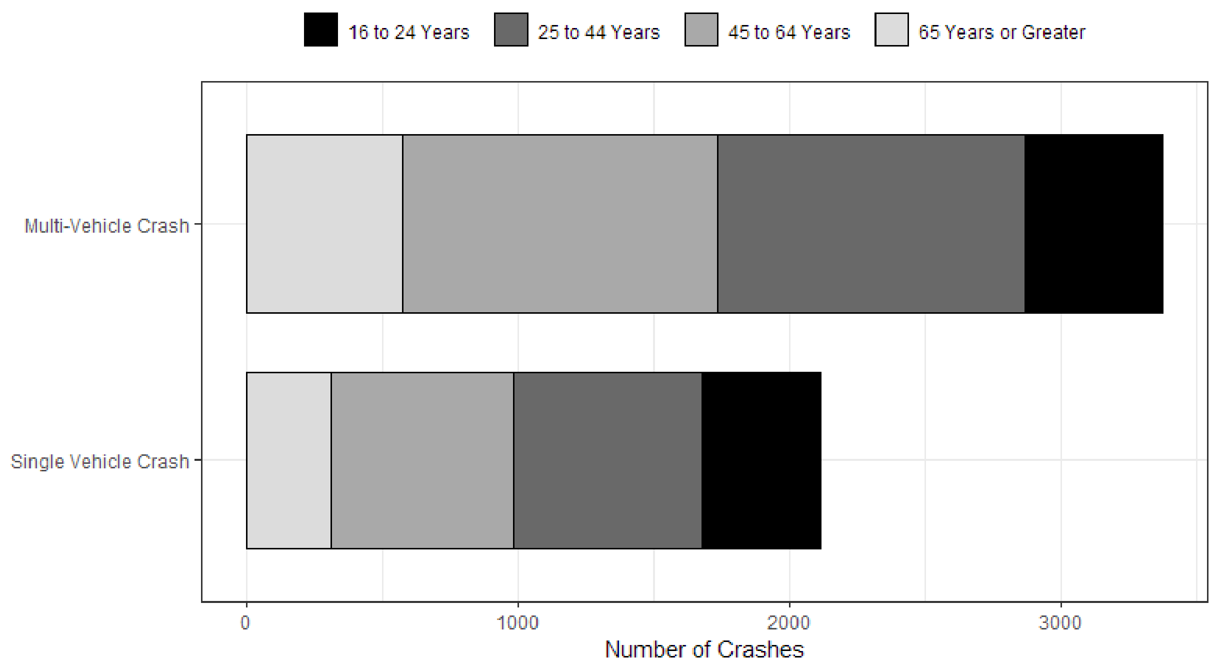

Figure 3.37: Driver fatal and serious injury crashes by number of vehicles involved and age group

3.3.10 Driver Fatal and Serious Injury Crashes by Driver Residence

Once more, according to Figure 3.38, one attribute accounts for the largest proportion of crashes for all age groups. For residency, the majority of drivers for each age group were reported to be Oregon residents within 20 miles from home, with similar proportions for older drivers and younger drivers (drivers aged 16 years to 24 years). In regards to Oregon residents more than 20 miles from home, older drivers represent a larger proportion compared to younger drivers. Lastly, older and younger drivers represent roughly the same proportion of non-resident drivers involved in fatal and serious injury crashes.

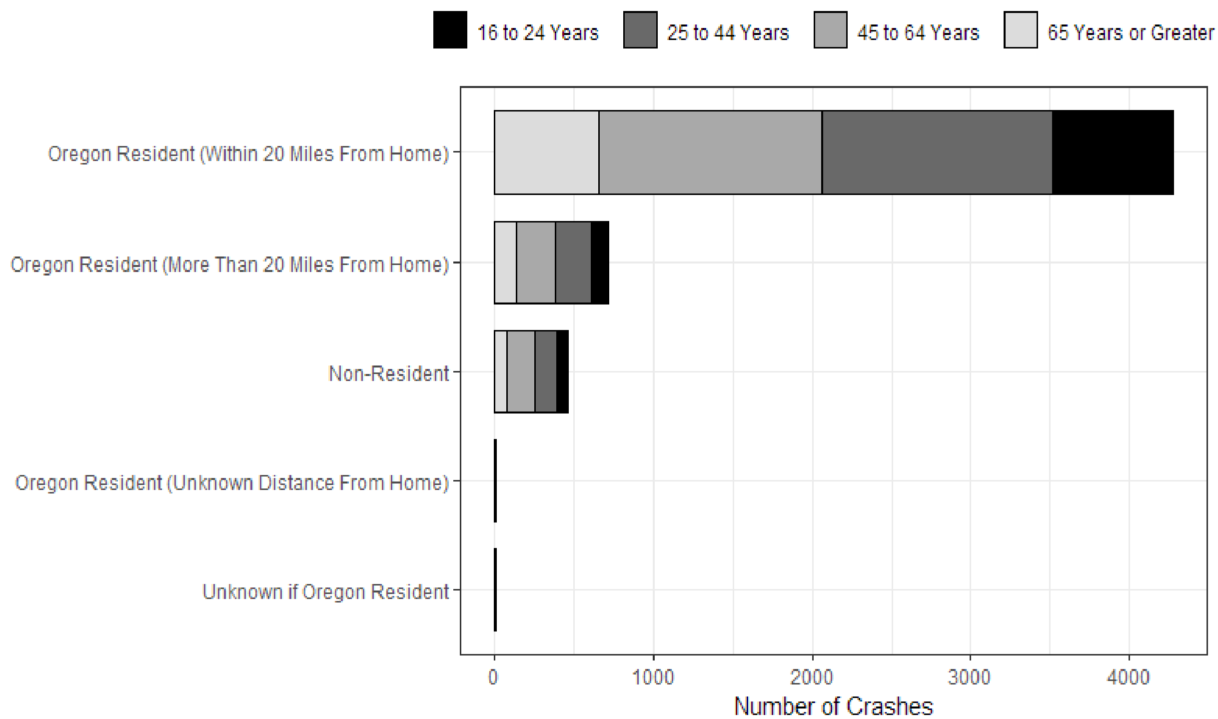

Figure 3.38: Driver fatal and serious injury crashes by residency and age group

3.3.11 Driver Fatal and Serious Injury Crashes by Driver Gender

Referring to Figure 3.39, roughly the same proportion of older and younger drivers in fatal and serious injury crashes were male, and roughly the same proportion were female.

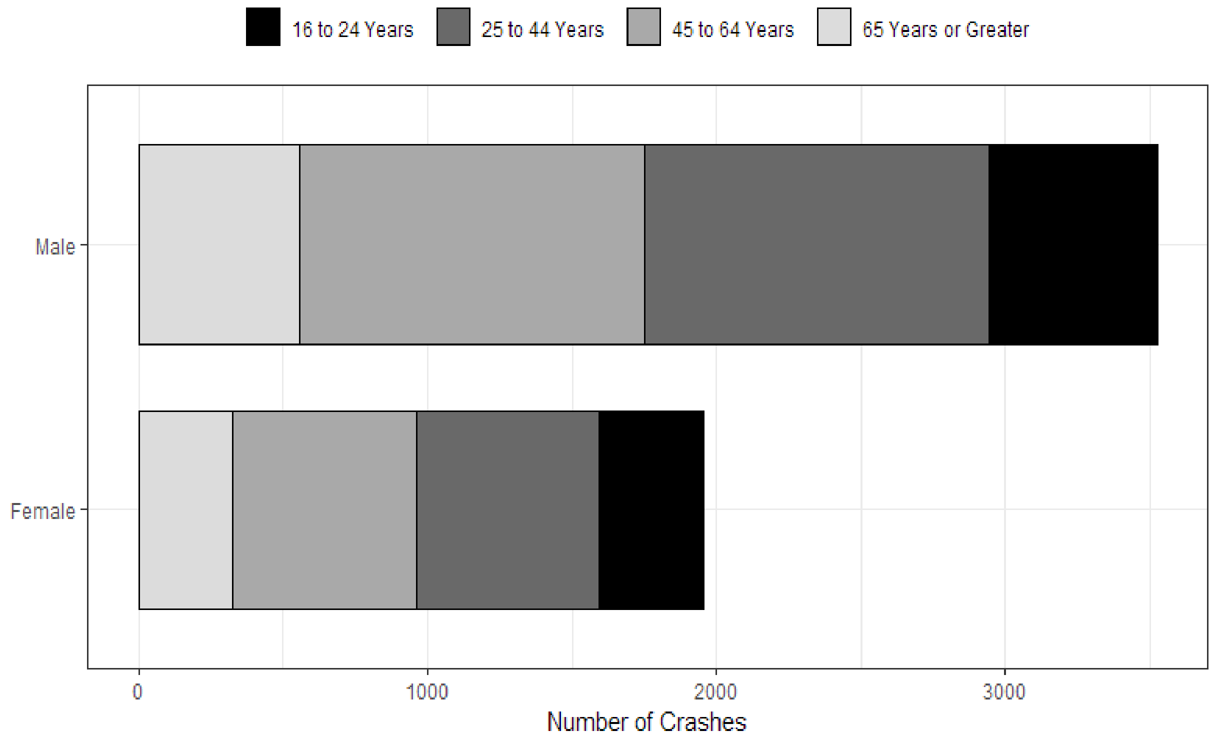

Figure 3.39: Driver fatal and serious injury crashes by gender and age group

3.3.12 Driver Fatal and Serious Injury Crashes by Driver-Level Crash Cause

Figure 3.40 shows that the largest proportion for each age group belongs to no associated crash cause (i.e., no cause attributed to the driver, according to Oregon crash records). Driver-level crash causes in which older drivers represent the smallest proportion include speeding too fast for conditions, fatigue, driving in excess of the posted speed limit, reckless driving, and driving left of center on a two-way road. Driver-level crash causes where older drivers represent the largest proportion include not yielding the right-of-way and physical illness. Causes in which older drivers represent the second largest proportion include failing to avoid a vehicle ahead.

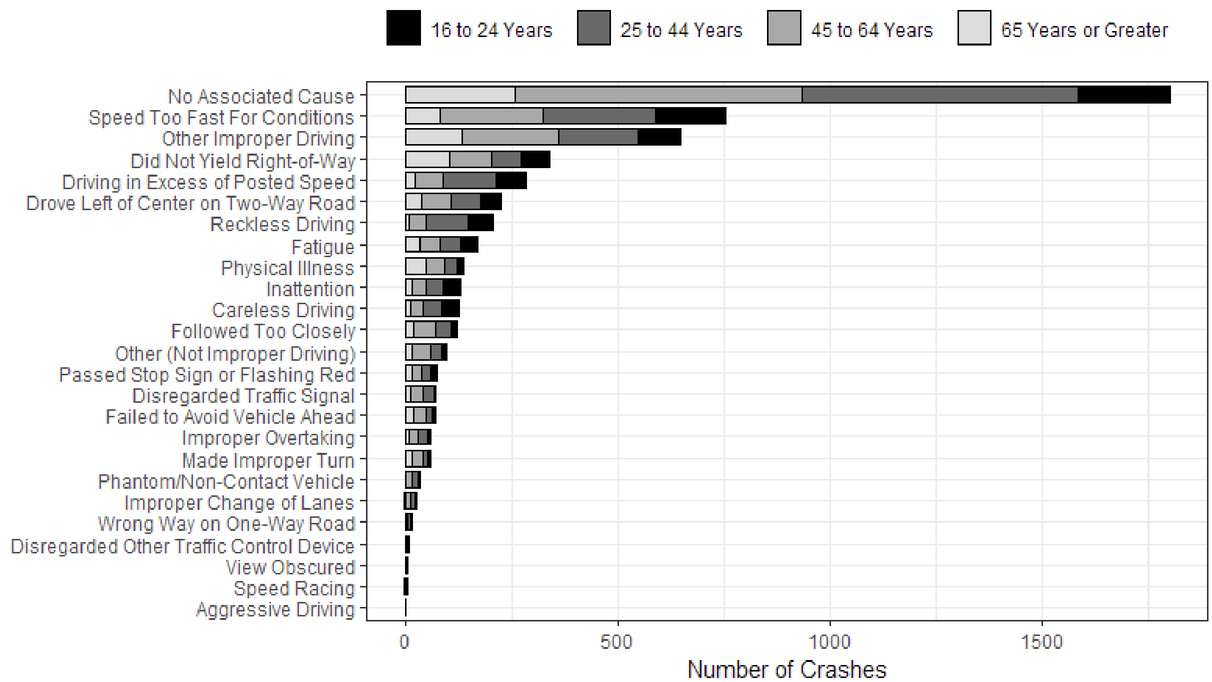

Figure 3.40: Driver fatal and serious injury crashes by driver-level crash cause and age group

3.3.13 Driver Fatal and Serious Injury Proportion Comparison

Lastly, to statistically compare the proportions between older driver crashes and each age group, a series of z-test of proportions are conducted. The test is conducted between older drivers and each age group to determine if proportions are statistically different.

The z-test of proportions is based on the following null and alternative hypotheses:

$$\boldsymbol{H_0: P_1 = P_2} \tag{3-1}$$

$$\boldsymbol{H_A: P_1 \neq P_2} \tag{3-2}$$

Where:

P_1 and P_2 are the proportions of sample one and sample two, respectively.

With these hypotheses in mind, a z-statistic is calculated to determine if the null hypothesis is rejected:

$$\boldsymbol{Z} = \frac{\left(\widehat{\boldsymbol{P}}_{\boldsymbol{1}} - \widehat{\boldsymbol{P}}_{\boldsymbol{2}}\right)}{\sqrt{\widehat{\boldsymbol{P}}\left(\boldsymbol{1} - \widehat{\boldsymbol{P}}\right)\left(\frac{\boldsymbol{1}}{\boldsymbol{N}_{\boldsymbol{1}}} + \frac{\boldsymbol{1}}{\boldsymbol{N}_{\boldsymbol{2}}}\right)}}$$

(3-3)

With:

$$\widehat{\boldsymbol{P}}_{\boldsymbol{1}} = \frac{\boldsymbol{S}_{\boldsymbol{1}}}{\boldsymbol{N}_{\boldsymbol{1}}} \quad \textbf{and} \quad \widehat{\boldsymbol{P}}_{\boldsymbol{2}} = \frac{\boldsymbol{S}_{\boldsymbol{2}}}{\boldsymbol{N}_{\boldsymbol{2}}}$$

(3-4)

$$\widehat{\boldsymbol{P}} = \frac{\boldsymbol{S}_{\boldsymbol{1}} + \boldsymbol{S}_{\boldsymbol{2}}}{\boldsymbol{N}_{\boldsymbol{1}} + \boldsymbol{N}_{\boldsymbol{2}}}$$

(3-5)

Where:

S_1 is the number of older driver or pedestrian crashes for a specific crash attribute (e.g., 12:00 p.m. to 2:59 p.m., clear weather, straight roadway segments, etc.);

S_2 is the number of crashes for the age group being tested against for the same crash attribute (16 years to 24 years, 25 years to 44 years, and 45 years to 64 years);

N_1 is the total number of crashes for the crash attribute category (e.g., time of day, weather condition, road character, etc.); and

N_2 is the total number of crashes for the crash category of the age group being tested against.

For the proportions test, a statistical significance threshold of p-value ≤ 0.05 is chosen. In the ensuing tables, statistical significance is denoted by an asterisk. For the proportions test, any crash record that was recorded as unknown was excluded. Results from the proportions test will be discussed by crash factor.

The first proportions test was for time of day. For nearly all time periods, there is a statistical difference between proportions of older driver fatal and serious injury crashes and the proportions of each age group considered. There is no statistical difference in proportions for older drivers and drivers aged 16 years to 24 years for the time period of 6:00 a.m. to 8:59 a.m. and 6:00 p.m. to 8:59 p.m. In regards to day of the week, there is a statistical difference in proportions compared to all age groups on Sunday, Monday, and Saturday.

For roadway classification proportions, there is a statistical difference compared to drivers age 16 years to 24 years on rural interstates, rural principal arterials, rural major collectors, rural minor collectors, rural local streets, and urban principal arterials. Proportions on rural principal arterials are also significantly different when compared to the other two age groups and is the only difference compared to drivers aged 45 years to 64 years. Compared to drivers aged 25 years to 44 years, there is also a significant difference in proportions on rural local streets and urban major collectors.

Considering roadway character, proportions are statistically different compared to drivers aged 16 years to 24 years for intersection crashes and crashes on straight roadway segments. In addition, these two roadway characters have significantly different proportions compared to the other two age groups. The only additional difference in proportions is observed for older drivers and drivers aged 25 years to 44 years, where the proportions are different for crashes that occurred on horizontal curves.

As it pertains to weather conditions, significant differences in proportions were found only compared to drivers aged 16 years to 24 years. The weather conditions with significant differences include clear weather, rainy weather, and foggy weather. Similar to weather conditions, differences in proportions for road surface conditions were observed only between older drivers and drivers aged 16 years to 24 years. In particular, there are significant differences in proportions for older drivers and drivers aged 16 years to 24 years on dry surface conditions and wet surface conditions.

Regarding lighting conditions, there were significant differences in proportions compared to all age groups. Compared to drivers' age 16 years to 24 years, there are significant differences for lighting conditions except dusk. Compared to drivers' age 25 years to 44 years, there are significant differences for crashes that occurred in daylight, crashes that happened in the dark with street lights, and crashes that took place in the dark with no street lights. Differences in proportions for the three lighting conditions were also significantly different compared to drivers' age 45 years to 64 years.

Referring to collision type, there are no significant differences in proportions compared to drivers age 45 years to 64 years. Compared to drivers' age 25 years to 44 years, just two collision types were found to have significant differences in proportions: angle collisions and turning-movement collisions. Once more, the majority of differences in proportions are observed when compared to drivers' age 16 years to 24 years. Specifically, there are significant differences for rear-end collisions, sideswipe (meeting) collisions, turning-movement collisions, and fixed-object collisions. Also, with significant differences with only drivers' age 16 years to 24 years are the number of vehicles involved in the crash, where there are significant differences in proportions for both single- and multivehicle crashes.

In regard to residency, differences in proportions were found compared to both drivers' age 16 years to 24 years and drivers' age 25 years to 44 years. In both cases, the differences in proportions are for Oregon residents within 20 miles of home and Oregon residents more than 20 miles from home. There were no significant differences in proportions when considering driver gender.

The final attribute compared via proportions was the driver-level crash cause. Compared to each age group, significant differences in proportions are observed for crashes in which the driver was speeding too fast for conditions, crashes that happened due to the driver not yielding the right-of-way, the driver being physically ill, and reckless driving. Other notable differences include crashes in which the driver made an improper turn, failing to avoid the vehicle ahead, disregarding a traffic control device other than a traffic signal, fatigue, and speeding. For crashes in which the driver made an improper turn, crashes where the driver failed to avoid the vehicle ahead, crashes in which the driver disregarded a traffic control device other than a traffic signal, and speeding, there are significant differences in proportions compared to both drivers aged 16 years to 24 years and drivers aged 25 years to 44 years. Significant differences in proportions of crashes where the driver-level cause was reported to be fatigue were found compared to drivers aged 25 years to 44 years and drivers aged 45 years to 64 years.

Table 3.2: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Time of Day and Age Group

Time of Day	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
12:00 a.m. to 2:59 a.m.	101	10.8 %	158	8.8%	54	3.0%	3	0.3%	**0.000***	**0.000***	**0.000***
3:00 a.m. to 5:59 a.m.	61	6.5%	106	5.9%	74	4.1%	17	1.9%	**0.000***	**0.000***	**0.004***
6:00 a.m. to 8:59 a.m.	99	10.6 %	199	11.0%	213	11.7%	73	8.4%	0.110	**0.031***	**0.008***
9:00 a.m. to 11:59 a.m.	81	8.6%	173	9.6%	248	13.7%	168	19.2%	**0.000***	**0.000***	**0.000***
12:00 p.m. to 2:59 p.m.	129	13.8 %	290	16.1%	360	19.8%	231	26.4%	**0.000***	**0.000***	**0.000***
3:00 p.m. to 5:59 p.m.	209	22.3 %	377	20.9%	448	24.7%	239	27.3%	**0.013***	**0.000***	0.136
6:00 p.m. to 8:59 p.m.	133	14.2 %	311	17.2%	293	16.1%	108	12.4%	0.254	**0.001***	**0.010***
9:00 p.m. to 11:59 p.m.	125	13.3 %	190	10.5%	126	6.9%	35	4.0%	**0.000***	**0.000***	**0.003***
Total	938		1804		1816		874				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.3: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Day of the Week and Age Group

Day of the Week	Number of Crashes										
	16 to 24 Years	**% of Total**	**25 to 44 Years**	**% of Total**	**45 to 64 Years**	**% of Total**	**65 Years or Greater**	**% of Total**	***p*-value[1]**	***p*-value[2]**	***p*-value[3]**
Sunday	144	15.3%	271	14.8%	252	13.8%	94	10.6%	**0.003***	**0.003***	**0.021***
Monday	114	12.1%	245	13.4%	237	13.0%	158	17.9%	**0.001***	**0.002***	**0.001***
Tuesday	114	12.1%	224	12.2%	269	14.7%	123	13.9%	0.246	0.221	0.574
Wednesday	129	13.7%	261	14.3%	242	13.2%	139	15.7%	0.217	0.314	0.082
Thursday	124	13.1%	232	12.7%	286	15.7%	136	15.4%	0.172	0.054	0.856
Friday	155	16.4%	294	16.1%	268	14.7%	140	15.8%	0.728	0.879	0.425
Saturday	163	17.3%	303	16.6%	273	14.9%	94	10.6%	**0.000***	**0.000***	**0.002***
Total	943		1830		1827		884				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.4: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Roadway Classification and Age Group

Classifications	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Rural Interstate	20	2.1%	63	3.4%	58	3.2%	35	4.0%	**0.022***	0.499	0.293
Rural Principal Arterial	131	13.9%	272	14.9%	288	15.8%	189	21.4%	**0.000***	**0.000***	**0.000***
Rural Minor Arterial	104	11.0%	166	9.1%	206	11.3%	96	10.9%	0.908	0.139	0.747
Rural Major Collector	152	16.1%	222	12.1%	221	12.1%	100	11.3%	**0.003***	0.536	0.554
Rural Minor Collector	39	4.1%	46	2.5%	61	3.3%	22	2.5%	**0.050***	0.969	0.228
Rural Local	56	5.9%	71	3.9%	58	3.2%	18	2.0%	**0.000***	**0.011***	0.092
Urban Interstate	44	4.7%	98	5.4%	93	5.1%	36	4.1%	0.536	0.148	0.243
Urban Freeway/Expressway	13	1.4%	34	1.9%	26	1.4%	11	1.2%	0.801	0.241	0.707
Urban Principal Arterial	150	15.9%	357	19.5%	373	20.4%	180	20.4%	**0.013***	0.601	0.974
Urban Minor Arterial	122	12.9%	254	13.9%	236	12.9%	106	12.0%	0.541	0.174	0.496
Urban Major Collector	77	8.2%	179	9.8%	162	8.9%	60	6.8%	0.264	0.010*	0.064
Urban Minor Collector	6	0.6%	3	0.2%	4	0.2%	4	0.5%	0.595	0.165	0.293
Urban Local	29	3.1%	65	3.6%	41	2.2%	27	3.1%	0.979	0.502	0.206
Total	943		1830		1827		884				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.5: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Road Character and Age Group

Road Character	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Intersection	265	28.1%	555	30.4%	576	31.5%	349	39.5%	**0.000***	**0.000***	**0.000***
Driveway or Alley Access	43	4.6%	112	6.1%	108	5.9%	55	6.2%	0.115	0.929	0.753
Straight Roadway	346	36.7%	632	34.6%	645	35.3%	254	28.7%	**0.000***	**0.002***	**0.001***
Transition in Number of Lanes	2	0.2%	3	0.2%	1	0.1%	1	0.1%	0.602	0.745	0.600
Horizontal Curve	234	24.8%	424	23.2%	400	21.9%	169	19.1%	0.003	**0.015***	0.095
Open Access or Turnout	1	0.1%	5	0.3%	4	0.2%	4	0.5%	0.157	0.449	0.294
Vertical Curve	38	4.0%	65	3.6%	66	3.6%	38	4.3%	0.774	0.346	0.385
Bridge Structure	14	1.5%	29	1.6%	26	1.4%	14	1.6%	0.863	0.993	0.746
Tunnel	0	0.0%	1	0.1%	0	0.0%	0	0.0%	-	0.487	-
Total	943		1826		1826		884				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.6: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Weather Condition and Age Group

Weather	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Clear	566	61.3%	1168	64.8%	1237	68.5%	589	67.5%	**0.006***	0.158	0.622
Cloudy	164	17.8%	321	17.8%	286	15.8%	146	16.7%	0.566	0.498	0.550
Rain	150	16.3%	234	13.0%	210	11.6%	103	11.8%	**0.007***	0.394	0.890
Sleet, Freezing Rain, or Hail	2	0.2%	6	0.3%	3	0.2%	3	0.3%	0.609	0.962	0.362
Fog	33	3.6%	46	2.6%	48	2.7%	17	1.9%	**0.036***	0.336	0.264
Snow	8	0.9%	25	1.4%	21	1.2%	13	1.5%	0.219	0.831	0.477
Dust	0	0.0%	1	0.1%	1	0.1%	0	0.0%	-	0.487	0.487
Smoke	0	0.0%	2	0.1%	0	0.0%	1	0.1%	0.303	0.978	0.150
Total	923		1803		1806		872				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.7: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Surface Condition and Age Group

Surface Conditions	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Dry	657	70.7%	1339	74.1%	1396	77.1%	670	76.7%	**0.004***	0.145	0.846
Wet	234	25.2%	385	21.3%	343	18.9%	166	19.0%	**0.002***	0.167	0.963
Snow	5	0.5%	8	0.4%	10	0.6%	9	1.0%	0.234	0.072	0.166
Ice	33	3.6%	74	4.1%	62	3.4%	28	3.2%	0.686	0.259	0.771
Total	929		1806		1811		873				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.8: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Light Condition and Age Group

Lighting Condition	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Daylight	506	53.9%	1049	57.7%	1294	71.0%	699	79.5%	**0.000***	0.000*	**0.000***
Dark (Street Lights)	118	12.6%	239	13.1%	156	8.6%	47	5.3%	**0.000***	**0.000***	**0.003***
Dark (No Street Lights)	244	26.0%	387	21.3%	261	14.3%	82	9.3%	**0.000***	**0.000***	**0.000***
Dawn	32	3.4%	52	2.9%	46	2.5%	15	1.7%	**0.022***	0.071	0.180
Dusk	39	4.2%	91	5.0%	65	3.6%	36	4.1%	0.951	0.296	0.498
Total	929		1806		1811		873				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.9: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Collision Type and Age Group

Collision Type	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Angle	72	7.6%	136	7.4%	166	9.1%	88	10.0%	0.080	**0.025***	0.469
Head-On	110	11.7%	221	12.1%	197	10.8%	98	11.1%	0.697	0.453	0.816
Rear-End	114	12.1%	294	16.1%	301	16.5%	135	15.3%	**0.048***	0.595	0.421
Sideswipe (Meeting)	38	4.0%	61	3.3%	65	3.6%	21	2.4%	**0.046***	0.172	0.099
Sideswipe (Overtaking)	16	1.7%	43	2.3%	32	1.8%	14	1.6%	0.849	0.192	0.750
Turning Movement	145	15.4%	345	18.9%	350	19.2%	196	22.2%	**0.000***	**0.043***	0.068
Parking Maneuver	0	0.0%	2	0.1%	3	0.2%	1	0.1%	0.302	0.978	0.745
Non-Collision	75	8.0%	118	6.4%	121	6.6%	50	5.7%	0.052	0.422	0.330
Fixed-Object	359	38.1%	579	31.6%	545	29.8%	265	30.0%	**0.000***	0.381	0.944
Backing	3	0.3%	7	0.4%	6	0.3%	3	0.3%	0.937	0.862	0.964
Miscellaneous	11	1.2%	23	1.3%	40	2.2%	12	1.4%	0.714	0.828	0.138
Total	943		1830		1826		884				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.10: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Number of Vehicles Involved and Age Group

Vehicles Involved	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Single Vehicle Crash	438	46.4%	696	38.0%	670	36.7%	310	35.1%	**0.000***	0.134	0.415
Multi-Vehicle Crash	505	53.6%	1134	62.0%	1157	63.3%	574	64.9%	**0.000***	0.134	0.415
Total	943		1830		1827		884				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.11: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Residency and Age Group

Driver Residence	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Oregon Resident (Within 20 Miles From Home)	762	80.8%	1454	79.5%	1399	76.6%	660	74.7%	**0.002***	**0.005***	0.275
Oregon Resident (More Than 20 Miles From Home)	105	11.1%	227	12.4%	253	13.8%	135	15.3%	**0.009***	**0.040***	0.321
Oregon Resident (Unknown Distance From Home)	3	0.3%	6	0.3%	3	0.2%	3	0.3%	0.937	0.961	0.363
Non-Resident	70	7.4%	141	7.7%	169	9.3%	85	9.6%	0.093	0.091	0.760
Unknown if Oregon Resident	3	0.3%	2	0.1%	3	0.2%	1	0.1%	0.349	0.978	0.745
Total	943		1830		1827		884				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.12: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Gender and Age Group

Gender	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Male	579	61.4%	1195	65.3%	1194	65.4%	556	62.9%	0.510	0.213	0.203
Female	364	38.6%	634	34.7%	632	34.6%	328	37.1%	0.510	0.213	0.203
Total	943		1829		1826		884				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.13: Comparison of Proportions of Fatal and Serious Injury Driver Crashes by Driver-Level Crash Cause and Age Group

Cause	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
No Associated Cause	217	23.0%	650	35.5%	674	36.9%	259	29.3%	**0.002***	**0.001***	**0.000***
Speed Too Fast For Conditions	165	17.5%	264	14.4%	241	13.2%	83	9.4%	**0.000***	**0.000***	**0.004***
Did Not Yield Right-of-Way	64	6.8%	73	4.0%	98	5.4%	104	11.8%	**0.000***	**0.000***	**0.000***
Passed Stop Sign or Flashing Red	15	1.6%	23	1.3%	23	1.3%	15	1.7%	0.858	0.361	0.363
Disregarded Traffic Signal	6	0.6%	25	1.4%	30	1.6%	12	1.4%	0.119	0.986	0.574
Drove Left of Center on Two-Way Road	49	5.2%	70	3.8%	70	3.8%	37	4.2%	0.308	0.651	0.657
Improper Overtaking	10	1.1%	20	1.1%	24	1.3%	8	0.9%	0.737	0.650	0.356
Made Improper Turn	6	0.6%	12	0.7%	25	1.4%	16	1.8%	**0.022***	**0.005***	0.377
Followed Too Closely	13	1.4%	40	2.2%	49	2.7%	21	2.4%	0.115	0.755	0.637
Other Improper Driving	98	10.4%	188	10.3%	228	12.5%	133	15.0%	**0.003***	**0.000***	0.065
Other (Not Improper Driving)	12	1.3%	27	1.5%	43	2.4%	16	1.8%	0.350	0.513	0.363
Improper Change of Lanes	4	0.4%	9	0.5%	10	0.5%	3	0.3%	0.769	0.575	0.462
Disregarded Other Traffic Control Device	0	0.0%	1	0.1%	4	0.2%	4	0.5%	**0.039***	**0.024***	0.293
Wrong Way on One-Way Road	4	0.4%	8	0.4%	5	0.3%	1	0.1%	0.203	0.169	0.404
Fatigue	40	4.2%	47	2.6%	47	2.6%	36	4.1%	0.856	**0.033***	**0.034***
Physical Illness	12	1.3%	32	1.7%	41	2.2%	51	5.8%	**0.000***	**0.000***	**0.000***
Phantom/Non-Contact Vehicle	4	0.4%	14	0.8%	16	0.9%	0	0.0%	0.053	**0.009***	**0.005***
Inattention	42	4.5%	39	2.1%	32	1.8%	17	1.9%	**0.002***	0.721	0.753

Table 3.13: Continued

Cause	Number of Crashes									
	16 to 24 Years	**% of Total**	**25 to 44 Years**	**% of Total**	**45 to 64 Years**	**% of Total**	**65 Years or Greater**	**% of Total**	***p*-value[1]**	***p*-value[2]**	***p*-value[3]**
Failed to Avoid Vehicle Ahead	6	0.6%	16	0.9%	28	1.5%	20	2.3%	**0.003***	0.003*	0.177
Driving in Excess of Posted Speed	71	7.5%	126	6.9%	64	3.5%	24	2.7%	**0.000***	**0.000***	0.278
Careless Driving	41	4.3%	45	2.5%	27	1.5%	14	1.6%	**0.001***	0.143	0.832
Speed Racing	3	0.3%	2	0.1%	1	0.1%	0	0.0%	0.093	0.326	0.487
Reckless Driving	61	6.5%	97	5.3%	43	2.4%	8	0.9%	**0.000***	**0.000***	**0.009***
Aggressive Driving	0	0.0%	0	0.0%	0	0.0%	1	0.1%	0.302	0.150	0.151
View Obscured	0	0.0%	2	0.1%	4	0.2%	1	0.1%	0.302	0.978	0.547
Total	943		1830		1827		884				

1 Comparison between Older Drivers and Drivers Aged 16 Years to 24 Years
2 Comparison between Older Drivers and Drivers Aged 25 Years to 44 Years
3 Comparison between Older Drivers and Drivers Aged 45 Years to 64 Years
* Significant With 95% Confidence

3.4 COMPARISON OF OLDER PEDESTRIAN FATAL AND SERIOUS INJURY CRASHES BY AGE GROUP

As stated previously, older pedestrian fatal and serious injury crashes are compared to fatal and serious injury crashes of other age groups, namely:

- 16 years to 24 years
- 25 years to 44 years
- 45 years to 64 years

The number of fatal and serious injury crashes for drivers of the different age groups are shown in Table 3.14, and the trend in fatal and serious injury crashes by age group is shown in Figure 3.41.

Table 3.14: Number of Pedestrian Fatal and Serious Injury Crashes by Age Group

Age Group	Number of Fatal and serious injury Crashes (Fatal and Incapacitating)
16 years to 24 years	86
25 years to 44 years	195
45 years to 64 years	209
65 years or greater	112

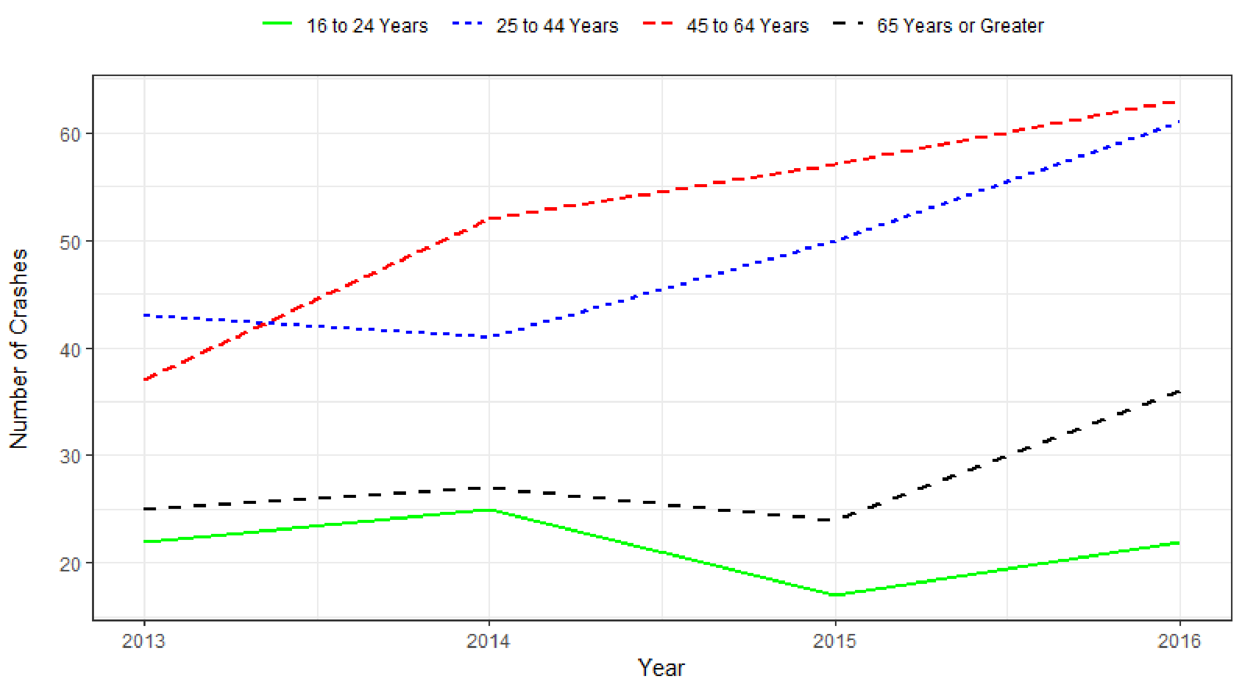

Figure 3.41: Pedestrian fatal and serious injury crashes by year and age group

To present the comparison, stacked bar charts are used with a brief description of the corresponding bar chart. The comparisons will be made based on the characteristics summarized in Section 3.2.

3.4.1 Pedestrian Fatal and Serious Injury Crashes by Time of Day

As observed in Figure 3.42, older pedestrian fatal and serious injury crashes represent the largest proportion for the following time periods:

- 6:00 a.m. to 8:59 a.m.
- 9:00 a.m. to 11:59 a.m.
- 12:00 p.m. to 2:59 p.m.

In addition, older pedestrians represent a larger proportion compared to younger pedestrians (pedestrians aged 16 years to 24 years) from 3:00 p.m. to 5:59 p.m. and 6:00 p.m. to 8:59 p.m.

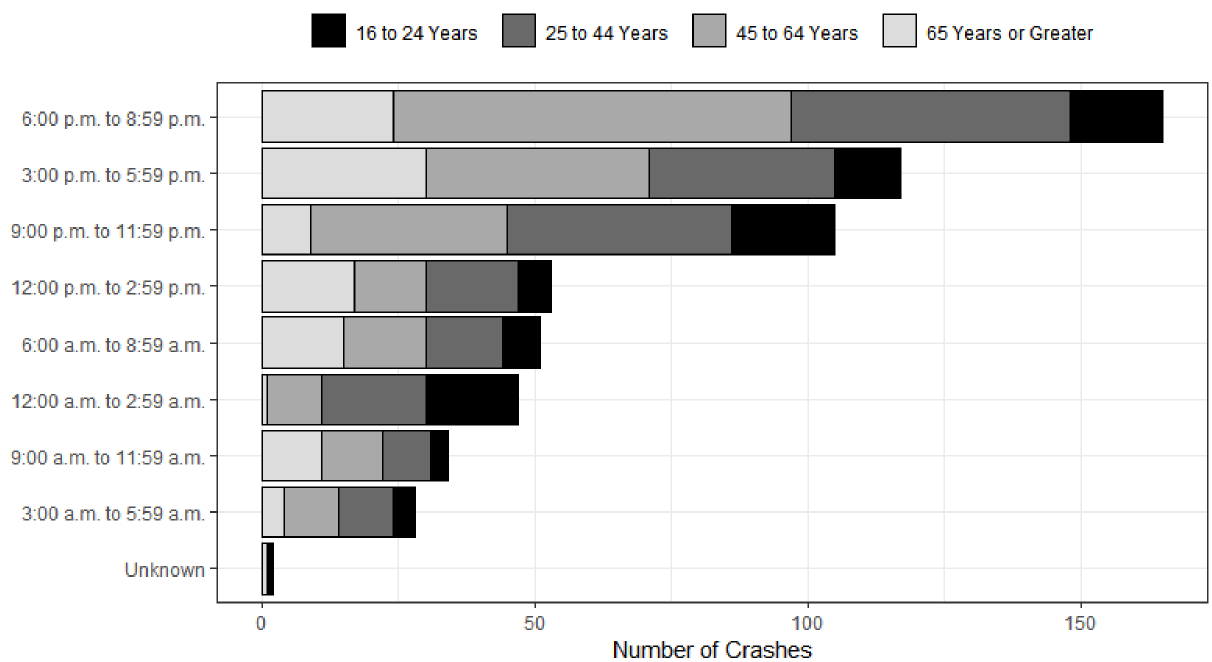

Figure 3.42: Pedestrian fatal and serious injury crashes by time of day and age group

3.4.2 Pedestrian Fatal and Serious Injury Crashes by Day of the Week

Figure 3.43 shows the proportion of drivers by age group for fatal and serious injury crashes by day of the week. In general, older pedestrians represent a smaller proportion of fatal and serious injury crashes when compared to pedestrians aged 45 years to 64 years; however, the two age groups represent similar proportions for fatal and serious injury crashes on Fridays. Compared to younger pedestrians, older pedestrians represent a large proportion of fatal and serious injury crashes on Mondays, Tuesdays, Thursdays, and Fridays, where both age groups have similar proportions on Wednesdays and weekends.

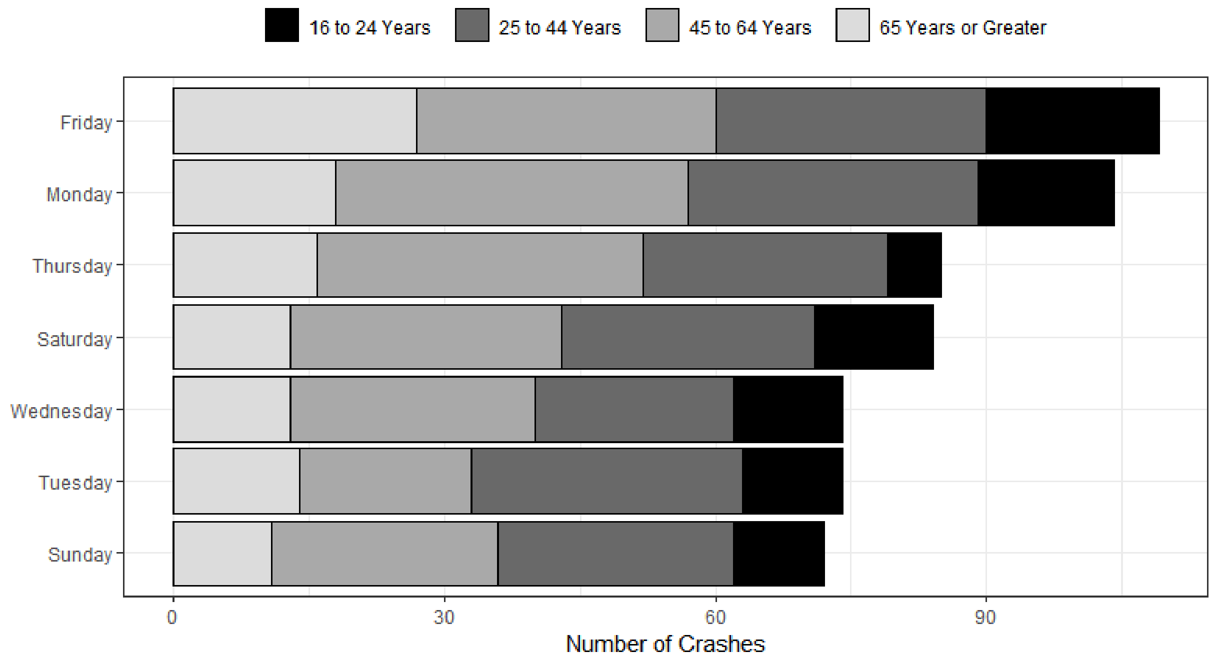

Figure 3.43: Pedestrian fatal and serious injury crashes by day of the week and age group

3.4.3 Pedestrian Fatal and Serious Injury Crashes by Roadway Classification

As seen in Figure 3.44, the largest proportions for all age groups are represented by urban classifications. However, older pedestrians account for larger proportions for rural classifications. Specifically, older pedestrians account for the largest proportion of fatal and serious injury crashes on rural major collectors, rural minor collectors, and have roughly the same proportion as the other age groups for rural principal arterials. As for urban classifications, older pedestrians represent larger proportions for fatal and serious injury crashes when compared to younger pedestrians.

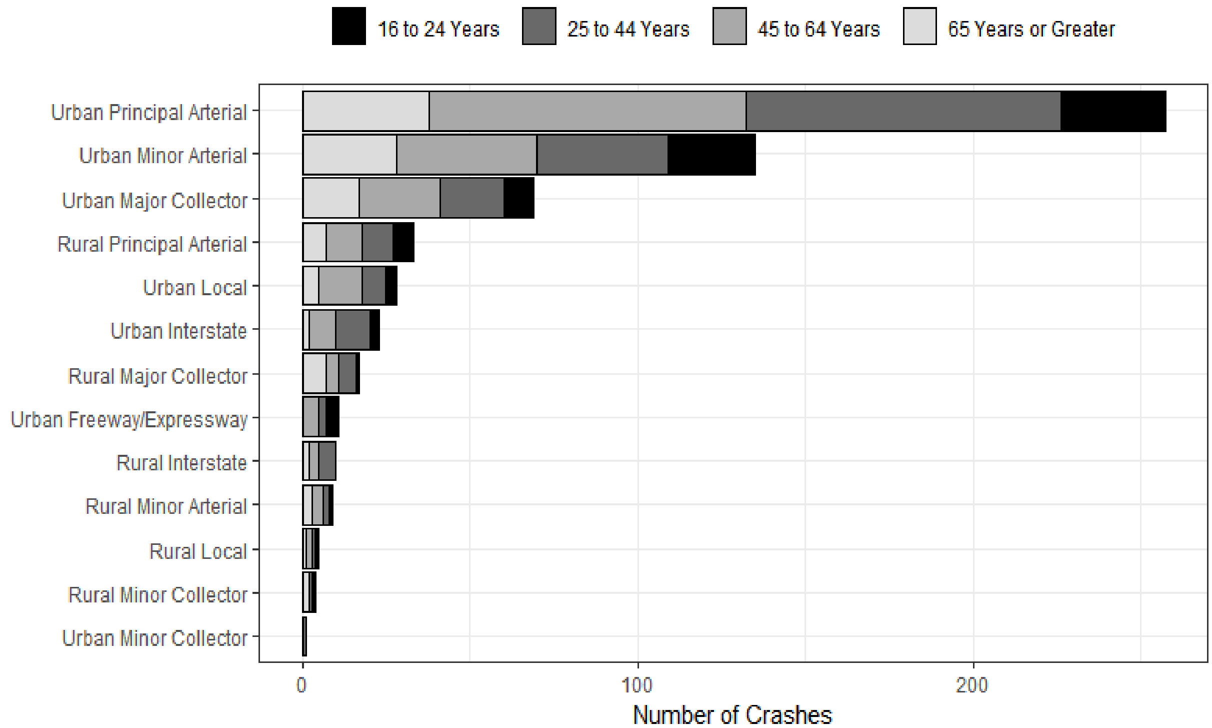

Figure 3.44: Pedestrian fatal and serious injury crashes by roadway classification and age group

3.4.4 Pedestrian Fatal and Serious Injury Crashes by Roadway Character

As it pertains to roadway character and fatal and serious injury pedestrian crashes, Figure 3.45 shows that intersections account for the largest proportion for each age group. For intersections, older pedestrians account for a larger proportion compared to younger pedestrians and slightly less compared to the other two age groups. For straight roadway segments, older pedestrians and younger pedestrians account for roughly the same proportion of fatal and serious injury crashes. But, for driveway or alley access locations and open access or turnout locations, older pedestrians account for the largest proportion of fatal and serious injury crashes.

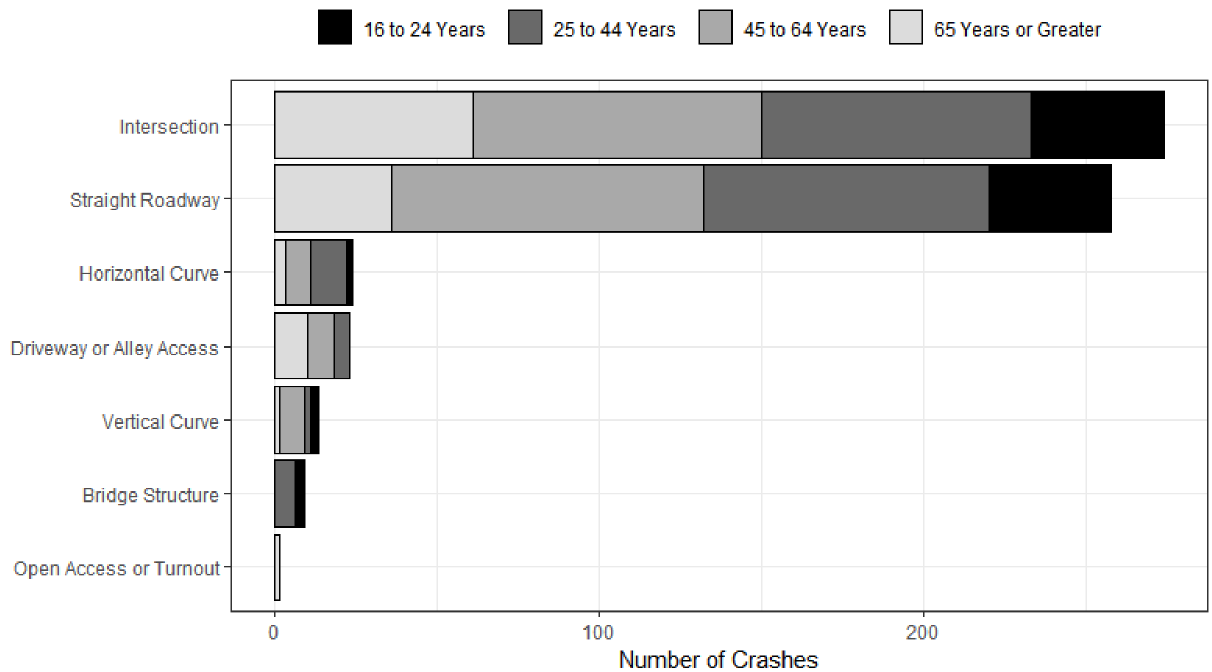

Figure 3.45: Pedestrian fatal and serious injury crashes by roadway character and age group

3.4.5 Pedestrian Fatal and Serious Injury Crashes by Weather Condition

Figure 3.46 shows the proportion of pedestrians by age group for fatal and serious injury crashes by weather condition. The majority of fatal and serious injury crashes for each age group occurred during clear conditions, with older pedestrians having a larger proportion compared to younger pedestrians. For cloudy conditions and foggy conditions, older pedestrians account for a larger proportion compared to younger pedestrians.

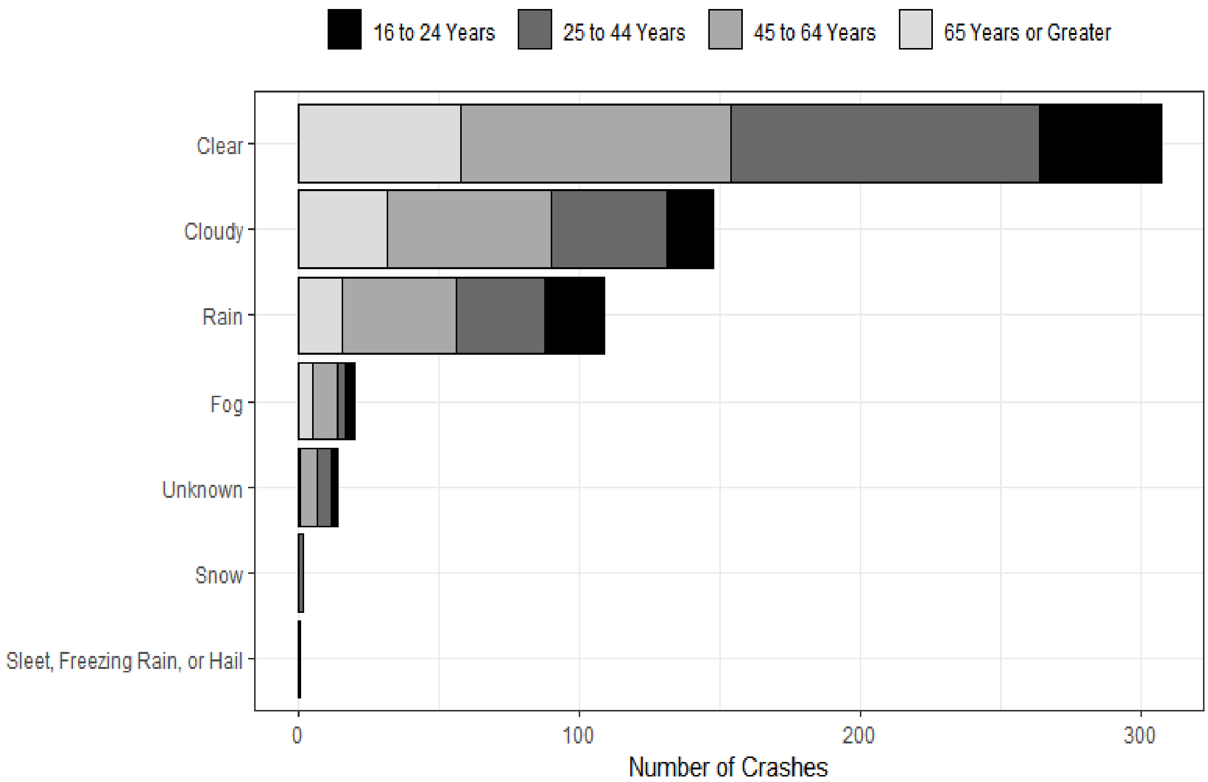

Figure 3.46: Pedestrian fatal and serious injury crashes by weather condition and age group

3.4.6 Pedestrian Fatal and Serious Injury Crashes by Road Surface Condition

Figure 3.47 shows that older pedestrians account for a larger proportion, compared to younger pedestrians, for fatal and serious injury crashes that happened on dry surface conditions and wet surface conditions. For snowy surface conditions, older pedestrians represent the largest proportion of fatal and serious injury crashes.

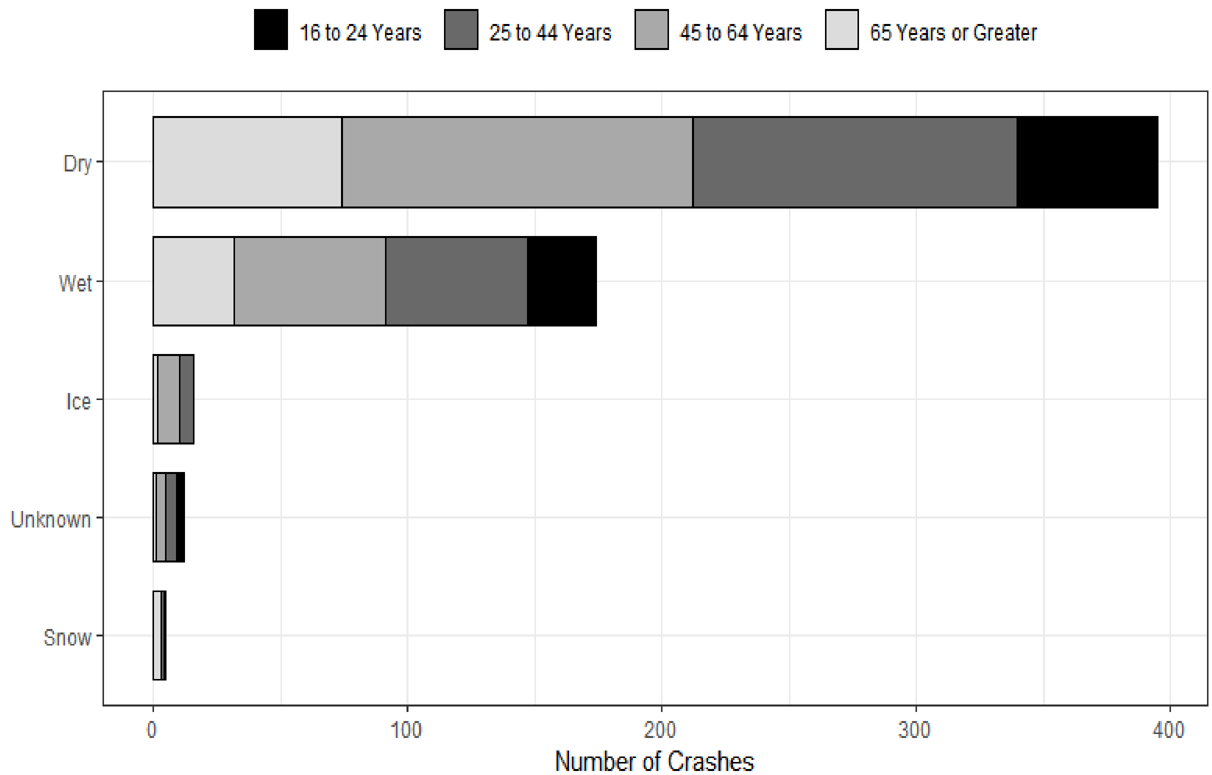

Figure 3.47: Pedestrian fatal and serious injury crashes by road surface condition and age group

3.4.7 Pedestrian Fatal and Serious Injury Crashes by Lighting Condition

Referring to Figure 3.48, older pedestrians (along with pedestrians aged 45 years to 64 years) represent the largest proportion of fatal and serious injury crashes that occurred under daylight conditions. For both dark conditions, with and without street lights, older pedestrians represent the smallest proportions. Of the fatal and serious injury crashes that happened at dawn, older pedestrians account for the largest proportion.

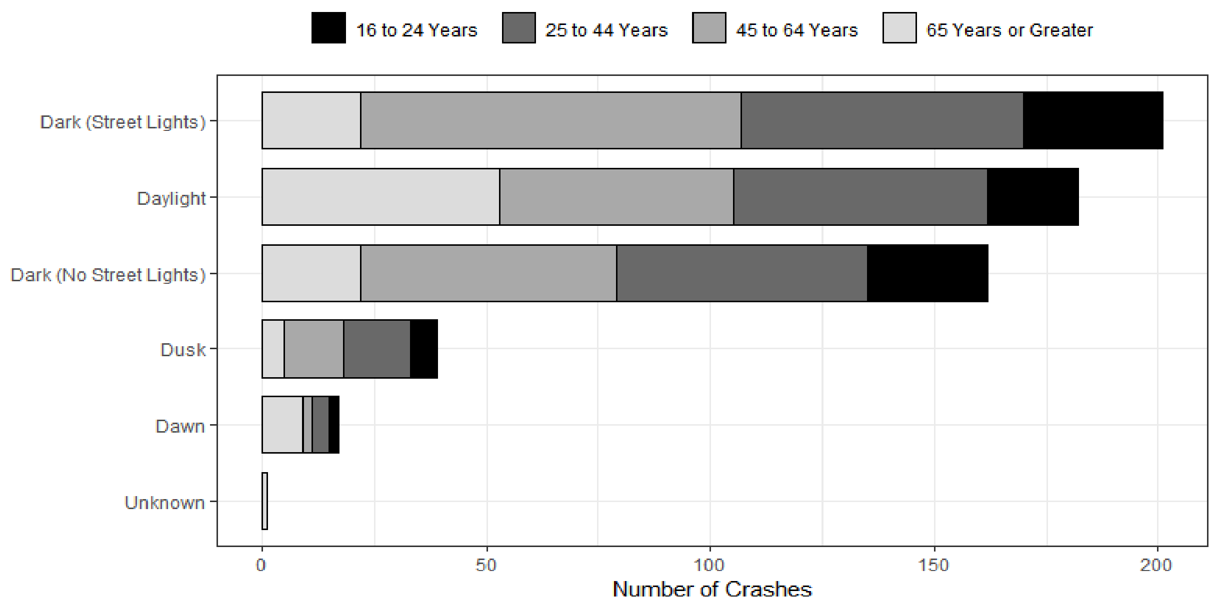

Figure 3.48: Pedestrian fatal and serious injury crashes by lighting condition and age group

3.4.8 Pedestrian Fatal and Serious Injury Crashes by Pedestrian Gender

According to Figure 3.49, there is larger proportion of older male and female pedestrians involved in fatal and serious injury crashes when compared to younger pedestrians.

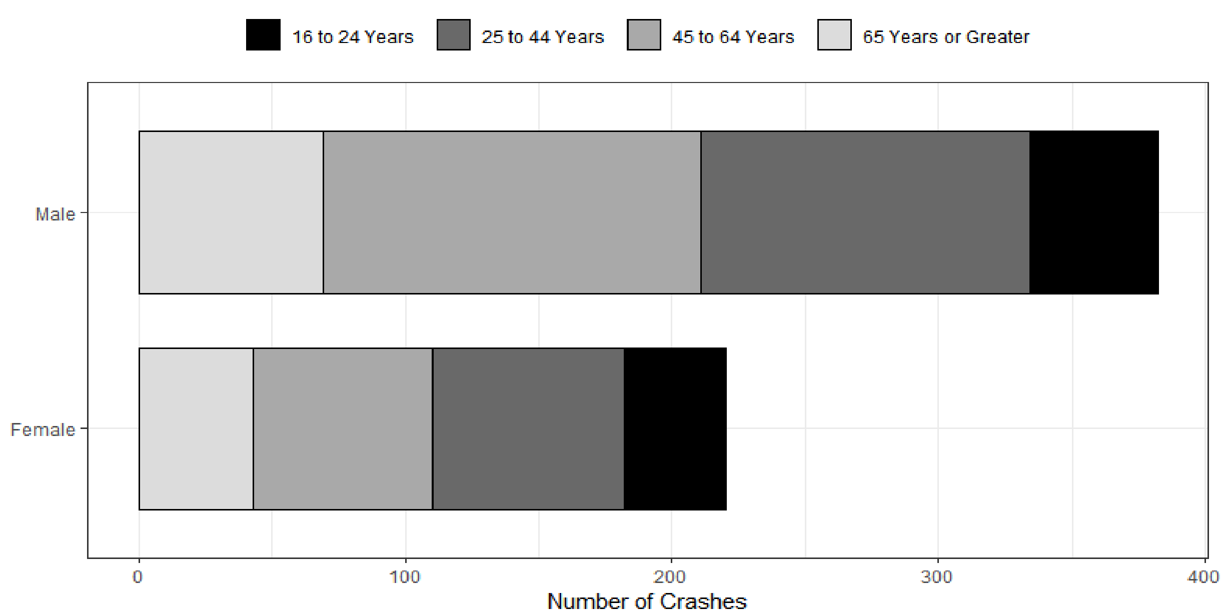

Figure 3.49: Pedestrian fatal and serious injury crashes by gender and age group

3.4.9 Pedestrian Fatal and Serious Injury Crashes by Pedestrian Action

Figure 3.50 shows pedestrian fatal and serious injury crashes by age group and pedestrian action. As observed, older pedestrians account for large proportions of fatal and serious injury crashes in which the pedestrian action was crossing at an intersection with no traffic signal, crossing at an intersection with a traffic signal, and crossing between intersections. Of these actions, older pedestrians represent the second largest proportion for crossing at an intersection with no traffic signal. For the other two actions, older pedestrians account for larger proportions when compared to younger pedestrians.

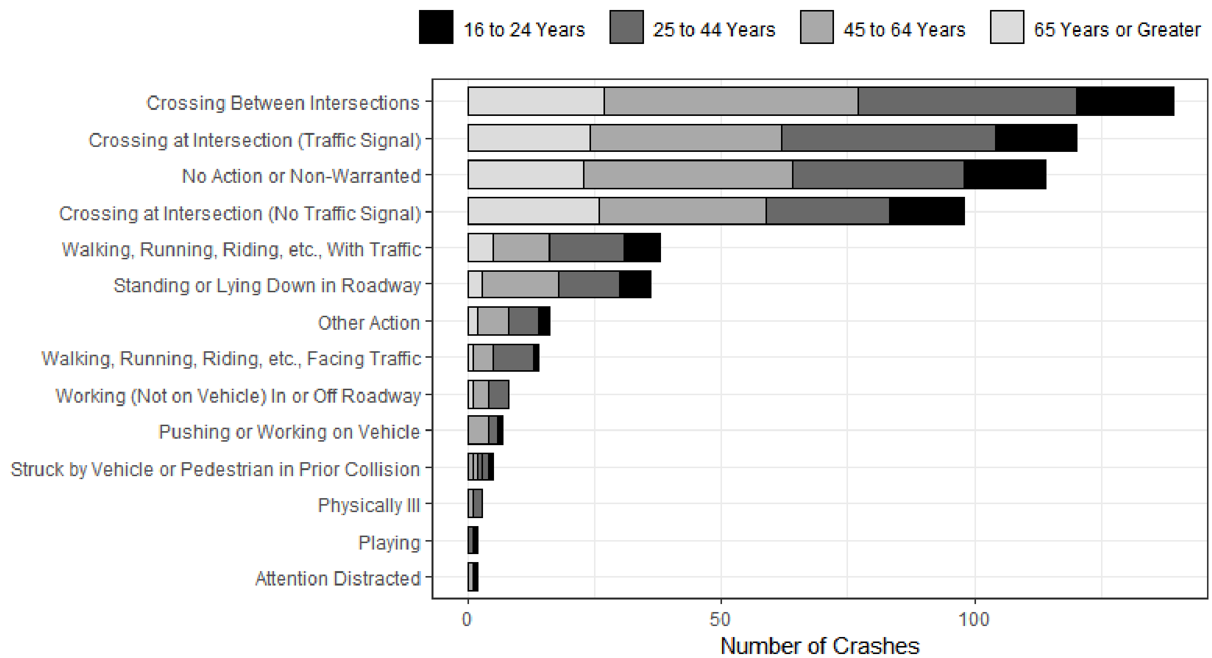

Figure 3.50: Pedestrian fatal and serious injury crashes by pedestrian action and age group

3.4.10 Pedestrian Fatal and Serious Injury Crashes by Pedestrian Location

As shown in Figure 3.51, older pedestrians account for the largest proportion of fatal and serious injury crashes when the pedestrian was located at an intersection (not in the roadway). For fatal and serious injury crashes in which the pedestrian was located at an intersection, but not in a crosswalk, older pedestrians and pedestrians aged 25 years to 44 years account for the largest proportions. Compared to younger pedestrians, older pedestrians account for a larger proportion of fatal and serious injury crashes when the pedestrian was located at an intersection and inside a crosswalk, located in the roadway, located on the shoulder, and located on the sidewalk.

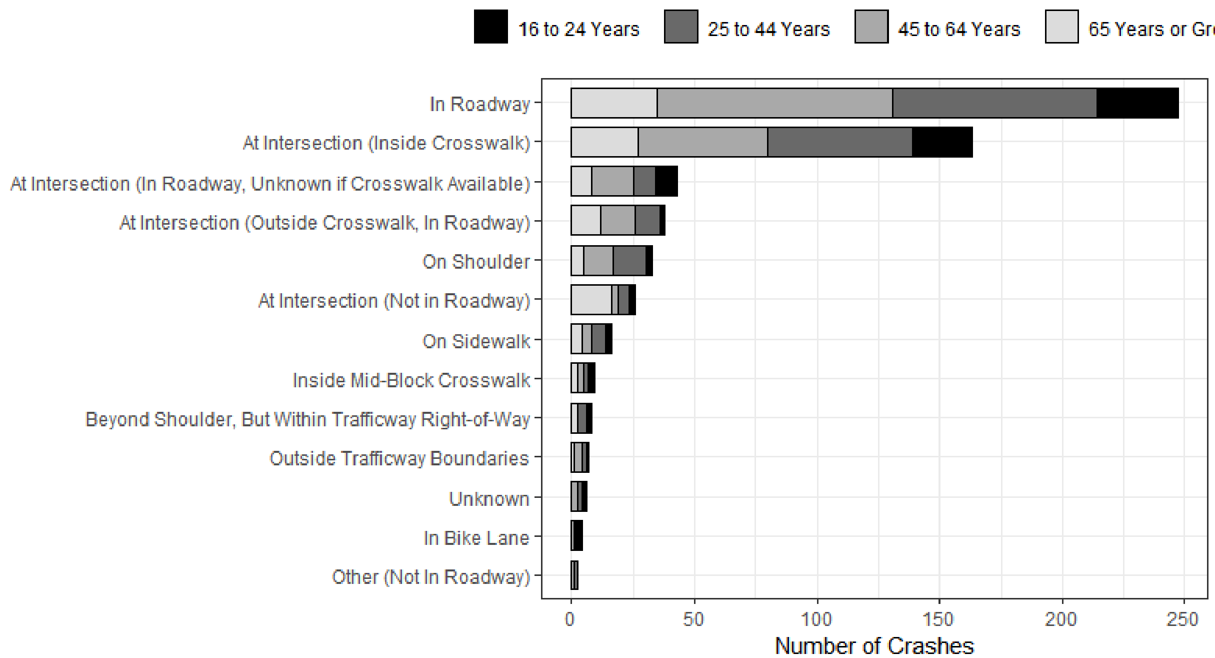

Figure 3.51: Pedestrian fatal and serious injury crashes by pedestrian location and age group

3.4.11 Pedestrian Fatal and Serious Injury Crashes by Pedestrian-Level Crash Cause

Figure 3.52 shows that older pedestrians account for larger proportions of fatal and serious injury crashes when compared to younger pedestrians, where the pedestrian-level crash cause was not yielding the right-of-way and disregarding a traffic signal. For the causes of illegally in the roadway and not being visible, older pedestrians represent the smallest proportions of fatal and serious injury crashes.

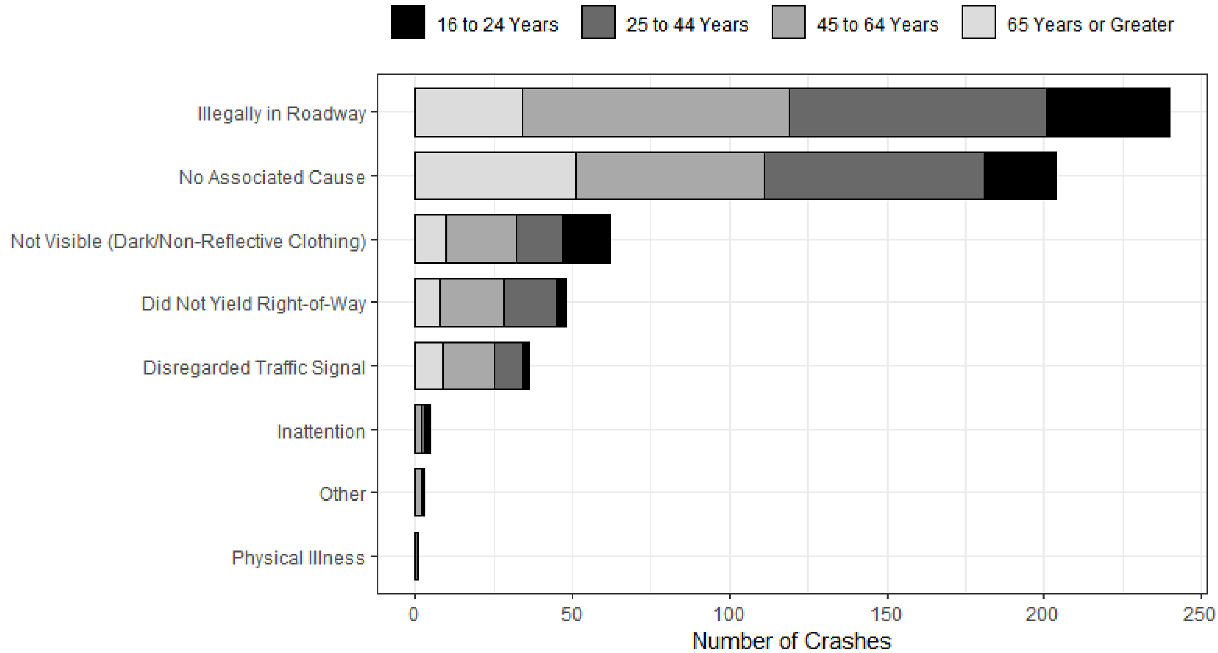

Figure 3.52: Pedestrian fatal and serious injury crashes by pedestrian-level crash cause and age group

3.4.12 Pedestrian Fatal and Serious Injury Proportion Comparison

Following the methodology outlined in Section 3.3.13, proportions of pedestrian fatal and serious injury crashes by crash attribute and age group are compared. As outlined previously, this is accomplished through the *z*-test of proportions.

Tantamount to the proportions test for driver fatal and serious injury crashes, any crash record recorded as unknown has been excluded.

The first proportions test was for time of day. Unlike older driver fatal and serious injury crashes, only select time periods have significant differences in proportions for older fatal and serious injury crashes. Older pedestrian fatal and serious injury crash proportions were found to be statistically different for crashes that occurred from 9:00 p.m. to 11:59 p.m. when compared to all age groups. Compared to pedestrians aged 16 years to 24 years and pedestrians aged 25 years to 44 years, difference in proportions were found for crashes that occurred from 12:00 a.m. to 2:59 a.m. No significant differences were found for crashes by day of the week.

For roadway classification proportions, notable significant differences were found for two classifications. On rural major collectors, there was a significant difference in proportions compared to pedestrians aged 45 years to 64 years. On urban principal arterials, there was a significant difference in proportions compared to pedestrians aged 25 years to 44 years. For road character, three characters were found to have significantly different proportions among pedestrian crashes. Intersection crashes, compared to pedestrians aged 25 years to 44 years and pedestrians aged 45 years to 64 years, have significantly different proportions. Compared to pedestrians aged 16 years to 24 years and pedestrians aged 25 years to 44 years, there is a significant difference in proportions of pedestrian crashes at driveways or alley access points. Lastly, compared to pedestrians aged 25 years to 44 years, there is a significant difference in proportions of pedestrian crashes on straight roadway segments.

In regards to weather, no significant difference in proportions was observed. The one proportion significantly different was snowy surface conditions. Specifically, compared to pedestrians aged 45 years to 64 years, there was a significant difference in proportions of pedestrian crashes in which the roadway surface was snowy.

Referring to lighting conditions, there was a significant difference in proportions for all age groups for crashes that occurred under daylight conditions and dark conditions with street lights. In addition, compared to pedestrians aged 25 years to 44 years and pedestrians aged 45 years to 64 years, there was a significant difference in proportions of crashes that occurred at dawn. No significant differences in proportions were observed for pedestrian fatal and serious injury crashes by gender.

One significant difference in proportions was found for pedestrian action. In particular, compared to pedestrians aged 25 years to 44 years, there was a significant difference in proportions for crashes in which the pedestrian was crossing an intersection with no traffic signal. Considering pedestrian location, there were significant differences in proportions for all age groups when the crash happened while the pedestrian was at an intersection, but not in the roadway. Compared to pedestrians aged 16 years to 24 years, there were significant differences in proportions for crashes in which the pedestrian was outside the crosswalk at an intersection and when the pedestrian was located in the bike lane. The final pedestrian location found to have significantly different proportions was crashes where the pedestrian was in the roadway, in which proportions were significantly different compared to pedestrians aged 25 years to 44 years and pedestrians aged 45 years to 64 years.

The last characteristic testing for significant differences in proportions was the pedestrian-level crash cause. Compared to pedestrians aged 16 years to 24 years and pedestrians aged 25 years to 44 years, there was a significant difference in proportions for crashes in which the pedestrian was illegally in the roadway.

Table 3.15: Comparison of Proportions of Fatal and Serious Injury Pedestrian Crashes by Time of Day and Age Group

Time of Day	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
12:00 a.m. to 2:59 a.m.	17	20.0%	19	9.7%	10	4.8%	1	0.9%	**0.000***	**0.003***	0.070
3:00 a.m. to 5:59 a.m.	4	4.7%	10	5.1%	10	4.8%	4	3.6%	0.699	0.539	0.623
6:00 a.m. to 8:59 a.m.	7	8.2%	14	7.2%	15	7.2%	15	13.5%	0.246	0.069	0.064
9:00 a.m. to 11:59 a.m.	3	3.5%	9	4.6%	11	5.3%	11	9.9%	0.086	0.072	0.118
12:00 p.m. to 2:59 p.m.	6	7.1%	17	8.7%	13	6.2%	17	15.3%	0.075	0.077	**0.008***
3:00 p.m. to 5:59 p.m.	12	14.1%	34	17.4%	41	19.6%	30	27.0%	**0.029***	0.047	0.129
6:00 p.m. to 8:59 p.m.	17	20.0%	51	26.2%	73	34.9%	24	21.6%	0.782	0.376	**0.014***
9:00 p.m. to 11:59 p.m.	19	22.4%	41	21.0%	36	17.2%	9	8.1%	**0.005***	**0.003***	**0.026***
Total	85		195		209		111				

1 Comparison between Older Pedestrians and Pedestrians Aged 16 Years to 24 Years
2 Comparison between Older Pedestrians and Pedestrians Aged 25 Years to 44 Years
3 Comparison between Older Pedestrians and Pedestrians Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.16: Comparison of Proportions of Fatal and Serious Injury Pedestrian Crashes by Day of the Week and Age Group

Day of the Week	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value¹	*p*-value²	*p*-value³
Sunday	10	11.6%	26	13.3%	25	12.0%	11	9.8%	0.682	0.363	0.562
Monday	15	17.4%	32	16.4%	39	18.7%	18	16.1%	0.798	0.938	0.563
Tuesday	11	12.8%	30	15.4%	19	9.1%	14	12.5%	0.951	0.488	0.338
Wednesday	12	14.0%	22	11.3%	27	12.9%	13	11.6%	0.622	0.931	0.735
Thursday	6	7.0%	27	13.8%	36	17.2%	16	14.3%	0.105	0.915	0.496
Friday	19	22.1%	30	15.4%	33	15.8%	27	24.1%	0.739	0.058	0.068
Saturday	13	15.1%	28	14.4%	30	14.4%	13	11.6%	0.469	0.495	0.491
Total	86		195		209		112				

1 Comparison between Older Pedestrian and Pedestrian Aged 16 Years to 24 Years
2 Comparison between Older Pedestrian and Pedestrian Aged 25 Years to 44 Years
3 Comparison between Older Pedestrian and Pedestrian Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.17: Comparison of Proportions of Fatal and Serious Injury Pedestrian Crashes by Roadway Classification and Age Group

Classification	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Rural Interstate	0	0.0%	5	2.6%	3	1.4%	2	1.8%	0.213	0.660	0.809
Rural Principal Arterial	6	7.0%	9	4.6%	11	5.3%	7	6.3%	0.838	0.535	0.714
Rural Minor Arterial	1	1.2%	2	1.0%	3	1.4%	3	2.7%	0.452	0.271	0.433
Rural Major Collector	1	1.2%	5	2.6%	4	1.9%	7	6.3%	0.072	0.109	**0.042***
Rural Minor Collector	1	1.2%	1	0.5%	0	0.0%	2	1.8%	0.722	0.275	0.053
Rural Local	1	1.2%	1	0.5%	2	1.0%	1	0.9%	0.851	0.690	0.955
Urban Interstate	3	3.5%	10	5.1%	8	3.8%	2	1.8%	0.449	0.146	0.316
Urban Freeway/Expressway	4	4.7%	2	1.0%	5	2.4%	0	0.0%	**0.021***	0.282	0.099
Urban Principal Arterial	31	36.0%	94	48.2%	94	45.0%	38	33.9%	0.757	**0.015***	0.055
Urban Minor Arterial	26	30.2%	39	20.0%	42	20.1%	28	25.0%	0.413	0.307	0.311
Urban Major Collector	9	10.5%	19	9.7%	24	11.5%	17	15.2%	0.330	0.154	0.345
Urban Minor Collector	0	0.0%	1	0.5%	0	0.0%	0	0.0%	-	0.448	-
Urban Local	3	3.5%	7	3.6%	13	6.2%	5	4.5%	0.730	0.704	0.515
Total	86		195		209		112				

1 Comparison between Older Pedestrians and Pedestrians Aged 16 Years to 24 Years
2 Comparison between Older Pedestrians and Pedestrians Aged 25 Years to 44 Years
3 Comparison between Older Pedestrians and Pedestrians Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.18: Comparison of Proportions of Fatal and Serious Injury Pedestrian Crashes by Road Character and Age Group

Road Character	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Intersection	41	47.7%	83	42.6%	89	42.6%	61	54.5%	0.343	**0.044***	**0.042***
Driveway or Alley Access	0	0.0%	5	2.6%	8	3.8%	10	8.9%	**0.004***	**0.013***	0.058
Straight Roadway	38	44.2%	88	45.1%	96	45.9%	36	32.1%	0.083	**0.026***	0.017
Horizontal Curve	2	2.3%	11	5.6%	8	3.8%	3	2.7%	0.875	0.231	0.590
Open Access or Turnout	0	0.0%	0	0.0%	0	0.0%	1	0.9%	0.380	0.186	0.171
Vertical Curve	2	2.3%	2	1.0%	8	3.8%	1	0.9%	0.413	0.909	0.129
Bridge Structure	3	3.5%	6	3.1%	0	0.0%	0	0.0%	0.046	0.061	-
Total	86		195		209		112				

1 Comparison between Older Pedestrians and Pedestrians Aged 16 Years to 24 Years
2 Comparison between Older Pedestrians and Pedestrians Aged 25 Years to 44 Years
3 Comparison between Older Pedestrians and Pedestrians Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.19: Comparison of Proportions of Fatal and Serious Injury Pedestrian Crashes by Weather Condition and Age Group

Weather	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Clear	43	51.2%	110	58.2%	96	47.3%	58	52.3%	0.883	0.316	0.401
Cloudy	17	20.2%	41	21.7%	58	28.6%	32	28.8%	0.171	0.164	0.962
Rain	21	25.0%	32	16.9%	40	19.7%	16	14.4%	0.062	0.566	0.242
Sleet, Freezing Rain, or Hail	0	0.0%	1	0.5%	0	0.0%	0	0.0%	-	0.443	-
Fog	3	3.6%	3	1.6%	9	4.4%	5	4.5%	0.745	0.130	0.977
Snow	0	0.0%	2	1.1%	0	0.0%	0	0.0%	-	0.277	-
Total	84		189		203		111				

1 Comparison between Older Pedestrians and Pedestrians Aged 16 Years to 24 Years
2 Comparison between Older Pedestrians and Pedestrians Aged 25 Years to 44 Years
3 Comparison between Older Pedestrians and Pedestrians Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.20: Comparison of Proportions of Fatal and Serious Injury Pedestrian Crashes by Surface Condition and Age Group

Surface Condition	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
Dry	55	66.3%	128	67.0%	138	67.3%	74	66.7%	0.953	0.951	0.907
Wet	27	32.5%	56	29.3%	59	28.8%	32	28.8%	0.579	0.928	0.993
Snow	1	1.2%	1	0.5%	0	0.0%	3	2.7%	0.468	0.110	**0.018***
Ice	0	0.0%	6	3.1%	8	3.9%	2	1.8%	0.219	0.485	0.309
Total	83		191		205		111				

1 Comparison between Older Pedestrians and Pedestrians Aged 16 Years to 24 Years
2 Comparison between Older Pedestrians and Pedestrians Aged 25 Years to 44 Years
3 Comparison between Older Pedestrians and Pedestrians Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.21: Comparison of Proportions of Fatal and Serious Injury Pedestrian Crashes by Lighting Condition and Age Group

Lighting Condition	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value¹	*p*-value²	*p*-value³
Daylight	20	23.3%	57	29.2%	52	24.9%	53	47.7%	**0.000***	**0.001***	**0.000***
Dark (Street Lights)	31	36.0%	63	32.3%	85	40.7%	22	19.8%	**0.011***	**0.019***	**0.000***
Dark (No Street Lights)	27	31.4%	56	28.7%	57	27.3%	22	19.8%	0.062	0.086	0.141
Dawn	2	2.3%	4	2.1%	2	1.0%	9	8.1%	0.080	**0.012***	**0.001***
Dusk	6	7.0%	15	7.7%	13	6.2%	5	4.5%	0.454	0.278	0.526
Total	86		195		209		111				

1 Comparison between Older Pedestrians and Pedestrians Aged 16 Years to 24 Years
2 Comparison between Older Pedestrians and Pedestrians Aged 25 Years to 44 Years
3 Comparison between Older Pedestrians and Pedestrians Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.22: Comparison of Proportions of Fatal and Serious Injury Pedestrian Crashes by Gender and Age Group

Gender	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value¹	*p*-value²	*p*-value³
Male	48	55.8%	123	63.1%	142	67.9%	69	61.6%	0.411	0.798	0.254
Female	38	44.2%	72	36.9%	67	32.1%	43	38.4%	0.411	0.798	0.254
Total	86		195		209		112				

1 Comparison between Older Pedestrians and Pedestrians Aged 16 Years to 24 Years
2 Comparison between Older Pedestrians and Pedestrians Aged 25 Years to 44 Years
3 Comparison between Older Pedestrians and Pedestrians Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.23: Comparison of Proportions of Fatal and Serious Injury Crashes by Pedestrian Action and Age Group

Pedestrian Action	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
No Action or Non-Warranted	16	18.6%	34	17.4%	41	19.6%	23	20.5%	0.735	0.501	0.844
Struck by Vehicle or Pedestrian in Prior Collision	1	1.2%	1	0.5%	1	0.5%	0	0.0%	0.253	0.448	0.463
Struck by Vehicle or Pedestrian in Prior Collision	0	0.0%	1	0.5%	1	0.5%	0	0.0%	-	0.448	0.463
Physically Ill	0	0.0%	2	1.0%	1	0.5%	0	0.0%	-	0.282	0.463
Crossing at Intersection (No Traffic Signal)	15	17.4%	24	12.3%	33	15.8%	26	23.2%	0.320	**0.013***	0.102
Crossing at Intersection (Traffic Signal)	16	18.6%	42	21.5%	38	18.2%	24	21.4%	0.624	0.982	0.483
Crossing Between Intersections	19	22.1%	43	22.1%	50	23.9%	27	24.1%	0.739	0.679	0.971
Attention Distracted	1	1.2%	0	0.0%	1	0.5%	0	0.0%	0.253	-	0.463
Playing	1	1.2%	1	0.5%	0	0.0%	0	0.0%	0.253	0.448	-
Pushing or Working on Vehicle	1	1.2%	2	1.0%	4	1.9%	0	0.0%	0.253	0.282	0.141
Working (Not on Vehicle) In or Off Roadway	0	0.0%	4	2.1%	3	1.4%	1	0.9%	0.380	0.440	0.676
Walking, Running, Riding, etc., With Traffic	7	8.1%	15	7.7%	11	5.3%	5	4.5%	0.283	0.270	0.754
Walking, Running, Riding, etc., Facing Traffic	1	1.2%	8	4.1%	4	1.9%	1	0.9%	0.851	0.109	0.481
Standing or Lying Down in Roadway	6	7.0%	12	6.2%	15	7.2%	3	2.7%	0.150	0.174	0.095
Other Action	2	2.3%	6	3.1%	6	2.9%	2	1.8%	0.789	0.494	0.552
Total	86		195		209		112				

1 Comparison between Older Pedestrians and Pedestrians Aged 16 Years to 24 Years
2 Comparison between Older Pedestrians and Pedestrians Aged 25 Years to 44 Years
3 Comparison between Older Pedestrians and Pedestrians Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.24: Comparison of Proportions of Fatal and Serious Injury Pedestrian Crashes by Pedestrian Location and Age Group

Pedestrian Location	Number of Crashes										
	16 to 24 Years	**% of Total**	**25 to 44 Years**	**% of Total**	**45 to 64 Years**	**% of Total**	**65 Years or Greater**	**% of Total**	***p*-value[1]**	***p*-value[2]**	***p*-value[3]**
At Intersection (Not in Roadway)	3	3.6%	4	2.1%	3	1.4%	16	14.3%	**0.012***	**0.000***	**0.000***
At Intersection (Inside Crosswalk)	24	28.6%	59	30.6%	53	25.6%	27	24.1%	0.481	0.227	0.769
At Intersection (Outside Crosswalk, In Roadway)	2	2.4%	10	5.2%	14	6.8%	12	10.7%	**0.025***	0.072	0.218
At Intersection (In Roadway, Unknown if Crosswalk Available)	9	10.7%	9	4.7%	17	8.2%	8	7.1%	0.379	0.363	0.734
In Roadway	33	39.3%	83	43.0%	96	46.4%	35	31.3%	0.242	**0.042***	**0.009***
On Shoulder	3	3.6%	13	6.7%	12	5.8%	5	4.5%	0.755	0.417	0.613
Beyond Shoulder, But Within Trafficway Right-of-Way	2	2.4%	4	2.1%	0	0.0%	2	1.8%	0.771	0.862	0.054
On Sidewalk	2	2.4%	6	3.1%	4	1.9%	4	3.6%	0.632	0.827	0.372
In Bike Lane	3	3.6%	0	0.0%	1	0.5%	0	0.0%	**0.044***	-	0.461
Inside Mid-Block Crosswalk	2	2.4%	2	1.0%	3	1.4%	2	1.8%	0.771	0.579	0.817
Outside Trafficway Boundaries	1	1.2%	2	1.0%	3	1.4%	1	0.9%	0.837	0.903	0.670
Other (Not In Roadway)	0	0.0%	1	0.5%	1	0.5%	0	0.0%	-	0.445	0.461
Total	84		193		207		112				

1 Comparison between Older Pedestrians and Pedestrians Aged 16 Years to 24 Years
2 Comparison between Older Pedestrians and Pedestrians Aged 25 Years to 44 Years
3 Comparison between Older Pedestrians and Pedestrians Aged 45 Years to 64 Years
* Significant With 95% Confidence

Table 3.25: Comparison of Proportions of Fatal and Serious Injury Pedestrian Crashes by Pedestrian-Level Crash Cause and Age Group

Cause	Number of Crashes										
	16 to 24 Years	% of Total	25 to 44 Years	% of Total	45 to 64 Years	% of Total	65 Years or Greater	% of Total	*p*-value[1]	*p*-value[2]	*p*-value[3]
No Associated Cause	23	26.7%	70	35.9%	60	28.7%	51	45.5%	**0.007***	0.096	**0.003***
Did Not Yield Right-of-Way	3	3.5%	17	8.7%	20	9.6%	8	7.1%	0.266	0.627	0.448
Disregarded Traffic Signal	2	2.3%	9	4.6%	16	7.7%	9	8.0%	0.082	0.220	0.923
Physical Illness	0	0.0%	1	0.5%	0	0.0%	0	0.0%	-	0.448	-
Illegally in Roadway	39	45.3%	82	42.1%	85	40.7%	34	30.4%	**0.030***	**0.042***	0.059
Not Visible (Dark/Non-Reflective Clothing)	15	17.4%	15	7.7%	22	10.5%	10	8.9%	0.074	0.703	0.630
Inattention	2	2.3%	1	0.5%	2	1.0%	0	0.0%	0.105	0.448	0.297
Other	1	1.2%	0	0.0%	2	1.0%	0	0.0%	0.253	-	0.297
Total	86		195		209		112				

1 Comparison between Older Pedestrians and Pedestrians Aged 16 Years to 24 Years
2 Comparison between Older Pedestrians and Pedestrians Aged 25 Years to 44 Years
3 Comparison between Older Pedestrians and Pedestrians Aged 45 Years to 64 Years
* Significant With 95% Confidence

3.5 VARIABLE IMPORTANCE

3.5.1 Older Driver Fatal and Serious Injuries

To determine variable importance in regards to older driver fatal and serious injury crashes, two random forest analyses were conducted. A random forest analysis is an ensemble-based machine learning technique. This method utilizes a set of data, where a dependent variable and a set of explanatory variables are defined. The explanatory variables are then used to predict the dependent variable through the random forest analysis. In the case of the current study, the dependent variable is binary (1 if the older driver or pedestrian sustained a fatal and serious injury, 0 otherwise), and the set of explanatory variables are the crash characteristics summarized through Section 3.1 and Section 3.2. Through the prediction process of the random forest analysis, variable importance is determined.

The use of a random forest stems from the disadvantages of decision trees. The major disadvantage of decision trees is their susceptibility to overfitting and that they are generally non-robust (Alteryx, 2019). On the other hand, random forests, as stated previously, use an ensemble-based learning technique to generate a stronger and more robust model (Alteryx, 2019). This is accomplished by random forests using multiple decision trees and averaging the results (Hartshorn, 2017). Of interest for the current study is the determination of variable importance through the use of a random forest. This is assessed by two metrics: mean decrease in accuracy and mean decrease in the Gini Index. These can often be referred to as accuracy-based importance and Gini-based importance. Accuracy-based importance is associated with the prediction accuracy of a specific outcome (Hoare, n.d.). This is computed during the out-of-bad error calculation in the random forest algorithm (Dinsdale Lab, n.d.). The higher the accuracy due to exclusion of a specific variable, the more important that variable is (Dinsdale Lab, n.d.; Harb, Yan, Radwan & Su, 2009). In this case, the outcome is 1 if the crash resulted in a fatal and serious injury and 0 otherwise.

The other metric for variable importance is the Gini Index (or coefficient) (Hartshorn, 2017; Sullivan, 2017). This refers to the measure of each variable in regards to contribution of homogeneity in the nodes and leaves of the random forest (Dinsdale Lab, n.d.). In the end, variables that result in tree nodes with a higher "purity" (or homogeneity) then result in a higher decrease in the Gini Index. Lastly, variable importance may differ across importance metrics; however, it is important to view and compare the importance ranking across both measures (Hoare, n.d.).

Figure 3.53 presents the results of the analysis. Four variables have significantly larger decreases in mean accuracy when compared to the remaining variables. These include single-vehicle crashes, fixed-object crashes, crashes in which the driver-level crash cause was speeding too fast for conditions, and straight roadway segments. Figure 3.54 shows variable importance based on the Gini Index. As observed, the variable ranking differs compared to that shown in Figure 3.53. Based on the Gini Index, two variables are deemed substantially more important than the others: head-on collisions and male older drivers.

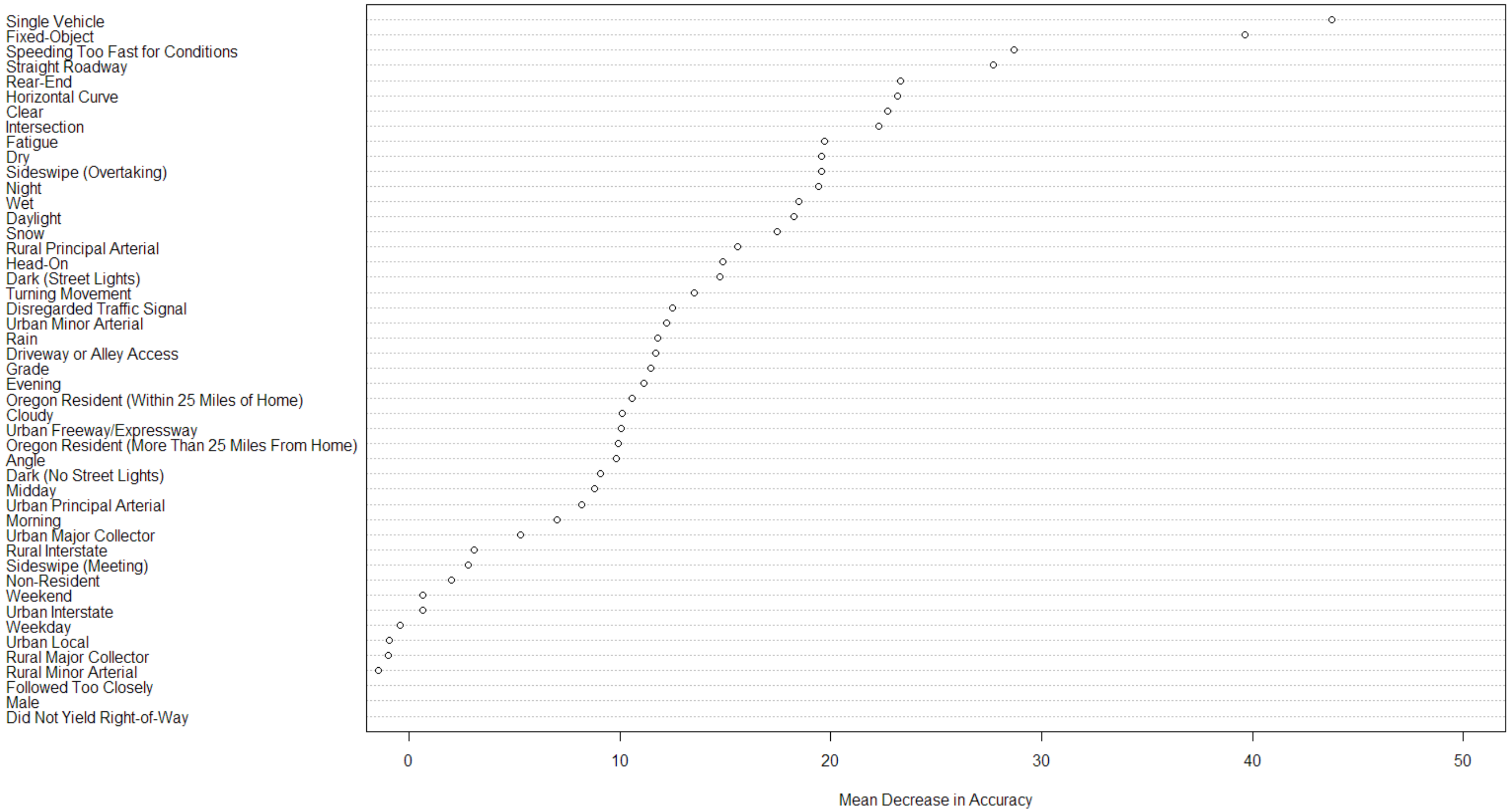

Figure 3.53: Variable importance for older driver fatal and serious injury crashes based on mean decrease in accuracy

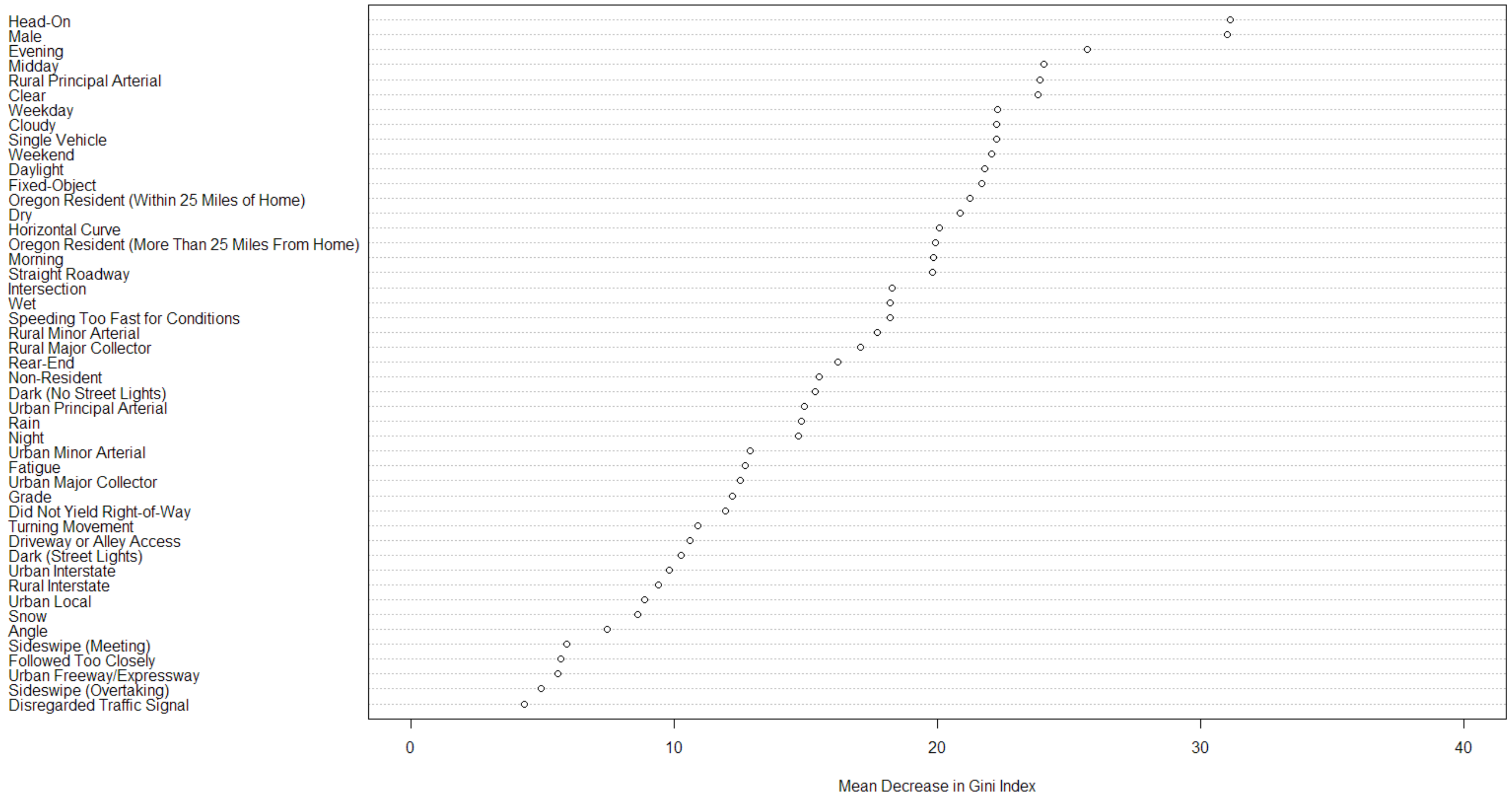

Figure 3.54: Variable importance for older driver fatal and serious injury crashes based on mean decrease in Gini Index

3.5.2 Older Pedestrian Fatal and Serious Injuries

The same random forest analyses were applied to the older pedestrian fatal and serious injury crash data. The result: variable importance on older pedestrian fatal and serious injury crashes based on the mean decrease in accuracy and the mean decrease in Gini Index.

Variable importance based on mean decrease in accuracy is shown in Figure 3.55. As shown, one variable has a much larger impact on probability accuracy of an older pedestrian fatal and serious injury crash: dark lighting conditions with no street lights. Also, important based on mean decrease in accuracy are intersection crashes, crashes in which the older pedestrian was at an intersection and inside a crosswalk, and cloudy weather conditions.

As it pertains to mean decrease in the Gini Index, variable importance is shown in Figure 3.56. The most important variable in terms of the Gini Index is a roadway classification; specifically, urban principal arterials. Next is another roadway classification, urban minor arterials. The other two variables with higher importance on older pedestrian fatal and serious injury crashes are also important based on mean decrease in accuracy. These variables are dark lighting conditions with no street lights and cloudy weather conditions**.**

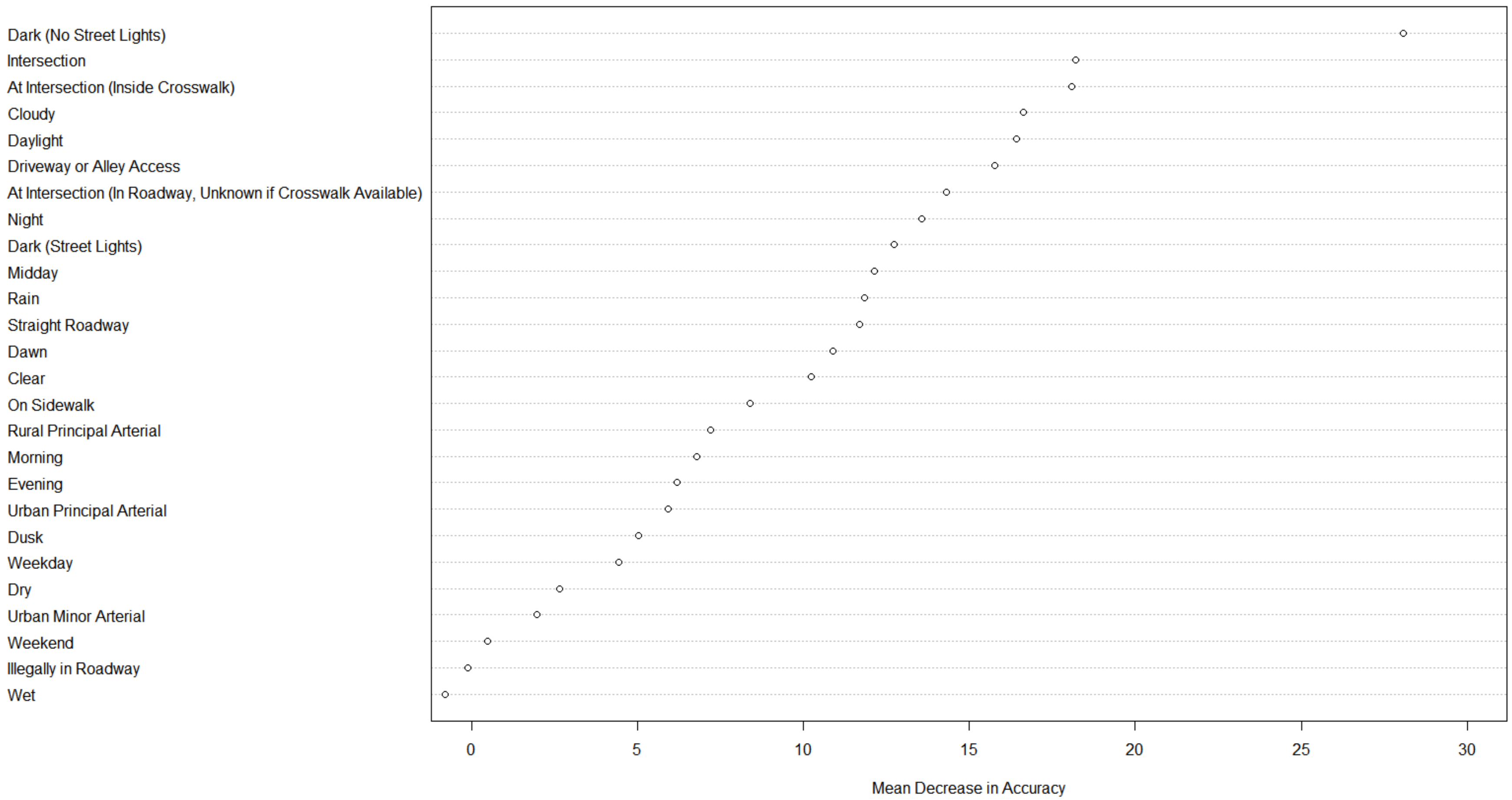

Figure 3.55: Variable importance for older pedestrian fatal and serious injury crashes based on mean decrease in accuracy

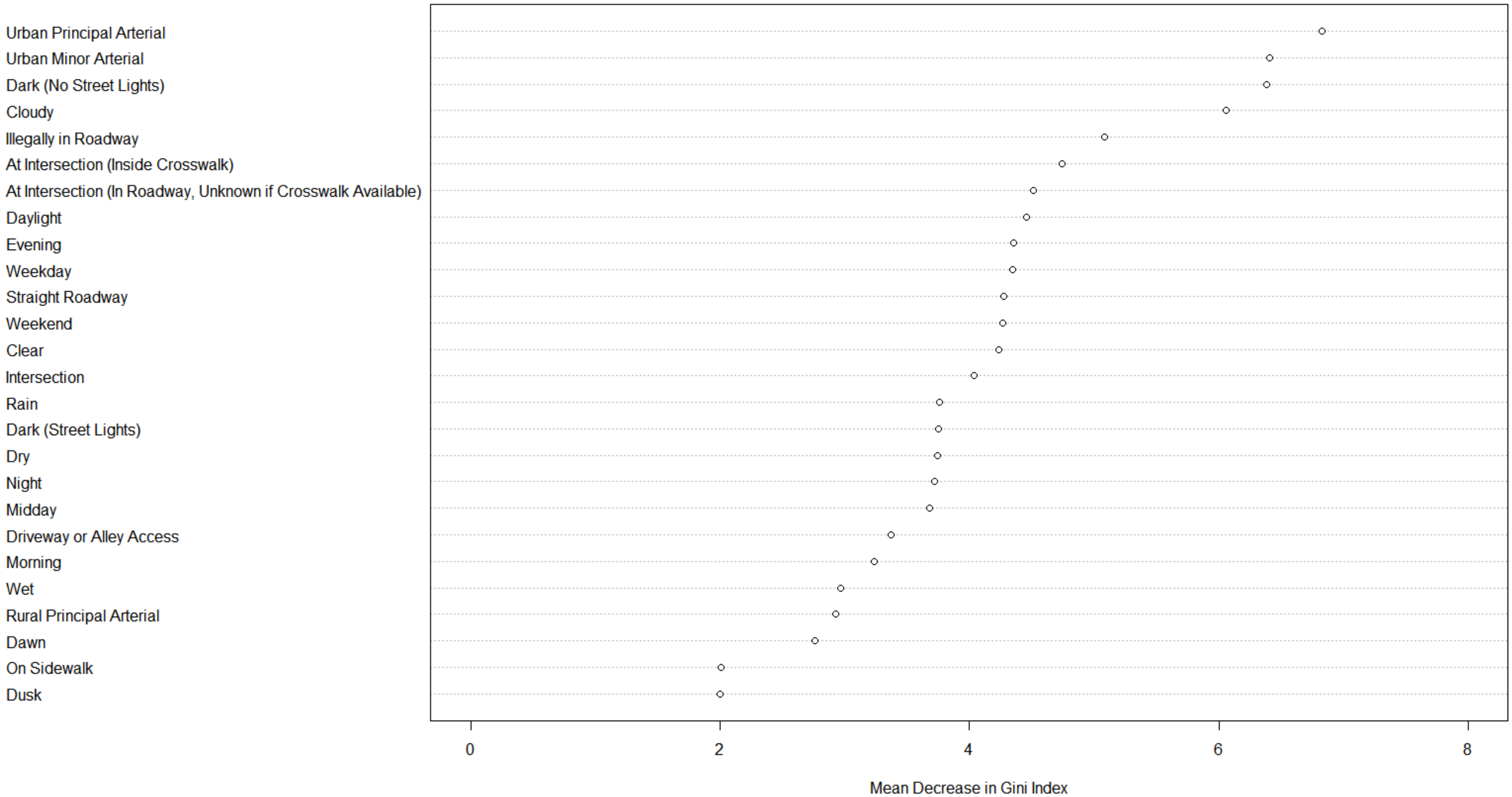

Figure 3.56: Variable importance for older pedestrian fatal and serious injury crashes based on mean decrease in Gini Index

3.6 OLDER DRIVER FATAL AND SERIOUS INJURY CRASHES AND POPULATION

To analyze older driver fatal and serious injury crashes in a spatial context, older driver crashes and population were examined. This was accomplished by focusing on Oregon resident drivers, both within 25 miles of home and 25 miles from home, and county-level population based on the 2010 census. A visual of older driver crashes based on residency and Oregon counties is provided in Figure 3.57, and older driver crashes and county-based population is shown in Figure 3.58.

Upon identification of older driver crashes, county populations were extracted from the census data. Extracted populations include total county population and population for the age cohorts presented during the driver and pedestrian comparisons (Section 3.3 and Section 3.4). A summary of older driver and other age cohort crashes by county are shown in Table 3.26.

Using county-level population and the total number of crashes by age, a population-based crash rate was calculated for each county and each age cohort. The current study identifies the number of crashes per 10,000 population for each county and each age cohort. The number of fatal and serious injury crashes per 10,000 population was then compared across age groups.

The first population-based crash rate was calculated using the total population of the county. Results of these calculations are provided in Table 3.7. As observed, in most counties, the number of crashes per 10,000 population for each age group are similar. However, of particular interest is the older driver population-based crash rate in Harney County. This is the only county in which the older driver crash rate is higher compared to other age groups.

The second set of calculations consisted of computing a crash rate per 10,000 population for each group based on their respective population. These results are shown in Table 3.28. The number of fatal and serious injury crashes for each age group within their respective population is quite large. Focusing on specifically older drivers and older population, the highest observed number of fatal and serious injury crashes per 10,000 population of persons aged 65 years or older is 72. This crash rate is present in Gilliam County. Also, with a high number of fatal and serious injury crashes per 10,000 population are Harney County (36), Lincoln County (33), Polk County (29), Tillamook County (28), and Morrow County (28). When compared to the crash rates of the other groups, older drivers have higher crash rates within their age group in three counties: Lane County, Lincoln County, and Polk County.

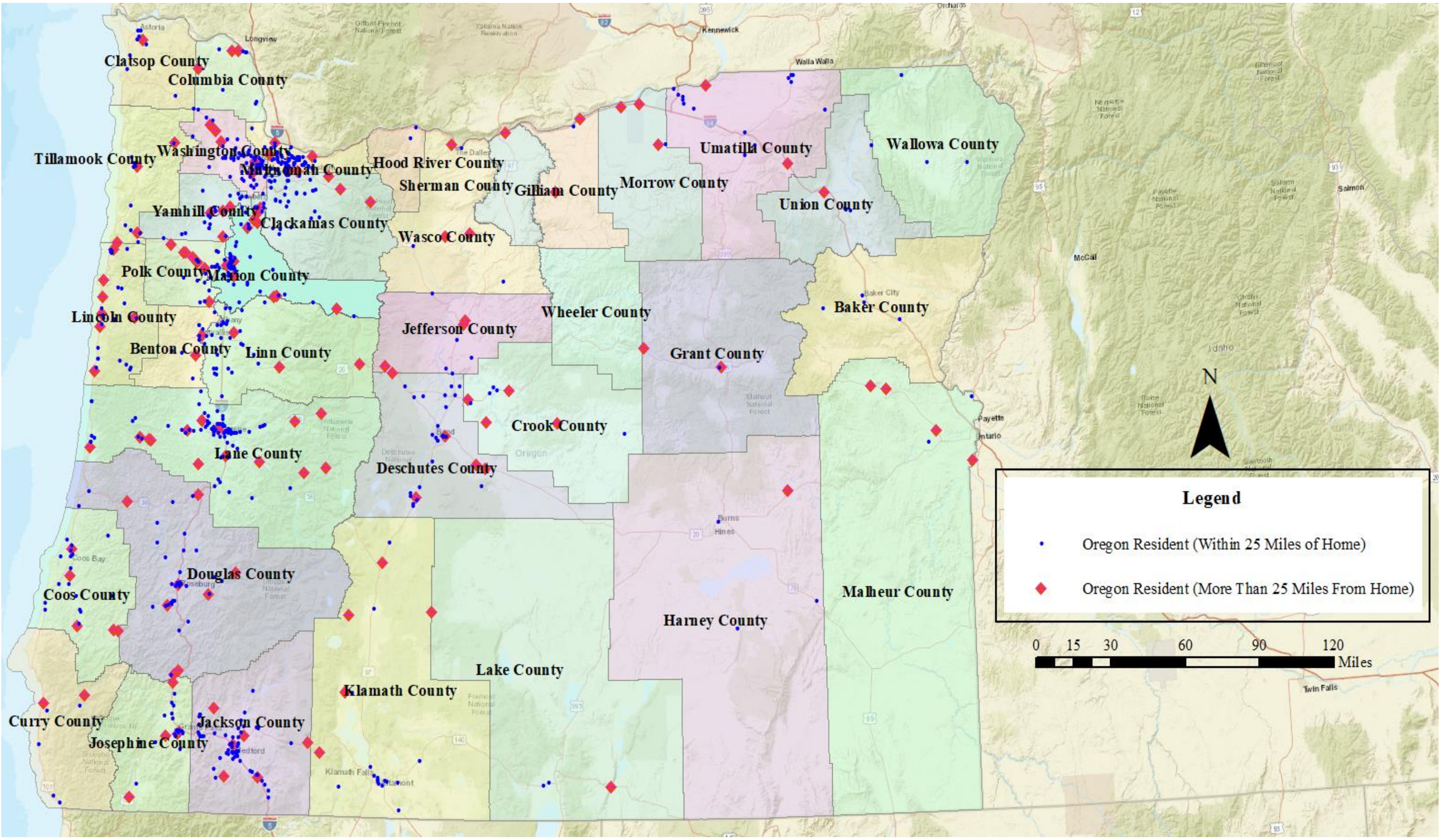

Figure 3.57: Older driver fatal and serious injury crashes and county

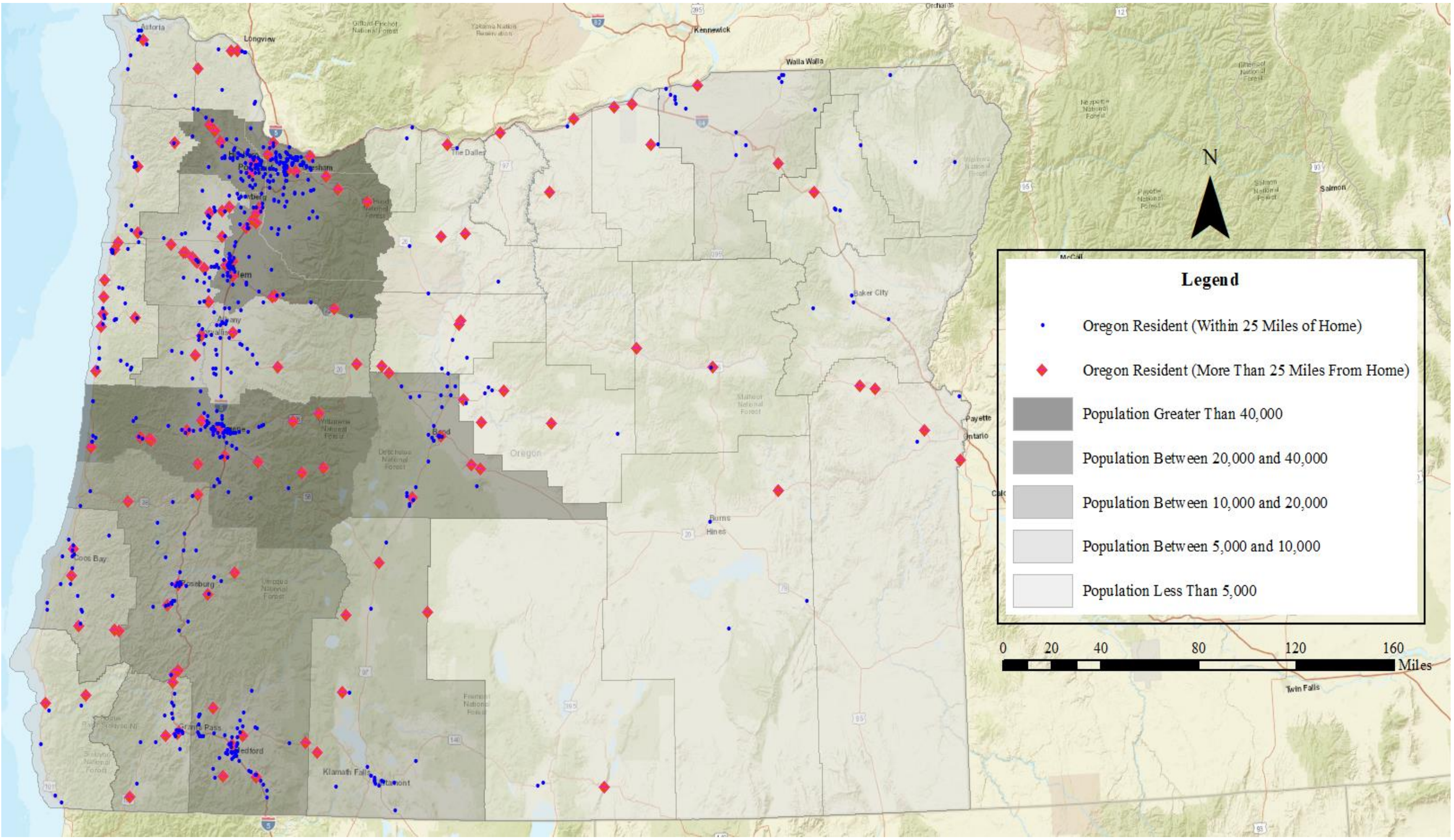

Figure 3.58: Older driver fatal and serious injury crashes and county population

Table 3.26: Number of Driver Fatal and Serious Injury Crashes by Age Group and County Population

County	Number of Crashes (65 Years or Older)	Number of Crashes (16 to 24 Years)	Number of Crashes (25 to 44 Years)	Number of Crashes (45 to 64 Years)	Total Population
Baker	4	1	9	13	16,134
Benton	11	14	22	28	85,579
Clackamas	42	62	129	112	375,992
Clatsop	10	17	16	31	37,039
Columbia	10	9	24	26	49,351
Coos	22	9	27	19	63,043
Crook	9	7	9	18	20,978
Curry	7	9	10	7	22,364
Deschutes	31	35	77	65	157,733
Douglas	41	36	51	85	107,667
Gilliam	3	2	3	2	1,871
Grant	3	4	3	4	7,445
Harney	5	4	3	3	7,422
Hood River	2	7	7	5	22,346
Jackson	66	59	97	110	203,206
Jefferson	8	4	18	16	21,720
Josephine	26	27	44	53	82,713
Klamath	21	21	31	40	66,380
Lake	4	4	5	5	7,895
Lane	92	61	149	153	351,715
Lincoln	33	14	30	37	46,034
Linn	34	38	80	81	116,672
Malheur	6	17	8	10	31,313
Marion	61	96	149	141	315,335
Morrow	4	5	13	6	11,173
Multnomah	69	115	299	231	735,334
Polk	32	34	47	43	75,403
Sherman	1	1	6	3	1,765
Tillamook	15	11	21	12	25,250
Umatilla	16	24	32	45	75,889
Union	6	5	13	8	25,748
Wallowa	3	2	2	4	7,008
Wasco	6	9	18	23	25,213
Washington	67	68	179	161	529,710
Wheeler	0	1	0	3	1,441
Yamhill	25	35	50	49	99,193
Total	**795**	**867**	**1,681**	**1,652**	

Table 3.27: Driver Fatal and Serious Injury Crashes Per 10,000 Total Population

County	Driver Fatal and serious injury Crash Rate Per 10,000 Total Population			
	65 Years or Older	16 to 24 Years	25 to 44 Years	45 to 64 Years
Baker	2	1	6	8
Benton	1	2	3	3
Clackamas	1	2	3	3
Clatsop	3	5	4	8
Columbia	2	2	5	5
Coos	3	1	4	3
Crook	4	3	4	9
Curry	3	4	4	3
Deschutes	2	2	5	4
Douglas	4	3	5	8
Gilliam	16	11	16	11
Grant	4	5	4	5
Harney	7	5	4	4
Hood River	1	3	3	2
Jackson	3	3	5	5
Jefferson	4	2	8	7
Josephine	3	3	5	6
Klamath	3	3	5	6
Lake	5	5	6	6
Lane	3	2	4	4
Lincoln	7	3	7	8
Linn	3	3	7	7
Malheur	2	5	3	3
Marion	2	3	5	4
Morrow	4	4	12	5
Multnomah	1	2	4	3
Polk	4	5	6	6
Sherman	6	6	34	17
Tillamook	6	4	8	5
Umatilla	2	3	4	6
Union	2	2	5	3
Wallowa	4	3	3	6
Wasco	2	4	7	9
Washington	1	1	3	3
Wheeler	0	7	0	21
Yamhill	3	4	5	5

Table 3.28: Fatal and Serious Injury Crash Rate per 10,000 Population by Age Group Population

County	Fatal and serious injury Crashes Per 10,000 Population			
	65 Years or Older	16 to 24 Years	25 to 44 Years	45 to 64 Years
Baker	11	6	28	25
Benton	11	6	12	13
Clackamas	8	14	14	10
Clatsop	16	36	19	27
Columbia	15	16	20	17
Coos	16	13	21	10
Crook	21	33	20	28
Curry	11	47	27	9
Deschutes	13	19	19	14
Douglas	18	29	23	26
Gilliam	72	121	84	30
Grant	17	57	22	16
Harney	36	47	20	13
Hood River	7	26	12	8
Jackson	18	23	21	19
Jefferson	24	15	35	27
Josephine	14	30	27	21
Klamath	19	24	21	21
Lake	25	50	29	19
Lane	17	11	17	16
Lincoln	33	31	33	23
Linn	19	26	28	25
Malheur	13	39	10	13
Marion	15	21	18	18
Morrow	28	34	49	20
Multnomah	9	12	12	12
Polk	29	28	27	22
Sherman	26	57	176	52
Tillamook	28	42	41	15
Umatilla	17	23	16	23
Union	14	13	23	11
Wallowa	18	34	16	17
Wasco	13	30	32	32
Washington	13	10	11	12
Wheeler	0	82	0	66
Yamhill	19	24	20	19

3.7 OLDER PEDESTRIAN FATAL AND SERIOUS INJURY CRASHES AND POPULATION

A population-based crash rate for older pedestrian fatal and serious injury crashes was also computed. However, in Oregon crash data, the residency of the non-motorist is not provided. Therefore, for older pedestrian fatal and serious injury crashes, residency was not considered. In addition, due to the low number of crashes, the rate provided is the number of crashes per 100,000 population (as opposed to 10,000 population). Similar to the older driver fatal and serious injury crash rate, older pedestrian fatal and serious injury crash rate is provided at the county level. Figure 3.59 shows older pedestrian fatal and serious injury crashes by county, and Figure 3.60 shows older pedestrian fatal and serious injury crashes by county population. The number of pedestrian fatal and serious injury crashes by age group and total county population is shown in Table 3.29.

Following the same method as older driver fatal and serious injury crash rates, older pedestrian fatal and serious injury crash rates are displayed in Table 3.30. Of the 36 Oregon counties, the older pedestrian crash rate is the highest, or shared for the highest, in six. Of the six, the older pedestrian fatal and serious injury crash rate is the highest for five. The county in which the highest fatal and serious injury crash rate is shared with other age groups is Baker County, where the older pedestrian crash rate is six fatal and serious injury crashes per 100,000 population. Of the five counties where the older pedestrian fatal and serious injury crash is the highest, Morrow County is the only location where there is a crash rate for only older pedestrians (i.e., no serious crashes occurred for other pedestrian age groups). Morrow County has an older pedestrian fatal and serious injury crash rate of 18 fatal and serious injury crashes per 100,000 population. The older pedestrian crash rate is also the highest in Curry County (9), Hood River County (13), Umatilla County (7), and Washington County (4).

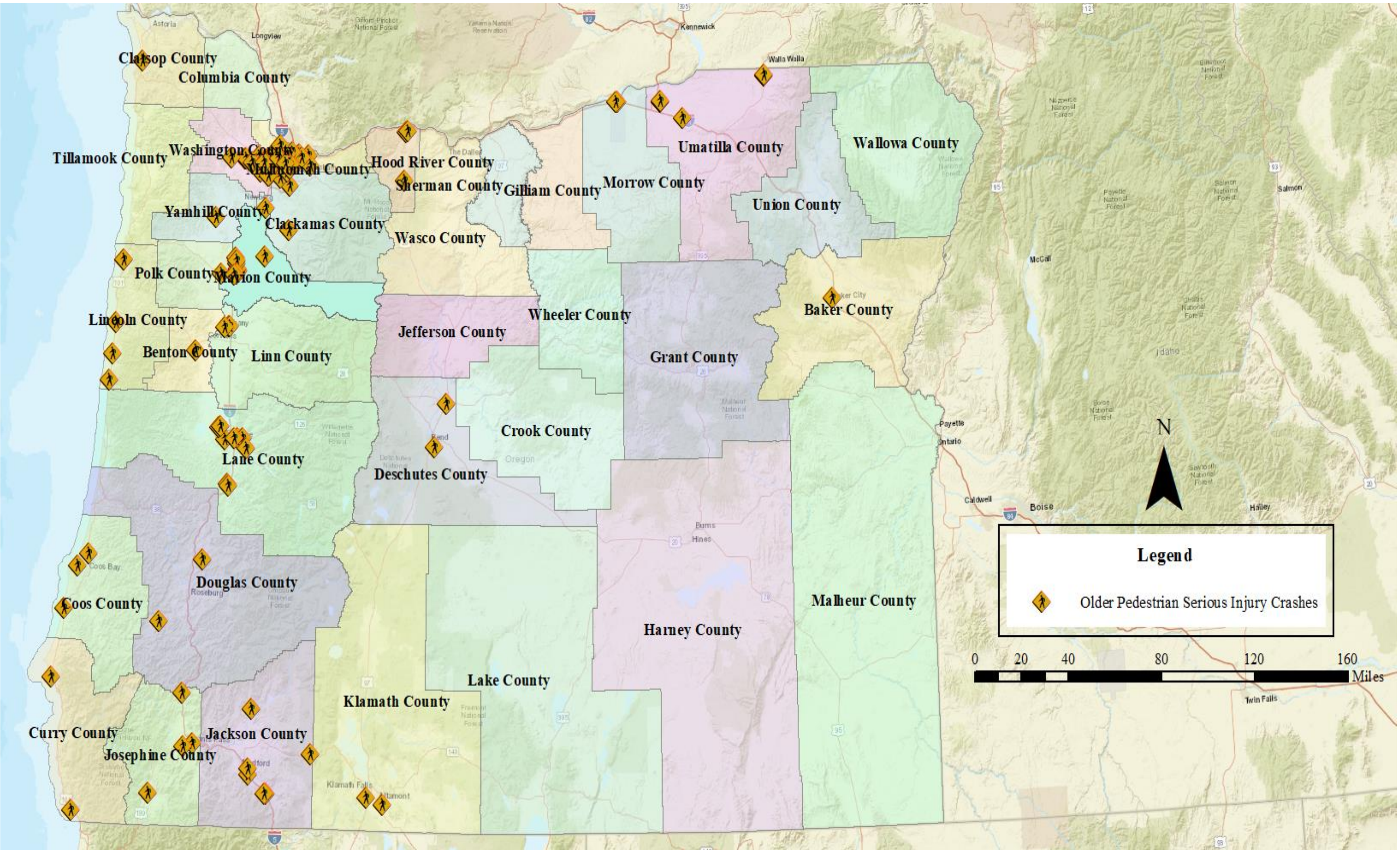

Figure 3.59: Older pedestrian fatal and serious injury crashes and county

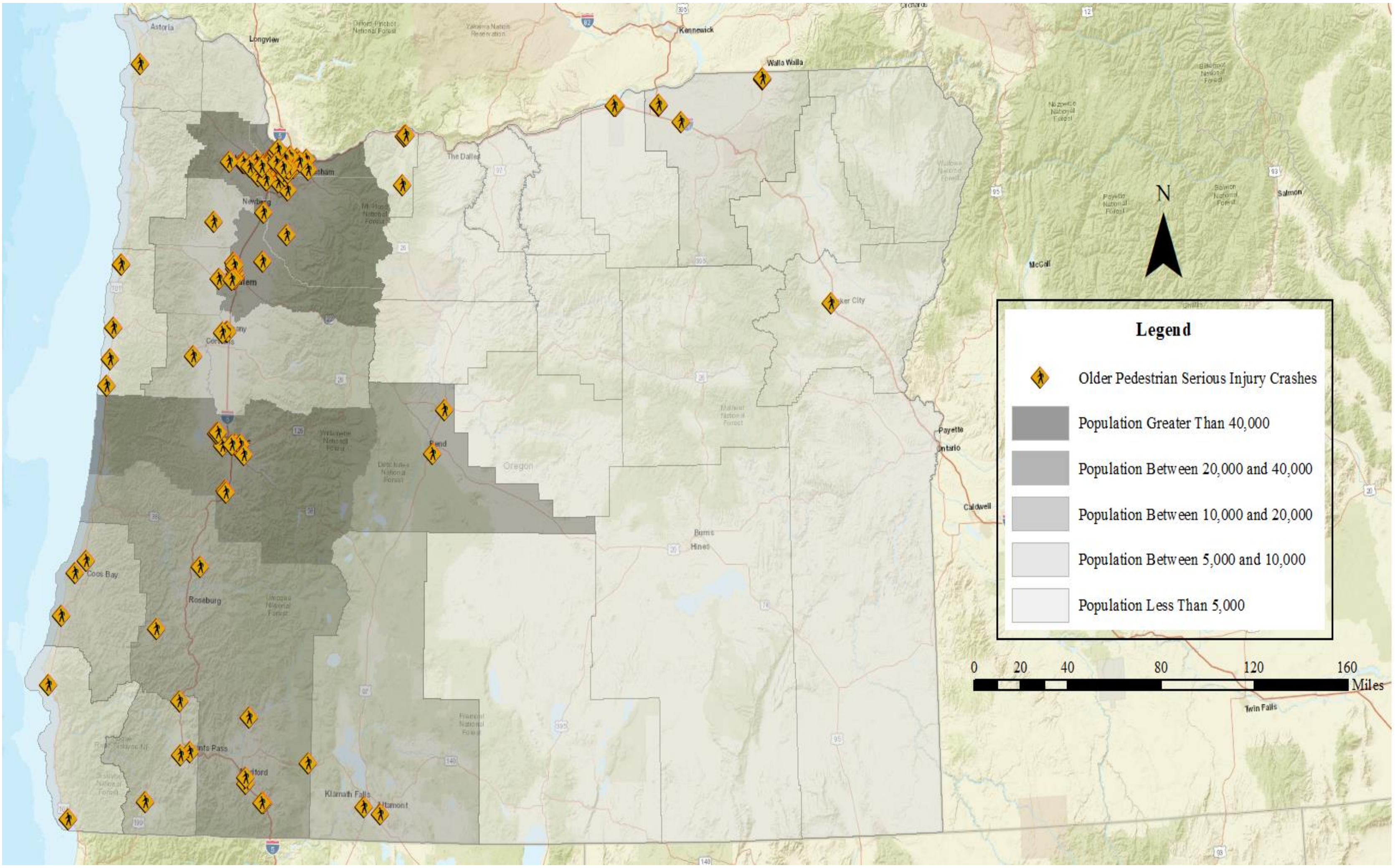

Figure 3.60: Older pedestrian fatal and serious injury crashes and county population

Table 3.29: Number of Pedestrian Fatal and Serious Injury Crashes by Age Group and County Population

County	Number of Crashes (65 Years or Greater)	Number of Crashes (16 to 24 Years)	Number of Crashes (25 to 44 Years)	Number of Crashes (45 to 64 Years)	Total Population
Baker	1	0	1	1	16,134
Benton	1	4	3	3	85,579
Clackamas	5	6	21	20	375,992
Clatsop	1	1	2	6	37,039
Columbia	0	0	0	1	49,351
Coos	3	1	1	6	63,043
Crook	0	0	0	0	20,978
Curry	2	0	1	0	22,364
Deschutes	2	2	4	6	157,733
Douglas	2	4	8	5	107,667
Gilliam	0	0	0	0	1,871
Grant	0	0	0	0	7,445
Harney	0	0	0	0	7,422
Hood River	3	0	0	0	22,346
Jackson	6	2	12	13	203,206
Jefferson	0	0	0	2	21,720
Josephine	4	1	5	5	82,713
Klamath	2	1	2	6	66,380
Lake	0	0	0	0	7,895
Lane	9	5	13	13	351,715
Lincoln	5	0	5	7	46,034
Linn	3	7	9	7	116,672
Malheur	0	0	2	0	31,313
Marion	9	9	12	22	315,335
Morrow	2	0	0	0	11,173
Multnomah	26	29	73	61	735,334
Polk	1	2	1	2	75,403
Sherman	0	0	0	0	1,765
Tillamook	0	0	1	1	25,250
Umatilla	5	2	1	1	75,889
Union	0	0	0	1	25,748
Wallowa	0	0	0	0	7,008
Wasco	0	1	1	1	25,213
Washington	19	9	16	16	529,710
Wheeler	0	0	0	0	1,441
Yamhill	1	0	1	3	99,193
Total	**112**	**86**	**195**	**209**	

Table 3.30: Pedestrian Fatal and Serious Injury Crashes per 100,000 Total Population

County	Pedestrian Fatal and serious injury Crashes Per 100,000 Population			
	65 Years or Greater	16 to 24 Years	25 to 44 Years	45 to 64 Years
Baker	6	0	6	6
Benton	1	5	4	4
Clackamas	1	2	6	5
Clatsop	3	3	5	16
Columbia	0	0	0	2
Coos	5	2	2	10
Crook	0	0	0	0
Curry	9	0	4	0
Deschutes	1	1	3	4
Douglas	2	4	7	5
Gilliam	0	0	0	0
Grant	0	0	0	0
Harney	0	0	0	0
Hood River	13	0	0	0
Jackson	3	1	6	6
Jefferson	0	0	0	9
Josephine	5	1	6	6
Klamath	3	2	3	9
Lake	0	0	0	0
Lane	3	1	4	4
Lincoln	11	0	11	15
Linn	3	6	8	6
Malheur	0	0	6	0
Marion	3	3	4	7
Morrow	18	0	0	0
Multnomah	4	4	10	8
Polk	1	3	1	3
Sherman	0	0	0	0
Tillamook	0	0	4	4
Umatilla	7	3	1	1
Union	0	0	0	4
Wallowa	0	0	0	0
Wasco	0	4	4	4
Washington	4	2	3	3
Wheeler	0	0	0	0
Yamhill	1	0	1	3

3.8 SUMMARY

Using four years of self- and police-reported Oregon crash data, a series of analyses were conducted on older driver and pedestrian fatal and serious injury crashes. Analyses included a descriptive analysis utilizing the raw frequencies in the crash data, a comparison of raw frequencies to other age groups, a proportions test to determine significant differences in crash proportions among age groups, a random forest analysis to determine variable importance on predicting older driver and pedestrian fatal and serious injury crashes, and a population-based spatial analysis with crash rate per population.

Raw crash frequencies indicated that older driver fatal and serious injury crashes most often happened from 3:00 p.m. to 5:59 p.m., on Mondays, and on rural principal arterials. Further, the majority of older driver fatal and serious injury crashes occurred at an intersection, while the most occurring collision types were fixed object and turning movement. Nearly 75% of older driver fatal and serious injury crashes occurred within 20 miles of the driver's home. Lastly, the most occurring driver-level crash causes were determined to no cause (i.e., not at fault), not yielding the right-of-way, and speeding too fast for conditions.

Older pedestrian fatal and serious injury crashes were found to be most frequent between 3:00 p.m. to 5:59 p.m. The day of the week differed for older pedestrian fatal and serious injury crashes, where Friday accounted for the majority of crashes. Similar to older driver fatal and serious injury crashes, the largest percentage of older pedestrian fatal and serious injury crashes occurred at an intersection. Crossing between intersections was the pedestrian action that accounted for the most crashes, along with crossing at an intersection with no traffic signal. In terms of location, pedestrians who were in the crosswalk at an intersection and pedestrians who were in the roadway accounted for more than 65% of older pedestrian fatal and serious injury crashes. The leading crash causes at the pedestrian level were no-cause associated (i.e., not at fault), the pedestrian being illegally in the roadway, and the pedestrian not being visible (e.g., they were wearing dark or non-reflection clothing). Lastly, the major of vehicle movements in the pedestrian crashes were straight and turning left or right.

County-level summaries of a select of crash statistics are presented in Appendix E for older driver crashes and Appendix F for older pedestrian crashes.

Through a series of proportions tests, it was found that older driver and pedestrian crash proportions were statistically different for various crash characteristics, such as time of day, day of the week, roadway classification, and participant-level crash cause. In regards to variable importance, important variables were identified based on mean decrease in accuracy and mean decrease in the Gini Index. For older driver fatal and serious injury crashes, important variables included single-vehicle crashes, fixed-object crashes, speeding too fast for conditions, head-on collisions, and male drivers. For older pedestrian fatal and serious injury crashes, important variables included dark conditions with no street lights, pedestrians being in a crosswalk at an intersection, cloudy weather conditions, and urban roadway classifications.

The final analysis conducted was a population-based crash rate analysis. It was determined that older driver fatal and serious injury crashes have a higher rate compared to other age groups in Harney County. For the older pedestrian crash rate, older pedestrians have the highest rate in six counties: Baker, Morrow, Curry, Hood River, Umatilla, and Washington counties.

4.0 COUNTERMEASURES

A comprehensive list of potential countermeasures was identified from the findings of *Task 1: Review Best Practices for Addressing Older Driver Safety*. These potential countermeasures are summarized in Table 4.1. These countermeasures are then matched to crash factors presented in Chapter 4.1. For ease of presentation, Table 4.1 begins on the following page.

The columns in Table 4.1 summarizes the information about each countermeasure. The first column provides the countermeasure category and the countermeasure. The second, third, and fourth columns provide the associated crash modification factor (CMF), its rating, and its effectiveness or crash reduction factor (CRF).[1] Not all possible countermeasures have a quantitative CMF, especially those related to policy or education. The fifth column provides the CRF, as stated in the ODOT CRF list.[2] The final two columns provide the scope of the countermeasure (i.e., policy-driven, project-level, systemic, etc.) and if the countermeasure is currently listed in one of ODOT's systemic approaches documents.[3,4,5] Lastly, each countermeasure is associated with an identifier (e.g., GP1, TSH1, etc.) to map to crash-factor-specific countermeasures outlined in Chapter 4.2.

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[1] CMFs have been obtained from the CMF Clearinghouse: www.cmfclearinghouse.org
[2] ODOT's CRF list can be found here: https://www.oregon.gov/ODOT/Engineering/Pages/ARTS.aspx
[3] https://www.oregon.gov/ODOT/Engineering/Pages/Roadway-Departures.aspx
[4] https://www.oregon.gov/ODOT/Engineering/Pages/Intersection-Safety.aspx
[5] https://www.oregon.gov/ODOT/Engineering/Docs_TrafficEng/Bike-Ped-Safety-Implementation-Plan.pdf

Table 4.1: List of Potential Countermeasures by Category

Category	CMF (ID)	Rating	CRF	ODOT CRF (ID)	Scope	ODOT's Systemic Approach
General and Policy-Level Countermeasures						
Education and Awareness (GP1)					Policy	
Licensure and Testing Screening (GP2)					Policy	
Discounts for Completed Defensive Driving Courses (GP3)					Policy	
In-Vehicle Lane-Departure Warning Systems (GP4)						
Development of Autonomous Vehicles (GP5)						
Insurance Installed In-Vehicle Monitoring Devices (GP6)						
Law Enforcement and Other Judicial Programs (GP7)					Policy	
Frequency DL Renewals, Vision Screening, and In-Person Renewals (GP8)					Policy	
Shorter Renewal Periods for DL (GP9)					Policy	
Intersection Countermeasures						
Address Lack of Separate Traffic Signal Heads (I1)	0.54 (1485)a	★★	46%	NA	Project	✓
Address Limited or Restricted Sight Distance at Left-Turns (I2)					Project	✓
Use of Less Than 2.5 Seconds for PRT (I3)					Design	
Use More than One NO TURN ON RED Sign (I4)	$f(x)$ (5194)	NA	NA	NA	Systemic	
Prohibit Right-turn-on-red at Skewed Intersections (I5)					Design	
Geometric Design Countermeasures						
Minimum Receiving Lane of 12 ft. With 4 ft. Shoulder (GD1)					Design	
Positive Offset of Left-Turn Lanes (GD2)	0.35 (2799)	★★	65%	NA	Project	
90-Degree Angle Approaches (GD3)					Project	
Raised Channelization With Sloped Curbs for Exclusive Turn Lanes (GD4)	0.87 (279)b	★★★	13%	35% (H6)c	Project	
Convert 4-Lane Roadways to 3-Lane Roadways (GD5)	0.812 (5554)d	★★★★	18.8 %	29% (H48)d	Project	

Table 4.1: Continued

Install Roundabouts (GD6)	0.439 (10094)e	★★★	56.1 %	78% (H17)	Project	
Shoulder and Centerline Rumble Strips (GD7)	0.80 (6850)	★★★★★	20%	12% (RD15)f	Systemic	✓
Signage Countermeasures						
Larger and More Reflective Regulatory Signs (S1)	NA	NA	NA	25% (I12)g	Systemic	
Redundancy and Larger Lettering Size for Street-Name Signage (S2)						✓
More Overhead-Lighted Signage (S3)						
Railroad Crossing Signage (S4)	0.50 (482)h	★★★★★	50%	NA	NA	
Pavement Markings Countermeasures						
Treat Raised Medians With Reflective Markings (P1)						
More Visible and Durable Pavement Markings (P2)	6842/6843					✓
Transverse Pavement Striping or Rumble Strips at Stop-Controlled Intersections (P3)	0.87 (9045)i	★★★★	13%	25% (I16)i	Systemic	✓
Arrow Pavement Markings in Advance of Exclusive Turn Lanes (P4)						
Edge Lines to Guide Motorists (P5)	0.97 (83)j	★★★	3%	11% (RD14)k	Systemic	✓
Improved Island Delineation (P6)						
Traffic Signal Operations Countermeasures						
Increase Use of Protected Left-Turn Lanes and Use Separate Signal Face (TSO1)	0.65 (1581)	★	35%	NA	Systemic	✓
Use Leading Left-Turns as Opposed to Lagging (TSO2)					Policy	
Use Red Arrow for Left-Turn Signals (TSO3)	0.75 (10030)l	★★★	25%	NA	Systemic	

Table 4.1: Continued

Use Yellow and All Red Formulas in ITE Traffic Engineering Handbook (More Conservative) (TSO4)	0.92 (380)	★★★	8%	NA	Design	
Assume Slower Walking Speeds for Pedestrian Intervals (TSO5)	0.5 (4115)	★★	50%	NA	Design	
Traffic Signal and Hardware Countermeasures						
Use 12 in. Signal Lenses (TSH1)	0.54 (1444)	★★	46%	25% (I2)m	Systemic	✓
Use Backplates on Signal Heads for Roads With Speeds of 40 mi/hr or Greater (TSH2)						✓
More Signal Heads and Overhead Traffic Signals (TSH3)	0.73 (1414)	★★★	28%	NA	Systemic	✓
Consider Post-Mounted Signals (TSH4)						
Roadway Lighting and Beacons Countermeasures						
Reduce Glare From Oncoming Headlamps by Increasing Lateral Separation of Opposing Vehicles Through Use of Wide Medians and Independent Alignments (RL1)	$f(x)$ (5416)	★★★	$f(x)$	NA	Project	
Fixed Illumination in Rural Areas (RL2)	0.80 (575)	★★★	20%	28% (H26)	Systemic	
Warning Signs (RL3)					Project	✓
Flashing Beacons (RL4)					Project	✓
Reflective Strips on Stop Sign Posts (RL5)	0.585 (6602)n	★★★	41.5 %	NA	Systemic	✓
Raised Pavement Markers (RL6)	0.81 (5496)	★★★	19%	15% (RD12)	Systemic	✓
Sign-Mounted Flashing Beacons for Pedestrians in Crosswalks (RL8)	0.526 (9024)o	★★	47.4 %	10% (BP8)p	Systemic	✓
Flashing LED lights Mounted in "Pedestrian Crossing" Warning Signs (RL9)						✓
Pedestrian Countermeasures						
Lower Speed Limits on Roadways with High Older Pedestrian Volumes (P1)	0.96 (1239)q	★★★	4%	NA	Design	

Table 4.1: Continued

Separate Pedestrians by Time and Space (Utilize Protected or Leading Pedestrian Intervals at Signalized Intersections) (P2)	0.87 (9916)	★★★★★	13%	37% (BP3)	Systemic	✓
Increase Visibility of Pedestrians to Drivers (P3)	0.6 (4123)r	★★	40%	NA	Systemic	✓
Pedestrian Countdown Signals (P4)	0.3 (5272)	★★★★	70%	70% (BP1)	Systemic	✓
Older Communities Countermeasures						
Promote Public Transportation by Educating Older Drivers on How to Use and Offer Door-To-Door Services (OC1)						
Bus Shelters and Benches Near Older Communities (OC2)						
Protected Pedestrian Phases Near Older Communities (OC3)						
Move Stop Bars to 15 ft. Before the Intersection at Busy Intersections (OC4)						
Pedestrian Islands in the Median of Wide and Busy Streets (OC5)	0.86 (9120)	★★★★	14%	31% (BP7)	Systemic	
Bus Bulbs on Wide and Busy Streets (OC6)						✓
Raised Crosswalks and Road Diets Near Older Communities (OC7)	0.55 (136)s	★	46%	NA	Systemic	
Curb Extensions on Commercial Streets and Bus Routes (OC8)						

[a] CMF for angle crashes
[b] CMF for left-turns
[c] CRF for right-turns
[d] CMF and CRF for converting 4-lane to 3-lane with center turn lane
[e] CMF applies to conversion of 3- or 4-leg intersection
[f] CRF for centerline rumble strips
[g] CRF for larger warning or regulatory signs at intersections
[h] CMF for installing flashing lights and sound signals
[i] CMF and CRF for transverse rumble strips on stop-controlled approaches
[j] CMF for placing standard edge line marking
[k] CRF for tangent or curve edge lines and run-off-road crashes
[m] CRF for increasing size, where size is not listed
[n] CMF for replacing stop signs with flashing LED stop signs and angle crashes

[o] CMF for vehicle-pedestrian crashes
[p] CRF for 2-lane roadways
[q] CMF based on 10 mi/hr posted speed limit reduction
[r] CMF is based on installing a high-visibility crosswalk
[s] CMF for vehicle-pedestrian crashes

4.1 CRASH FACTORS

Crash factors chosen for countermeasure selection are those that are both overrepresented in the raw frequencies and deemed important based on the results from the random forest analysis. For older driver crashes, these factors are summarized in Table 4.2. For older pedestrian crashes, these factors are summarized in Table 4.3. The crash factors summarized in these tables are then matched to potential countermeasures in Chapter 4.2.

Table 4.2: Overrepresented and Important Older Driver Crash Factors

Crash Type
Fixed-Object Crashes
Rear-End Crashes
Intersection-Related Crashes
Driver-Level Crash Cause
Speeding Too Fast For Conditions
Roadway Characteristics
Horizontal Curves
Time of Day
3:00 p.m. to 8:00 p.m.

Table 4.3: Overrepresented and Important Older Pedestrian Crash Factors

Lighting Condition
Dark With No Street Lights
Crash Location
Intersection-Related
Pedestrian Location
In Crosswalk at An Intersection
Roadway Classification
Urban Classifications
Pedestrian-Level Crash Cause
Pedestrian Illegally in Roadway
Pedestrian Not Visible

4.2 COUNTERMEASURE SELECTION

This section presents potential countermeasures for the crash factors presented in Chapter 4.1. This is done for both older driver crashes and older pedestrian crashes. Each crash factor is presented with its own table and countermeasures will be distinguished by the following categories:

- Low Cost or Ready to Implement.
- Medium Cost or Moderate Time to Implement.
- High Cost or Substantial Time to Implement.

As stated previously, these categories are defined based on potential countermeasures relative to one another. In addition, applicable crash modification factors have been matched to each countermeasure for each crash factor using the abbreviated codes in Table 4.1 (e.g., GP1, RL1, etc.).

4.3 OLDER DRIVER CRASH COUNTERMEASURES

Following the crash factors presented in Table 4.2, Table 4.4 to Table 4.9 show potential crash countermeasures for fixed-object crashes, rear-end crashes, intersection-related crashes, crashes in which the older driver was speeding too fast for conditions, crashes that occurred on horizontal curves, and crashes that occurred from 3:00 p.m. to 8:00 p.m., respectively.

Table 4.4: Potential Countermeasures for Older Driver Fixed-Object Crashes

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
Larger and More Reflective Regulatory Signs (S1)	More Overhead-Lighted Signage (S3)	In-Vehicle Lane-Departure Warning Systems (GP4)
Treat Raised Medians With Reflective Markings (P1)	Fixed Illumination in Rural Areas (RL2)	Development of Autonomous Vehicles (GP5)
More Visible and Durable Pavement Markings (P2)	Raised Pavement Markers (RL6)	Minimum Receiving Lane of 12 ft. With 4 ft. Shoulder (GD1)
Edge Lines to Guide Motorists (P5)	Shoulder and Centerline Rumble Strips (GD7)	Reduce Glare From Oncoming Headlamps by Increasing Lateral Separation of Opposing Vehicles Through Use of Wide Medians and Independent Alignments (RL1)
Warning Signs (RL3)	-	Discounts for Completed Defensive Driving Courses (GP3)
Flashing Beacons (RL4)	-	-

Table 4.5: Potential Countermeasures for Older Driver Rear-End Crashes

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
Warning Signs (RL3)	Fixed Illumination in Rural Areas (RL2)	Discounts for Completed Defensive Driving Courses (GP3)
-	Use of Less Than 2.5 Seconds for PRT (I3)	Development of Autonomous Vehicles (GP5)
-	-	Insurance Installed In-Vehicle Monitoring Devices (GP6)
-	-	Reduce Glare From Oncoming Headlamps by Increasing Lateral Separation of Opposing Vehicles Through Use of Wide Medians and Independent Alignments (RL1)

Table 4.6: Potential Countermeasures for Older Driver Intersection-Related Crashes

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
More Visible and Durable Pavement Markings (P2)	Education and Awareness (GP1)	Development of Autonomous Vehicles (GP5)
Arrow Pavement Markings in Advance of Exclusive Turn Lanes (P4)	Use of Less Than 2.5 Seconds for PRT	Law Enforcement and Other Judicial Programs (GP7)
Improved Island Delineation	Address Lack of Separate Traffic Signal Heads	Address Limited or Restricted Sight Distance at Left Turns (I2)
Use Leading Left-Turns as Opposed to Lagging (TSO2)	Use Red Arrow for Left-Turn Signals	Positive Offset or Left-Turn Lanes (GD2)
Use More than One NO TURN ON RED Sign (I4)	Use Yellow and All Red Formulas in ITE Traffic Engineering Handbook (More Conservative)	Raised Channelization With Sloped Curbs for Exclusive Turn Lanes (GD4)
Prohibit Right-turn-on-red at Skewed Intersections (I5)	Use 12 in. Signal Lenses	Install Roundabouts (GD6)
Reflective Strips on Stop Sign Posts (RL5)	Use Backplates on Signal Heads for Roads With Speeds of 40 mi/hr or Greater	Increase Use of Protected Left-Turn Lanes and Use Separate Signal Face (TSO1)
-	Raised Pavement Markers (RL6)	More Signal Heads and Overhead Traffic Signals (TSH3)
-	More Overhead-Lighted Signage (S3)	Consider Post-Mounted Signals (TSH4)

Table 4.7: Potential Countermeasures for Older Drivers Who Were Speeding Too Fast for Conditions

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
Larger and More Reflective Regulatory Signs (S1)	Education and Awareness (GP1)	Licensure and Testing Screening (GP2)
Flashing Beacons (RL4)	More Overhead-Lighted Signage (S3)	Discounts for Completed Defensive Driving Courses (GP3)
Warning Signs (RL9)	-	Development of Autonomous Vehicles (GP5)
-	-	Law Enforcement and Other Judicial Programs (GP7)
-	-	Insurance Installed In-Vehicle Monitoring Devices (GP6)

Table 4.8: Potential Countermeasures for Older Driver Crashes on Horizontal Curves

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
Larger and More Reflective Regulatory Signs (S1)	Education and Awareness (GP1)	In-Vehicle Lane-Departure Warning Systems (GP4)
More Visible and Durable Pavement Markings (P2)	Shoulder and Centerline Rumble Strips (GD7)	Development of Autonomous Vehicles (GP5)
Edge Lines to Guide Motorists (P5)	More Overhead-Lighted Signage (S3)	Minimum Receiving Lane of 12 ft. With 4 ft. Shoulder (GD1)
Warning Signs (RL3)	Raised Pavement Markers (RL6)	-
Flashing Beacons (RL4)	Fixed Illumination in Rural Areas (RL2)	-

Table 4.9: Potential Countermeasures for Older Driver Crashes That Occurred Between 3:00 p.m. to 8:00 p.m.

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
Larger and More Reflective Regulatory Signs (S1)	Education and Awareness (GP1)	Discounts for Completed Defensive Driving Courses (GP3)
Redundancy and Larger Lettering Size for Street-Name Signage (S2)	Use of Less Than 2.5 Seconds for PRT (I3)	Law Enforcement and Other Judicial Programs (GP7)
Railroad Crossing Signage (S4)	More Overhead-Lighted Signage (S3)	Reduce Glare From Oncoming Headlamps by Increasing Lateral Separation of Opposing Vehicles Through Use of Wide Medians and Independent Alignments (RL1)
Treat Raised Medians With Reflective Markings (P1)	Fixed Illumination in Rural Areas (RL2)	-
More Visible and Durable Pavement Markings (P2)	Raised Pavement Markers (RL6)	-
Warning Signs (RL3)	-	-
Flashing Beacons (RL4)	-	-
Reflective Strips on Stop Sign Posts (RL5)	-	-

4.4 OLDER PEDESTRIAN CRASH COUNTERMEASURES

Following the crash factors presented in Table 4.3, Table 4.10 to Table 4.15 show potential crash countermeasures for fixed-object crashes, rear-end crashes, intersection-related crashes, crashes in which the older driver was speeding too fast for conditions, crashes that occurred on horizontal curves, and crashes that occurred from 3:00 p.m. to 8:00 p.m., respectively. The same procedure for older driver countermeasure selection has been applied to older pedestrian countermeasures.

Table 4.10: Potential Countermeasures for Older Pedestrian Crashes That Occurred in the Dark with No Street Lights

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
	Education and Awareness (GP1)	Bus Shelters and Benches Near Older Communities (OC2)
Warning Signs (RL3)	Lower Speed Limits on Roadways With High Older Pedestrian Volumes (P1)	Protected Pedestrian Phases Near Older Communities (OC3)
Flashing Beacons (RL4)	Increase Visibility of Pedestrians to Drivers (P3)	Move Stop Bars to 15 ft. Before the Intersection at Busy Intersections (OC4)
Reflective Strips on Stop Sign Posts (RL5)	Pedestrians to Self-Report Problems With Pedestrian Infrastructure in Their Community (P5)	Pedestrian Islands in the Median of Wide and Busy Streets (OC5)
Use of In-Pavement Flashing Lights for Pedestrians in Crosswalks (RL7)	Promote Public Transportation Through Educating Older Drivers on How to Use and Offer Door-To-Door Services (OC1)	Bus Bulbs on Wide and Busy Streets (OC6)
Sign-Mounted Flashing Beacons for Pedestrians in Crosswalks (RL8)	More Overhead-Lighted Signage (S3)	Raised Crosswalks and Road Diets Near Older Communities (OC7)
Flashing LED lights Mounted in "Pedestrian Crossing" Warning Signs (RL9)	-	Curb Extensions on Commercial Streets and Bus Routes (OC8)
Pedestrians to Self-Report Problems With Pedestrian Infrastructure in Their Community (P5)	-	-

Table 4.11: Potential Countermeasures for Older Pedestrian Intersection-Related Crashes

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
	Education and Awareness (GP1)	Address Limited or Restricted Sight Distance at Left Turns (I2)
More Visible and Durable Pavement Markings (P2)	Lower Speed Limits on Roadways With High Older Pedestrian Volumes (P1)	Bus Shelters and Benches Near Older Communities (OC2)
Assume Slower Walking Speeds for Pedestrian Intervals (TSO5)	Separate Pedestrians by Time and Space (Utilize Protected or Leading Pedestrian Intervals at Signalized Intersections) (P2)	Protected Pedestrian Phases Near Older Communities (OC3)
Use More than One NO TURN ON RED Sign (I4)	Promote Public Transportation Through Educating Older Drivers on How to Use and Offer Door-To-Door Services (OC1)	Move Stop Bars to 15 ft. Before the Intersection at Busy Intersections (OC4)
Prohibit Right-turn-on-red at Skewed Intersections (I5)	More Overhead-Lighted Signage (S3)	Pedestrian Islands in the Median of Wide and Busy Streets (OC5)
Warning Signs (RL3)	-	Bus Bulbs on Wide and Busy Streets (OC6)
Flashing Beacons (RL4)	-	Raised Crosswalks and Road Diets Near Older Communities (OC7)
Reflective Strips on Stop Sign Posts (RL5)	-	Curb Extensions on Commercial Streets and Bus Routes (OC8)
Use of In-Pavement Flashing Lights for Pedestrians in Crosswalks (RL7)	-	-
Sign-Mounted Flashing Beacons for Pedestrians in Crosswalks (RL8)	-	-
Flashing LED lights Mounted in "Pedestrian Crossing" Warning Signs (RL9)	-	-
Increase Visibility of Pedestrians to Drivers	-	-
Pedestrian Countdown Signals (P3)	-	-
Pedestrians to Self-Report Problems With Pedestrian Infrastructure in Their Community (P5)	-	-

Table 4.12: Potential Countermeasures for Crashes Where Older Pedestrian Was Located in a Crosswalk at an Intersection

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
Increase Visibility of Pedestrians to Drivers (P3)	Education and Awareness (GP1)	Bus Shelters and Benches Near Older Communities (OC2)
Pedestrians to Self-Report Problems With Pedestrian Infrastructure in Their Community (P5)	Promote Public Transportation Through Educating Older Drivers on How to Use and Offer Door-To-Door Services (OC1)	Protected Pedestrian Phases Near Older Communities (OC3)
Use of In-Pavement Flashing Lights for Pedestrians in Crosswalks (RL7)	Lower Speed Limits on Roadways With High Older Pedestrian Volumes (P1)	Move Stop Bars to 15 ft. Before the Intersection at Busy Intersections (OC4)
Sign-Mounted Flashing Beacons for Pedestrians in Crosswalks (RL8)	Pedestrian Countdown Signals (P4)	Pedestrian Islands in the Median of Wide and Busy Streets (OC5)
Flashing LED lights Mounted in "Pedestrian Crossing" Warning Signs (RL9)	Assume Slower Walking Speeds for Pedestrian Intervals (TSO5)	Bus Bulbs on Wide and Busy Streets (OC6)
Warning Signs (RL3)	-	Raised Crosswalks and Road Diets Near Older Communities (OC7)
Flashing Beacons (RL4)	-	Curb Extensions on Commercial Streets and Bus Routes (OC8)
Reflective Strips on Stop Sign Posts (RL5)	-	Separate Pedestrians by Time and Space (Utilize Protected or Leading Pedestrian Intervals at Signalized Intersections) (P2)
Use More than One NO TURN ON RED Sign (I4)	-	-
Prohibit Right-turn-on-red at Skewed Intersections (I5)	-	-

Table 4.13: Potential Countermeasures for Older Pedestrian Crashes on Urban Roadway Classifications

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
Pedestrians to Self-Report Problems With Pedestrian Infrastructure in Their Community (P5)	Education and Awareness (GP1)	Bus Shelters and Benches Near Older Communities (OC2)
Increase Visibility of Pedestrians to Drivers (P3)	Promote Public Transportation Through Educating Older Drivers on How to Use and Offer Door-To-Door Services (OC1)	Protected Pedestrian Phases Near Older Communities (OC3)
Warning Signs (RL3)	Pedestrian Countdown Signals (P4)	Move Stop Bars to 15 ft. Before the Intersection at Busy Intersections (OC4)
Flashing Beacons (RL4)	Lower Speed Limits on Roadways With High Older Pedestrian Volumes (P1)	Pedestrian Islands in the Median of Wide and Busy Streets (OC5)
Reflective Strips on Stop Sign Posts (RL5)	Assume Slower Walking Speeds for Pedestrian Intervals (TSO5)	Bus Bulbs on Wide and Busy Streets (OC6)
Use of In-Pavement Flashing Lights for Pedestrians in Crosswalks (RL7)	-	Raised Crosswalks and Road Diets Near Older Communities (OC7)
Sign-Mounted Flashing Beacons for Pedestrians in Crosswalks (RL8)	-	Curb Extensions on Commercial Streets and Bus Routes (OC8)
Flashing LED lights Mounted in "Pedestrian Crossing" Warning Signs (RL9)	-	Separate Pedestrians by Time and Space (Utilize Protected or Leading Pedestrian Intervals at Signalized Intersections) (P2)
Use More than One NO TURN ON RED Sign (I4)	-	-
Prohibit Right-turn-on-red at Skewed Intersections (I5)	-	-

Table 4.14: Potential Countermeasures for Crashes Where Older Pedestrians Were Illegally in Roadway

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
Warning Signs (RL3)	Education and Awareness (GP1)	Bus Shelters and Benches Near Older Communities (OC2)
Flashing Beacons (RL4)	Promote Public Transportation Through Educating Older Drivers on How to Use and Offer Door-To-Door Services (OC1)	Bus Bulbs on Wide and Busy Streets (OC6)
Improved Island Delineation (P6)	-	Curb Extensions on Commercial Streets and Bus Routes (OC8)

Table 4.15: Potential Countermeasures for Crashes Where Older Pedestrians Were Not Visible

Low Cost or Ready to Implement	Medium Cost or Moderate Time to Implement	High Cost or Substantial Time to Implement
Warning Signs (RL3)	Education and Awareness (GP1)	Bus Shelters and Benches Near Older Communities (OC2)
Flashing Beacons (RL4)	Promote Public Transportation Through Educating Older Drivers on How to Use and Offer Door-To-Door Services (OC1)	Bus Bulbs on Wide and Busy Streets (OC6)
Improved Island Delineation (P6)	-	Curb Extensions on Commercial Streets and Bus Routes (OC8)
Use of In-Pavement Flashing Lights for Pedestrians in Crosswalks (RL7)	-	-
Sign-Mounted Flashing Beacons for Pedestrians in Crosswalks (RL8)	-	-
Flashing LED lights Mounted in "Pedestrian Crossing" Warning Signs (RL9)	-	-
Increase Visibility of Pedestrians to Drivers (P3)	-	-

4.5 SUMMARY

The interim report summarizes potential crash countermeasures for older driver and older pedestrian crashes. This is accomplished by identifying the overrepresented crash factors and factors determined to be important as part of the random forest analysis, then matching these factors to countermeasures identified in the literature.

Upon generating a comprehensive list of potential countermeasures, countermeasures were assigned to one of three distinct categories: low cost or ready to implement, medium cost or moderate time to implement, and high cost or substantial time to implement. Through this process, it was determined that various countermeasures in each category are applicable to each crash factor. For older drivers, warning signs and flashing beacons can serve as viable low cost or ready to implement countermeasures for each of the presented crash factors. For medium cost or moderate time to implement countermeasures, education and awareness can be applied to all crash factors. High cost or substantial time to implement countermeasures include vehicle enhancements (e.g., autonomous vehicles, warning systems, etc.), specific geometric design changes (e.g., changes in receiving lanes, changes in shoulder width, etc.), and policy-related changes (e.g., discounts for defensive driving courses, licensure and testing screening, law enforcement or other judicial programs, etc.).

Regarding older pedestrian crashes, the same is observed. For low cost or ready to implement countermeasures, signage-related countermeasures (e.g., warning signs, flashing beacons, lighted signage, etc.) and pedestrians reporting problems within their communities can be viable options. For medium cost or moderate time to implement countermeasures, education and awareness, signal-related countermeasures (e.g., countdown signals, assume slower walking speeds for older pedestrians, promoting public transportation, and lowering speed limits can be viable options. As for high cost or substantial time to implement countermeasures, viable options include infrastructure changes (e.g., bus shelters and benches, raised crosswalks, bus bulbs. etc.), moving stop bars at intersections, and separating older pedestrians by space and time.

5.0 WORKSHOP FINDINGS

This chapter presents the findings of a workshop conducted by the research team to identify possible opportunities for improving policies and procedures, based on the crash data analysis and review of best practices.

5.1 DESIGN

The objective of the workshop was to bring together the various stakeholders and experts with responsibilities for policy and design guidance that relate to older driver and pedestrian safety; present results of the data analysis, best practices and countermeasures; and identify possible opportunities for improving policies and procedures at ODOT. The input from the participants in the workshop would help guide the recommendations.

In consultation with the ODOT research coordinator and the Technical Advisory Committee (TAC), a list of participants was developed. In addition to the ODOT personnel who were responsible for policy and design guidance pertaining to older driver and pedestrian safety, the research team also invited representatives from counties that were overrepresented in either older driver or older pedestrian crashes (Gilliam, Harney, Lincoln, and Washington), agencies engaged with improving older driver safety (AAA, AARP), and the League of Oregon Counties. A poll was sent to identify a potential date in November 2019 from a list of alternatives. Based on the responses, Tuesday, November 26th, 2019, emerged as the optimal date. The research team sent invitations to the identified participants requesting they confirm their participation. A final list of participants is included in Appendix C.

5.2 IMPLEMENTATION

The workshop occurred between 8:00 a.m. and 1:00 p.m. in Salem, OR, at the ODOT Technical Leadership Center. The participants were carefully assigned to one of four groups by the research team with an attempt to get a mix of perspectives. The agenda for the workshop included a project overview, two breakout sessions, a working lunch, and wrap up and is included in the appendix. The research team presented the project overview, which included information on contributory crash factors, a review of state policies, a review of crash analysis findings, and a list of viable countermeasures. Figure 5.1 shows the workshop participants and the room layout.

The first breakout session following the project overview was on older driver safety issues, and the second breakout session was on older pedestrian safety issues. The structure for both breakout sessions was the same. At each of the four tables, participants were presented with charts showing the extent of the problem along with temporal and spatial characteristics of the older driver and pedestrian fatal and serious injury crashes. A list of countermeasures as identified from the literature and best practices review was included. During each breakout session, the participants at each table engaged in three group activities.

Figure 5.1: Workshop layout

The first activity was to document important patterns in older driver/pedestrian crash data. During this activity, participants at each table independently reviewed crash data information sheets and documented the patterns that seemed notable. Next, participants discussed with their groups the crash trends/overrepresentations that they individually identified as unexpected or expected and speculated on the causation. The participants then identified the most important trend/overrepresentations from each table's perspective and recorded them on the response sheet provided.

For the second activity, participants were asked to imagine that they were either the Governor or ODOT Director for a day and, ignoring cost and feasibility, brainstorm the changes that they would make to improve older driver/pedestrian safety. The research team provided the participants with a list of categories to aid the brainstorming process. These categories included licensing and assessment, education and awareness, intersections, roadway design and signing, roadway lighting, and aging in place. Participants were then asked in their designated groups to discuss their proposed solutions and determine if there were any shared ideas. Those shared ideas were documented on the data sheet at each table. Figure 5.2 shows a picture of the workshop participants engaged in brainstorming ideas at their table groups.

Figure 5.2: Workshop participants engaged in brainstorming solutions

For the final activity in the breakout session, participants individually reviewed the countermeasure list using their own expertise to highlight the countermeasures that would be implementable as a systemic treatment, through policy changes, or design guidance. Finally, the participants discussed systemic actions or changes to specific design standards or policies, and documented these using the data sheets provided at each table.

One member of the research team joined each table to observe the activities and take notes on the discussion. Following the two breakout sessions on older driver and pedestrian safety issues, while the participants ate lunch members of the research team synthesized findings from each table pertaining to older driver and pedestrian crash trends and brainstorming solutions. These results were presented back to the participants. Based on the feedback obtained regarding proposed solutions from the participants, the research team created posters with the proposed solutions aggregated by category. Participants were then asked to use colored post-it notes to rank their top three countermeasures, as shown in Figure 5.3.

Figure 5.3: Ranking of countermeasures

The workshop wrapped up following the ranking of the countermeasures by the participants and a quick review of the observations from each table on the older driver and pedestrian crash trends and brainstorming solutions. The following section describes the findings from the workshop in detail.

5.3 FINDINGS

As stated previously, workshop participants were tasked with three activities, each to be completed and documented by the four teams. Workshop findings are presented by activity and table, followed by a summary of responses that were consistent among groups.

5.3.1 Activity 1: Documenting Important Patterns in the Crash Data

The first activity involved each table documenting important patterns in the crash data materials provided to each group. The crash data materials included tables and plots pulled from the data analysis chapter of this report. Specifically, each table was directed to *"Discuss the crash trend/overrepresentation you identified as unexpected or expected. Take notes on your observations and feel free to speculate on causation."* Additionally, Activity 1 asked each table to *“Identify the most important trend/overrepresentations from the perspective of your table. Make brief notes on the response sheet for your table.”* This process was completed by each table for both older driver and older pedestrian crash data.

5.3.1.1 Older Drivers

A summary of Activity 1 for older drivers is shown in Table 5.1 and Table 5.2. In terms of expected or unexpected crash trends, and potential causation, the two most commonly identified trends by participants were: (1) rural arterials, rural classifications, and all arterials, and (2) intersection-related crashes (a summary of addition crash factors that were identified by participants is shown in Table 5.3). Workshop participants speculated on potential causation for crashes that occurred on rural arterials, rural classifications, and all arterials, including the following: higher speeds and traffic volumes, older drivers not doing well with conflicts on these classifications, more decisions to be made at higher speeds, not maintaining lane position, hitting objects, and being unfamiliar with the roadway. Likewise, workshop participants speculated on potential causation for intersection-related crashes, which included the following: increased complexity and visual demands, right-of-way complexity, speed measurement, and gap measurement. A summary of potential causations for these crash factors is presented in Table 5.4. One group posed questions to be considered for future research such as at-fault older drivers and rear-end crashes, and the correlation between older driver-at-fault crashes and crash type.

Table 5.1: Summary of Activity 1 for Older Drivers (Part A: Unexpected or Expected Crash Trends and Potential Causation)

Table 1	
Crash Trend	**Potential Causation**
Daytime Hours	Drivers May be Avoiding Nighttime Travel
Rural Arterials	Linked to Fixed-Object Collisions
Intersections	Complexity and Visual Demands
Table 2	
Crash Trend	**Potential Causation**
Straight Roadway Segments, Fixed-Object Crashes, Single-Vehicle Crashes	May be Correlated
Principal Arterials	Higher Speeds and Traffic Volumes
Daytime Hours	Lunch, Other Activities, etc.
Intersections	Select Gaps, Right-of-Way Complexity, Measuring Speed, Measuring Gaps
Table 3	
Crash Trend	**Potential Causation**
Not Yielding Right-of-Way	Inability to Just Distance
Comments	
Are Older Drivers More At-Fault for Rear-End Crashes?	
What is Correlation Between Driver-at-Fault and Crash Type?	
Expected Older Drivers and Younger Drivers to Have Similar Trends Regarding Following Too Close (Linked to PRT)	
Table 4	
Crash Trend	**Potential Causation**
Not Yielding Right-of-Way	-
Intersections	-
Physical Illness	-
Rural Arterials, All Arterials	Do Not Do Well With Conflicts, Higher Speeds With More Decisions to be Made

Table 5.2: Summary of Activity 1 for Older Drivers (Part B: Most Important Trend/Overrepresentation in the Crash Data)

Table 1	
Crash Trend	**Comments**
Intersections	-
Turning Movement Crashes	-
Rural Arterials	-
Table 3	
Crash Trend	**Comments**
Daytime Hours	Defensive Driving
Dry Surface Conditions	Likely Live in More Urban Areas Where Drivers are Close to Necessary Services
Weekdays	-
Table 4	
Crash Trend	**Comments**
Rural Classifications	Not Maintaining Lane, Hitting Objects, Unfamiliar With Roadway
Urban Classifications	Decision Making on Higher Speed Roadways With Intersections
US-101	-
Additional Comments	
Appear to be Having Problems With Decisions and Reaction Time, Including Going Into Autopilot	

Table 5.3: Most Selected Important Crash Trends

Crash Trend	Times Selected
Rural Arterials, Rural Classifications, or All Arterials	5
Intersections	4
Daytime Hours	3
Not Yielding Right-of-Way	2

Table 5.4: Potential Causation of Most Selected Crash Trends

Crash Trend	Potential Causation
Rural Arterials, Rural Classifications, All Arterials	• Higher Speeds and Traffic Volumes • Do Not Do Well With Conflicts • Higher Speeds With More Decisions to Make • Not Maintaining Lane • Hitting Objects • Unfamiliar With Roadway
Intersections	• Increased Complexity and Visual Demands • Gap Selection and Measurement • Right-of-Way Complexity • Speed Measurement

5.3.1.2 Older Pedestrians

A summary of Activity 1 for older drivers is shown in Table 5.5. As Part B of Activity 1 (defined in Table 5.2), just one table completed and identified lighting and crossing while not in the intersection. In terms of expected or unexpected crash trends, and potential causation, three trends were identified most often: (1) crossing between intersections, (2) daylight, and (3) urban areas. Workshop participants speculated on potential causation for crashes in which older pedestrians were crossing between intersections, including the following: jaywalking, crossing with no signal, and harder to estimate speed and gaps. Likewise, workshop participants speculated on potential causation for older pedestrian crashes that occurred on urban classifications; specifically, pedestrians may be crossing parallel to the mainline. As with the older drivers, one table posed questions to be considered for future research, such as at-fault older pedestrian crashes being a result of low enforcement, if rural facility crashes are related to older pedestrians checking their mail, and if there is any correlation between homeless and older pedestrians.

Table 5.5: Summary of Activity 1 for Older Pedestrians (Part A: Unexpected or Expected Crash Trends and Potential Causation)

Table 1	
Crash Trend	**Potential Causation**
Not in Intersection	-
Daylight	-
Rural Major Collectors	Too Far Between Road Crossings
Table 2	
Crash Trend	**Potential Causation**
Crossing Between Intersections	Jaywalking, Crossing With No Signal, Harder to Estimate Speed and Gaps
Daylight	-
3:00 p.m. to 6:00 p.m. and 6:00 p.m. to 9:00 p.m.	-
Table 3	
Crash Trend	**Potential Causation**
Urban Classifications	-
Crossing Between Intersections	How Close to Intersection Are These Locations?
Comments	
Is Not At-Fault Due to Low Enforcement?	
Gender Split is Surprising, Expected an Equal Split	
Are Rural Facility Crashes Due to Older Pedestrians Checking Their Mail?	
What Does "Not in Roadway" Mean?	
Homeless vs. Older Pedestrians, is There Any Correlation?	
Table 4	
Crash Trend	**Potential Causation**
At Intersection, Not in Roadway	-
Crossing at Intersection With No Signal	Difficult Task for All Pedestrians
Urban Areas and Tourist Areas	Pedestrians Crossing Parallel to Mainline

5.3.2 Activity 2: Brainstorming Solutions

The second activity consisted of each table brainstorming potential solutions based on the identified crash trends in Activity 1. Specifically, each table was directed to *"As a table, discuss your proposed solutions. Determine if there are any shared ideas. Make brief notes on the datasheet for your table."* This process was completed by each table for both older drivers and older pedestrians.

5.3.2.1 Older Drivers

A summary of Activity 2 for older drivers appears in Table 5.7. Table 5.7 presents both proposed solutions and specific comments, when provided, regarding the proposed solution. Of the various solutions proposed, two solutions were proposed by at least three of the groups, with one solution recommended by each group (a summary of the most selected solutions is shown in Table 5.6). The solution proposed by each group is related to older drivers' license testing and renewal. The group table proposed shorter renewal periods, accompanied by driver tests, with the driver tests being different by age group. This group also proposed cognitive tests for older drivers. The second group proposed retesting to judge driver ability; however, no additional comments were received. The third group proposed improvements to existing driver tests, including improvements to the written test, driving test, and vision test. This group also suggested administering perception-reaction-time tests. The final table simply proposed that a driving test be required every two years.

The first solution proposed by at least three groups is related to public transit. The first group proposed a shift to public transit, but no additional comments were provided. The second group suggested that there be more transit options in rural areas, where the focus of additional transit options should be on arterials from 9:00 a.m. to 6:00 p.m. Monday through Friday. The third group to propose a transit-based solution suggested free door-to-door transit options. The second solution proposed by at least three groups is the installation of rumble strips. No additional comments were provided regarding rumble strips; however, one group posed a question regarding the effects of rumble strips on older drivers.

Table 5.6: Most Frequent Proposed Solutions for Older Drivers

Proposed Solution	Groups Selected
Driver Testing, License Renewal, etc.	4
Public Transit	3
Rumble Strips	3
Roundabouts	2
More Protected Turning at Signalized Intersections	2

Table 5.7: Proposed Solutions for Older Drivers Based on Important Crash Trends Identified in Activity 1

Table 1	
Proposed Solutions	**Comments**
Education in High Risk Areas, to Specific Areas (Urban, Rural, etc.), and to Tourists	-
Shift to Public Transit	-
Ride Sharing (e.g., Uber)	-
Intersection Standardization	-
Shorter Renewal Period and Testing	Different Tests for Different Age Groups, Cognitive Tests
Sight Improvement at Intersections	-
Rumble Strips	-
Table 2	
Proposed Solutions	**Comments**
Simplification	Remove Conflicts, Make Intersections Easier, etc.
Install Lighting on All Roadways	-
Replace Traditional Intersections With Roundabouts	-
Reduce the Number of Signs	-
Retesting to Judge Driving Ability	-
Education	-
Lower Speeds	-
Signal Timing	More Leeway, More Time
Road Diets	-
Vehicle Design	Better Visibility, Better Safety Features
Vehicle Inspections	Headlight Brightness, etc.
Incentives to Get Safer Vehicles	-
Wider Shoulders to Create More "Recovery" Area	-
Rumble Strips	-
Headlight Technology	-
Table 3	
Proposed Solutions	**Comments**
More Transit Options in Rural Areas	Focus on Arterials from 9 a.m. to 6 p.m., Monday to Friday
More Roundabouts as Preferred Traffic Control	Required Training

Table 5.7: Continued

Improved Delineation With a Focus on All Weather Visibility Conditions (6-inch Strips)	High Cost and Requires Staff to Maintain
Enhance Enforcement Everywhere	Focus on Speeding and Aggressive Turning
Left-Turn Pockets and Offsets at Rural Intersections	-
Automatic Light Dimmers in Vehicle	Particularly in Rural Areas
Adjust Lighting in Transition Areas so That it Takes Less Time for Eyes to Adjust	-
Declutter Signage and Improve Traffic Control Device Maintenance	-
More Protected Turning at Signalized Intersections	Time of Day Restrictions on Permissive Left-Turns (Allow Only During Off Peak Hours), Lane Designation Arrows
Improve Access Control to Minimize Conflict Points	Focus on Driveway Density
Driver Testing Improvements	Written Test, Driving Test, PRT Tests, and Vision Tests
Table Ranking Proposed Solutions	
Ranking	**Solution**
1	Enforcement and Education
2	Maintenance Activity to Improve Delineation Signs
3	Intersection Treatments
4	Access Management (Driveway Density)
5	Access to Alternate Modes of Transportation
Table 4	
Proposed Solutions	**Comments**
Door-to-Door Transit	Make Free
Drive Test Every Two Years	-
Spread Out Decision Points	Intersection/Interchange Spacing, Arterial Intersection Only Every Half Mile
Big Signs, Large Fonts	Clear Messaging with an Arrow Per Lane
Protected-Only Signal Phasing	-
In-Vehicle Monitoring/Automated Vehicle Technology	-
Pavement Markings, Signs, Backplates, etc.	-
Rumble Strips	-
Invest on US-101, OR-18, and OR-22 to Lincoln County	Lifeline High-Capacity Facility, Shoulders, Roadside Guide, Clear Zones, Limited Access, Grade Separation

5.3.2.2 Older Pedestrians

A summary of Activity 2 for older pedestrians is shown in Table 5.9. Table 5.9 presents both proposed solutions and specific comments, when provided, regarding the proposed solution. Of the various solutions proposed, four solutions were proposed by at least three groups (a summary of the most selected solutions is shown in Table 5.8). The first solution proposed by three groups is access management and/or driveway spacing. One group proposed, specifically, access management with a focus on reducing driveway density. The remaining two groups that proposed access management and/or driveway spacing as a solution did not provide additional comments. However, one group proposed removing driveways from T-intersections.

The second solution proposed by three groups was crosswalk spacing. The second group proposed an “adequate” crosswalk spacing, each with additional protection (e.g., RRFBs, signals, etc.). The third group proposed an increase in marked or enhanced crosswalk spacing but did not provide additional comments. The final group proposed crosswalk spacing frequency, with an emphasis on spacing at consistent, safe intervals.

The third solution proposed by three groups is related to lighting/visibility at intersections. The first group proposed higher visibility for pedestrians at intersections (this group also proposed wider waiting areas on the curb and better sightlines). The second group also proposed additional lighting but did not provide additional comments. The third group proposed improved intersection lighting with the premise of increasing driver expectation of encountering pedestrians. This table also proposed improved lighting at midblock crossings and along the roadway.

The final solution proposed by three groups was crossing visibility. The first group recommended improved crossing visibility, where the focus should be on rural arterials. The second group proposed a requirement that an unspecified percentage of reflective clothing be worn to increase pedestrian visibility while crossing. The third group suggested improving crossing visibility through the addition of lit signage, flashing signals (e.g., RRFBs), and maintaining reflective striping.

Table 5.8: Most Frequent Proposed Solutions for Older Pedestrians

Proposed Solution	Groups Selected
Access Management, Driveway Spacing	3
Crosswalk Spacing	3
Lighting/Visibility at Intersections	3
Crossing Visibility	3
Turn Restrictions	2

Table 5.9: Proposed Solutions for Older Pedestrians Based on Important Crash Trends Identified in Activity 1

Table 1	
Proposed Solutions	**Comments**
Geofencing	-
Improved Crossing Opportunities and Visibility	Specific to Rural Arterials
Center Medians on Wide Streets With Improved Reflectors	-
Intersection Signal Timing	-
Sidewalks Need More Friendly Intersections	Specific to US-101
Driver Education	Focus on Pedestrian Safety and Driver Maneuvers
Intersection	Wider Waiting Areas for Pedestrians, Higher Visibility for Pedestrians, Better Sight Lines, Standardized Crossings
Improved Transit	Walk Shorter Distances, Ride Opportunities, TNC Services, Tourist Friendly, Mitigate Barriers to Ride Public Transit
Table 2	
Proposed Solutions	**Comments**
Lighting	-
Reduce Speed	-
Driveway Spacing	-
Signal Timing	More Time for Pedestrians to Cross
Bus Stop Placement	-
Adequate Crosswalk Spacing With Protection	RRFBs, Signals, etc.
Decrease Exposure at Crosswalks	Shorten Crossing Length
Buffer Between Sidewalk and Roadway	-
Require a Specific Percentage of Reflective Clothing to Worn	
Detect Pedestrians in Crosswalk to Extend Time	Needed Technology to Implement
Roundabouts	-
Table 3	
Proposed Solutions	**Comments**
Increase Enforcement	-
Improve Intersection Lighting, Lighting Along Roadway, and Lighting at Midblock Crossings	Increase Expectation of Encountering Pedestrians

Table 5.9: Continued

Improve Turning Radii and Curb Extensions/Median Islands to Shorten Crossing Length	-
Increase Pedestrian Walking Assumptions at Signalized Intersections	-
Lead Pedestrian Interval and no Pedestrian Flashing Yellow	-
RTOR Restrictions Where High Frequency of Crashes Exist	-
Access Management	Primary Focus is to Reduce Driveway Density
Increase Marked or Enhanced Crosswalk Spacing	-
Improve Crossing Visibility, Such as Signage, "Flashy Things,", and Maintaining Striping	More Maintenance Funding Required
Focus Improvements in Communities With Higher Percentage of Older or Retired Households	-
	Table 4
Proposed Solutions	**Comments**
Eliminate Driveways at T-Intersections	-
Better Access Management Regarding Driveways and Intersections	-
Crosswalk Spacing Frequency	Space at Consistent, Safe Intervals
Shorten Crosswalk Spacing	-
Require Right-Turn Signal	-
More Transit Options, Including Automated Vehicles	-
Eliminate Free Flow Turns or Prohibit Right-Turn Slip Lanes	-
Fully Implement Pedestrian Countdown Signals Statewide	-
Focus on Urban Areas and US-101	-
Promote Slower Speeds	-

5.3.3 Activity 3: Identify Potential Systemic, Policy, or Design High-Value Solutions

The third activity, also the primary focus during the latter half of the workshop, was focused on identifying potential systemic, policy, or design high-value solutions. Each table was directed to *"As a table, discuss and identify possible systemic actions (regular implementation of treatments to workflows) or changes to design standards or policies. Please identify specific design standards or policies. Make brief notes on the datasheet for your table. These ideas will be summarized and synthesized for the wrap-up."* Once more, this activity was completed for both older drivers and older pedestrians.

For Activity 3, group data sheets were summarized and presented to the workshop participants. Workshop participants were given three votes each and asked to vote on the potential systemic, policy, or design high-value solutions. Each attendee had a top priority vote, a second priority vote, and a third priority vote. At the conclusion of the workshop, votes were counted, and potential solutions were prioritized. In addition, each group was asked to specify an agency reference (e.g., design guidelines, etc.), if available, where the proposed solutions might be applied.

5.3.3.1 Older Drivers

Upon compiling the data sheets, potentially high-value systemic, policy, or design solutions for older drivers were assigned to seven categories:

1. Intersection-related
2. Licensing and assessments
3. Education and awareness
4. Roadway design
5. Roadway lighting
6. Aging in place
7. Other

A summary of potential solutions for older drivers, and votes by priority, appears in Table 5.10. Referring to Table 5.10, the solution with the highest number of votes was an Intersection Control Evaluation Policy. This solution received 12 total votes, including nine top priority votes. Shorter renewal periods for driver licensing also had a higher number of top priority votes, relative to other solutions (four votes), age-specific driver assessments (four votes), and increased enforcement (four votes).

In terms of second priority, two solutions received a higher number of votes. The first of these solutions, with four second priority votes, was roadway design improvements (e.g., road diets, rumble strips, etc.). Also receiving four second-priority votes was increased enforcement. With three second-priority votes was alternative treatment types at intersections, education on alternate modes of transportation (e.g., ride-sharing, public transit, etc.), and access to multiple modes of transportation.

Lastly, in terms of third-priority votes, there were three solutions that received at least three votes. Age-specific driver assessments received five third-priority votes and were the highest number of third-priority votes. Two additional notable third-priority solutions based on votes (each with three votes) was an education on alternate modes of transportation (e.g., ride-sharing, public transit, etc.) and roadway design improvements (e.g., road diets, rumble strips, etc.).

Additionally, as stated previously, groups were asked to specify references to the proposed solutions when applicable. For older driver solutions, the following references were specified by workshop participants:

- Oregon Transportation Safety Action Plan (TSAP)[6]
- Oregon Transportation Plan (OTP)[7]
- Oregon Highway Plan (OHP)[2]
- Oregon Highway Design Manual (HDM)[8]
- Oregon Analysis Procedures Manual (APM)[9]

[6] The TSAP and related documents can be viewed here: https://www.oregon.gov/ODOT/Safety/Pages/TSAP.aspx
[7] The OPT, OHP, and related documents can be viewed here: https://www.oregon.gov/odot/planning/pages/plans.aspx
[8] The HDM and related documents can be viewed here: https://www.oregon.gov/ODOT/Engineering/Pages/Hwy-Design-Manual.aspx
[9] The APM and related documents can be viewed here: https://www.oregon.gov/ODOT/Planning/Pages/APM.aspx

Table 5.10: Potential Solutions for Older Drivers by Priority

Solution	Top Priority	Second Priority	Third Priority
Intersections			
Alternative Treatment Types	2	3	1
Criteria for Left-Turn Queueing	0	0	0
Rural Intersection Criteria for Right-Turn Offsets	0	0	2
Intersection Control Evaluation Policy (ICE)	9	2	1
Licensing and Assessments			
Shorter Renewal Periods	4	1	1
Cognitive Testing for Older Drivers in DMV Offices	1	0	1
Age-Specific Driver Assessment	4	2	5
Online Testing with Video	0	0	2
Education and Awareness			
Education on Alternate Options (e.g., Ride Sharing, Public Transit, etc.)	1	3	3
Older Driver Safety Awareness Week	0	0	2
Notify Older Drivers of High-Risk Areas	0	0	1
Specific Instructions for Specific Areas	0	0	0
Roadway Design			
Bigger Signs and Fonts	1	1	2
Wider Pavement Markings	1	0	2
Design Improvements (e.g., Road Diets, Rumble Strips, etc.)	3	4	3
Install and Maintain Delineator Reflectors	1	1	1
Roadway Lighting			
Transitional Lighting on Intersection Approach	3	1	0
Aging-in-Place			
Access to Alternate Modes of Transportation	3	3	2
Other			
Increased Enforcement	4	4	1
Incentives for Safer Vehicles Along With Vehicle Inspections	0	2	0
Connected or Automated Vehicles, Access to Their Technology	1	2	2

* Value in green indicate countermeasures with the highest number of top priority votes
* Value in yellow indicate countermeasures with the highest number of second priority votes
* Value in orange indicate countermeasures with the highest number of third priority votes

5.3.3.2 Older Pedestrians

Upon compiling the data sheets, potentially high-value systemic, policy, or design solutions for older pedestrians were assigned to five specific categories:

1. Intersection-related
2. Education
3. Roadway lighting
4. Roadway design
5. Other

A summary of potential solutions for older drivers, and votes by priority, is shown in Table 5.11. Referring to Table 5.11, five solutions received at least two top-priority votes, where four of these received three top-priority votes. These solutions included the increased use of protected left turns (eliminate permissive movements), illumination to increase pedestrian visibility, and eliminating driveway access near intersections. The solutions with two top priority votes included shorter crossing distances/curb extensions/medians and lower speed limits.

In terms of second-priority votes, four solutions received more votes compared to others. The solution with the highest number of second-priority votes was shorter crossing distances/curb extensions/medians (received six votes). The remaining solutions each received four second-priority votes, including adequate pedestrian crossings at regular intervals, illumination to increase pedestrian visibility, and eliminating free-flow turn and right-turn slip lanes.

Lastly, in terms of third-priority votes, three solutions received more votes compared to others. In addition, each of these solutions belong to the intersection-related category. Of these, shorter crossing distances/curb extensions/medians received six votes, and increasing the use of protected left turns (eliminating permissive movements) and adequate pedestrian crossings at regular intervals received three votes.

Additionally, as stated previously, groups were asked to specify references to the proposed solutions when applicable. For older pedestrian solutions, a reference was specified by workshop participants:

- Blueprint for Urban Design: ODOT's Approach for Design in Oregon Communities[10,11]

[10] Vol. 1 can be viewed here: https://www.oregon.gov/ODOT/Engineering/Documents_RoadwayEng/Blueprint-for-Urban-Design_v1.pdf
[11] Vol. 2 can be viewed here: https://www.oregon.gov/ODOT/Engineering/Documents_RoadwayEng/Blueprint-for-Urban-Design_v2.pdf

Table 5.11: Potential Solutions for Older Pedestrians by Priority

Solution	Top Priority	Second Priority	Third Priority
Intersections			
Extended Crossing Times	0	1	1
Shorter Crossing Distances/Curb Extensions/Medians	2	1	6
Adequate Pedestrian Crossing at Regular Intervals	1	4	3
Increased Use of Protected Left Turns (Eliminate Permissive Movements)	3	6	5
Mid-Block Crossings	0	0	0
Education			
Educate on Crosswalk Use	0	0	1
Roadway Lighting			
Illumination to Increase Pedestrian Visibility	3	4	1
Roadway Design			
Lower Speeds	2	2	2
Grade Separate at Intersections	0	0	0
Eliminate Free Flow Turns and Right-Turn Slip Lanes	0	4	0
Eliminate Driveway Access in Close Proximity to Intersections	3	2	0
Make Pedestrian Safety More of a Priority	1	1	0
Other			
Better Transit Route and Stops	1	1	2
Reduce Barriers to Obtaining Rides	1	0	2

* Value in green indicate countermeasures with the highest number of top priority votes
* Value in yellow indicate countermeasures with the highest number of second priority votes
* Value in orange indicate countermeasures with the highest number of third priority votes

5.4 SUMMARY

A one-day workshop was held with various stakeholders and experts. Workshop participants were distributed among four groups, each at their own table, and asked to take part in three activities related to older driver and pedestrian safety. The three activities were based on findings from extensive crash data analysis that focused solely on older drivers and pedestrians. To ensure ample time was allocated to both older drivers and pedestrians, the workshop consisted of two breakout sessions in which the three activities were completed once for drivers and once for pedestrians.

Through Activity 1, workshop participants identified expected or unexpected crash trends and the most important crash trends. Regarding older drivers, the consensus among the majority of groups was that rural arterials (rural classifications and all arterials as well) and intersection-related crashes showed the most important crash trends. In this activity, workshop participants were also asked to speculate on causation. For rural arterials, the most common causal factors were suggested to be higher speed limits and traffic volumes, while for intersection-related crashes, speculated causation was most often related to complexity (e.g., visual, right-of-way, etc.). As for older pedestrians, the important crash trends were identified as crossing between intersections, daylight conditions, and urban areas/roadway classifications. In terms of potential causation, jaywalking, crossing with no signal, and crossing parallel to the mainline were speculated.

In Activity 2, workshop participants were asked to brainstorm solutions based on the identified crash trends as part of Activity 1. One solution was proposed by each group at the workshop: solutions related to driver testing and license renewal. This included shorter renewal periods that are accompanied by a driving test and cognitive test, different driver tests by age group, retesting drivers, improvements to the existing tests, the addition of a perception-reaction-time test, and a policy that requires older drivers to be tested every two years. For older pedestrians, there were four solutions proposed by three of the four groups. These solutions included improvements to access management (primarily a reduction in driveway density), crosswalk spacing, improved lighting/visibility at intersections, and crossing visibility.

In the final activity, Activity 3, workshop participants were given three votes, one vote for a top-priority solution, one vote for a second-priority solution, and one vote for a third-priority solution. For older-driver solutions, a proposed Intersection Control Evaluation Policy received the highest number of top-priority votes, roadway design improvements (e.g., road diets, rumble strips, etc.) and increased enforcement received the highest number of second-priority votes, and age-specific driver assessments received the highest number of third-priority votes. Turning to older-pedestrian solutions, increased use of protected left turns (eliminate all permissive movements), illumination to increase pedestrian visibility, and eliminating driveway access near intersections received the highest number of top-priority votes. Pertaining to second-priority votes and third-priority votes, increased use of protected left turns (eliminate all permissive movements) and shorter crossing distances/curb extensions/medians received the highest number of votes, respectively.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The objective of this research was to identify strategies for inclusion in the next State Strategic Highway Safety Plan (SHSP) update to address older driver and pedestrian safety issues. This research was triggered by the Special Rule for Older Drivers and Pedestrians (SRODP) in the "Fixing America's Surface Transportation (FAST)" Act. To accomplish these objectives, the research team followed a robust research plan. First, a review of published literature was conducted with a focus on older driver and pedestrian safety (design manuals, guidance documents). The review of the literature found that left turns at intersections, situations that require complex visual searches, and rural roadways pose a higher crash risk for older drivers. Additionally, a review of state policies found varying requirements in states for driver's license renewals, with a few states requiring more frequent renewals, vision screening, and in-person renewals for older drivers. Next, four years of fatal and serious injury crash data for older driver and pedestrian crashes were analyzed to determine trends and factors resulting in fatal and serious injury crashes. Random forest analyses were conducted to determine significant factors that can predict older driver and pedestrian fatal and serious injury crashes. A population-based crash rate analysis was also conducted to determine the counties that were overrepresented in pedestrian and driver fatal and serious injury crashes. Using the crash factors that were significant, a list of countermeasures was developed. Crash factors were matched to potential countermeasures based on cost and anticipated implementation duration. Finally, a workshop was conducted with key stakeholders and experts who are responsible for policy and design guidance to identify opportunities for improving policies and procedures at ODOT to increase older driver and pedestrian safety.

The following sections summarize the results of these tasks and are followed by recommendations for practice.

6.1 CRASH DATA ANALYSIS

A series of analyses were conducted on older driver and pedestrian fatal and serious injury crashes using four years of self- and police-reported Oregon crash data. Analyses included descriptive statistics with crash frequencies, a comparison of crash frequencies to other age groups, a proportions test to determine significant differences in crash proportions among age groups, a random forest analysis to determine variable importance on predicting older driver and pedestrian, and a population-based spatial analysis with a crash rate per population. From 2013 to 2016, Oregon crash data records indicate that 884 older driver and 112 older pedestrian fatal and serious injury crashes occurred.

Analysis of the raw crash frequencies indicated that older driver fatal and serious injury crashes most often occurred between 3:00 p.m. to 5:59 p.m., on Mondays, and on rural principal arterials. Further, the majority of older driver fatal and serious injury crashes occurred at an intersection, while the most frequently occurring collision types were fixed-object and turning-movement crashes. Nearly 75% of older driver fatal and serious injury crashes occurred within

20 miles of the driver's home. Lastly, the most frequently occurring driver-level crash causes were determined to be no cause (i.e., not at fault), not yielding the right-of-way, and speeding too fast for conditions.

For older pedestrian fatal and serious injury crashes, the time period between 3:00 p.m. to 5:59 p.m. also accounted for the most crashes. The majority of older pedestrian fatal and serious injury crashes differed from driver crashes, and crashes occurred on Friday. Similar to older driver fatal and serious injury crashes, the largest percentage of older pedestrian fatal and serious injury crashes occurred at an intersection. Crossing between intersections was the pedestrian action that accounted for the most crashes, along with crossing at an intersection without a traffic signal. In terms of location, pedestrians who were in the crosswalk at an intersection and pedestrians who were in the roadway accounted for more than 65% of older pedestrian fatal and serious injury crashes. The leading crash causes at the pedestrian level were no-cause associated (i.e., not at fault), the pedestrian being illegally in the roadway, and the pedestrian not being visible (e.g., they were wearing dark or non-reflection clothing). Lastly, the majority of vehicle movements associated with pedestrian crashes were straight and turning left or right.

Through a series of proportions tests, it was found that older driver and pedestrian crash proportions were statistically different for various crash characteristics, such as time of day, day of the week, roadway classification, and participant-level crash cause. Important variables were identified based on a mean decrease in accuracy and mean decrease in the Gini Index. For older driver fatal and serious injury crashes, important variables included single-vehicle crashes, fixed-object crashes, speeding too fast for conditions, head-on collisions, and male drivers. For older pedestrian fatal and serious injury crashes, important variables included dark conditions with no street lighting, pedestrians being in a crosswalk at an intersection, cloudy weather conditions, and urban roadway classifications.

The final analysis conducted was a population-based crash rate analysis. It was determined that older driver fatal and serious injury crashes have a higher rate compared to other age groups in Harney County. For the older pedestrian crash rate, older pedestrians have the highest rate in six counties: Baker, Morrow, Curry, Hood River, Umatilla, and Washington counties.

6.2 COUNTERMEASURE SELECTION

Potential crash countermeasures for older drivers and older pedestrian crashes were determined by first identifying the overrepresented crash factors and factors determined to be important as part of the random forest analysis, and then matching these factors to countermeasures identified in the literature.

Upon generating a comprehensive list of potential countermeasures, countermeasures were assigned to one of three distinct categories: low cost or ready to implement, medium cost or moderate time to implement, and high cost or substantial time to implement. For older drivers, warning signs and flashing beacons can serve as viable low cost or ready to implement countermeasures for each of the presented crash factors. For medium cost or moderate time to implement countermeasures, education and awareness can be applied to all crash factors. High cost or substantial time to implement countermeasures include vehicle enhancements (e.g., autonomous vehicles, warning systems, etc.); specific geometric design changes (e.g., changes in receiving lanes, changes in shoulder width, etc.); and policy-related changes (e.g., discounts for defensive driving courses, licensure, and testing screening, law enforcement or other judicial programs, etc.).

For older pedestrian crashes, the same is observed. For low cost or ready to implement countermeasures, signage-related countermeasures (e.g., warning signs, flashing beacons, lighted signage, etc.) and pedestrians reporting problems within their communities can be viable options. For medium cost or moderate time to implement countermeasures, education and awareness, signal-related countermeasures (e.g., countdown signals, assume slower walking speeds for older pedestrians, promoting public transportation, and lowering speed limits) can be viable options. As for high cost or substantial time to implement countermeasures, viable options include infrastructure changes (e.g., bus shelter and benches, raised crosswalks, bus bulbs. etc.), moving stop lines at intersections, and separating older pedestrians by space and time.

6.3 WORKSHOP

A one-day workshop was held with various stakeholders and experts to identify important crash trends and propose potential solutions regarding older driver and pedestrian safety. Workshop participants were distributed among four groups with five to six at a table and asked to take part in three activities related to older driver and pedestrian safety. The three activities were based on findings from extensive crash data analysis that focused solely on older drivers and pedestrians. The workshop consisted of two breakout sessions in which the three activities were completed once for drivers and once for pedestrians.

Through the first activity, workshop participants identified expected or unexpected crash trends and the most important crash trends. Regarding older drivers, the consensus among the majority of groups was that rural arterials (rural classifications and all arterials as well) and intersection-related crashes showed the most important crash trends. During this activity, workshop participants were also asked to speculate on causation. For rural arterials, the most common suggested causal factors were higher speed limits and traffic volumes, while for intersection-related crashes, speculated causation was most often related to complexity (e.g., visual, right-of-way). As for older pedestrians, the important crash trends were identified as crossing between intersections, daylight conditions, and urban areas/roadway classifications. In terms of potential causation, jaywalking, crossing with no signal, and crossing parallel to the mainline were proposed.

During the second activity, workshop participants were asked to brainstorm solutions based on the identified crash trends as part of Activity 1. One solution commonly proposed by each workshop group focused on solutions related to driver testing and license renewal. This included shorter renewal periods that are accompanied by a driving test and cognitive test, different driver tests by age group, retesting drivers, improvements to the existing tests, the addition of a perception-reaction-time test, and a policy that requires older drivers to be tested every two years. For older pedestrians, there were four solutions proposed by three of the four workshop groups. These solutions included improvements to access management (primarily a reduction in driveway density), crosswalk spacing, improved lighting/visibility at intersections, and crossing visibility. In the final activity, workshop participants were asked to submit three votes, one vote for a top-priority solution, one vote for a second-priority solution, and one vote for a third-priority solution. For older driver solutions, a proposed Intersection Control Evaluation Policy received the highest number of top-priority votes, roadway design improvements (e.g., road diets, rumble strips, etc.) and increased enforcement received the highest number of second-priority votes, and age-specific driver assessments received the highest number of third-priority votes. For older pedestrian solutions, increased use of protected left turns (eliminate all permissive movements), illumination to increase pedestrian visibility, and eliminating driveway access in close proximity to intersections received the highest number of top-priority votes. Pertaining to second- and third-priority votes, increased use of protected left turns (eliminate all permissive movements) and shorter crossing distances/curb extensions/medians received the highest number of votes, respectively.

6.4 RECOMMENDATIONS FOR PRACTICE

Based on the findings of this research, the following recommendations separated by older drivers and pedestrians are made for ODOT to consider:

6.4.1 Older Drivers

Based on the crash data analysis, available countermeasures and workshop findings, three focus areas are proposed to increase older driver safety. These are further described below.

6.4.1.1 Intersections

Intersections accounted for 40% of older driver fatal and serious injury crashes. Therefore, intersection improvements have the potential to improve safety for older drivers. These were also voted as the top priority during the workshop. Countermeasures that ODOT can consider to improve safety at intersections for older drivers include:

- More overhead lighted signage (medium - high cost)
- More visible and durable pavement markings (low cost)
- Arrow pavement markings in advance of exclusive turn lanes (low cost)
- Prohibiting right-turn-on-red at skewed intersections (low cost)
- Using back plates for signal heads on roads with speeds of 40 mi/hr or greater (medium cost)
- Addressing limited or restricted sight distance for left turns (high cost)
- Increase use of protected left-turn lanes and use of separate signal faces for left-turns (high cost)
- Use of 12-inch signal lenses (medium cost) and back plates (low cost)

6.4.1.2 Rural Principal Arterials

Rural areas accounted for 52% of older driver fatal and serious injury crashes, and rural principal arterials accounted for 21% of the total crashes. In addition to the intersection improvements listed above which can be implemented on rural principal arterials, other specific countermeasures include:

- Larger and more reflective regulatory signs (low cost)
- Maintain consistent, visible and durable pavement markings throughout a corridor (low cost)
- Edge lanes to guide motorists (low cost)
- Treat raised medians with reflective markings (low cost)
- Raised or recessed reflective pavement markers (low cost)
- More delineators to guide drivers at night especially at curves (low cost)
- Fixed illumination in rural areas (medium cost)
- Use of wide medians and independent alignments to reduce glare from oncoming headlamps (high cost)

6.4.1.3 Licensing and Education

While some states require more frequent renewals for older drivers, Oregon requires license renewal once every eight years for both the general public and older drivers. Oregon does require that drivers 50 years or older provide proof of adequate vision for every renewal. While there is evidence that older drivers are likely to self-regulate and will not choose to drive in unsafe conditions or conditions outside their perceived abilities (Charlton et al., 2006), certain physical performance measures may not be an accurate indicator of driver safety and often need further evaluation. Age alone may not be an accurate indicator of crash risk; however, research does show that states with a valid and reliable system for assessing the competency of older drivers have seen decreases in older driver crash rates (Stefano and Macdonald, 2003). Therefore, Oregon should consider more frequent testing for older drivers, including both driving and cognitive tests.

6.4.2 Older Pedestrians

Based on the crash data analysis, available countermeasures and workshop findings, three focus areas are proposed to increase older pedestrian safety. These are further described below.

6.4.2.1 Improving Pedestrian Visibility and Illumination

Lighting is a significant factor in older pedestrian fatal and serious injury crashes. Crash data analysis showed that 20% of the crashes occurred in the dark with no street lighting, and an additional 8% and 5% of the crashes occurred during dawn and dusk, respectively, where the ambient lighting is low. Improving pedestrian visibility and illumination was voted as the top priority by the workshop participants. Countermeasures that improve illumination and visibility of the pedestrian include:

- Improved lighting at intersections and near crossing locations
- RRFB flashing beacons or other active warning devices such as flashing LED mounted "Pedestrian Crossing" warning signs

6.4.2.2 Treatments for Left Turns

Vehicles turning left accounted for 19% of the older pedestrian fatal and serious injury crashes. Eliminating the use of permissive left turns and increasing the use of protected left turns can improve older pedestrian safety as drivers often focus on the oncoming traffic looking for gaps and thereby miss the crossing pedestrians during permissive left turns. This countermeasure also improves older driver safety by reducing their cognitive load. Additionally, slowing down the left-turning vehicles may be another strategy to improve pedestrian safety. Cities such as Portland and New York City have been using wedges and centerlines to decrease vehicle speeds and improve pedestrian safety. Implementing protected pedestrian phases and leading pedestrian intervals near older communities may also improve safety.

6.4.2.3 Shorten Crossing Distances

The proportion of older pedestrian fatal and serious injury crashes when the pedestrians were in the roadway were statistically significantly different when compared to the proportions of the crashes for pedestrians between 25-44 years of age and 45-64 years of age. Shortening the crossing distance for the pedestrians will shorten their exposure time, thus increasing their safety. Specific countermeasures include:

- Pedestrian islands in the median to shorten the crossings and provide refuge (high cost)
- Curb extensions on commercial streets and bus routes (high cost)
- Raised crosswalks and road diets near older communities (high cost)

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APPENDIX A: GLOSSARY

This glossary contains the definitions of abbreviations, acronyms, and common terms.

Table A.1: Definitions of Abbreviations and Acronyms

Acronym/Abbreviation	Definition
SRODP	Special Rule for Older Drivers and Pedestrians
FAST Act	Fixing America's Surface Transportation Act
SHSP	Strategic Highway Safety Plan
MDOT	Michigan Department of Transportation
FDOT	Florida Department of Transportation
ADOT	Arizona Department of Transportation
NCHRP	National Cooperative Highway Research Program

Table A.2: Definitions of Common Terminology in the Report

Term	Definition
Older Driver	Drivers age 65 years and older
Older Pedestrian	Pedestrians age 65 years and older
Endogeneity	Results when explanatory variables in a regression model are correlated with the model's error term.
Unobservables	Attributes not present in the data and unobserved to the analyst. This can be a result of missing data or data that has not been included, collected, or reported.

APPENDIX B: NHTSA DATA

www.nhtsa.gov NHTSA

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
Alabama	N/A	N/A	No. Standard renewal – every 4 years. *Ala. §32-6-1*	N/A	Yes *Ala. §32-6-44*	Yes *Ala. §32-6-41*	N/A
Alaska	69 *AS §28.15.101*	In-person *AS §28.15.101*	No. Standard renewal – every 5 years. *AS §28.15.101*	N/A	N/A	No	N/A
Arizona	65 *A.R.S. §28-3171*	In-person at age 70 *A.R.S. §28-3172*	Yes – every 5 years. *A.R.S. §28-3171*	Vision or proof of verification of test conducted less than 3 months before submission. *A.R.S. §28-3172*	Yes *A.R.S. §28-3314*	Yes *A.R.S. §28-3051*	A driver's license is valid until age 65, unless medical restrictions require a shorter expiration period. *A.R.S. §28-3171*
Arkansas	N/A	N/A	No. Standard renewal – every 4 years. *A.C.A. §27-16-901*	N/A	Yes *A.C.A. §27-16-909*	Yes *A.C.A. §27-16-909*	N/A
California	70 *Cal.Vehicle Code §12814.5*	In-person *CA DMV*[5]	No. Standard renewal – every 5 years. *Cal.Vehicle Code §12816*	Vision *CA DMV*	Yes *CA DMV*	No	N/A

[1] This is the age at which the State Department of Motor Vehicle places restrictions or modifications on the driver.
[2] In this chart, restrictions on licensing renewal and testing mandates, when applicable, apply to drivers when they reach the older driver age, referenced in the preceding column.
[3] An examination may include, among other things, a physical examination, vision test, written driver's test, or submission of medical reports from licensed physicians.
[4] Legislatively authorized
[5] All California DMV references are sourced to information available to the public on that State's DMV Web site. *See* www.dmv.ca.gov/portal/dmv/detail/about/senior/senior_top

www.nhtsa.gov NHTSA

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
Colorado	66 *C.R.S.A. §42-2-118*	In-person or by mail *C.R.S.A. §42-2-118*	No. Standard renewal – every 5 years. *C.R.S.A. §42-2-114*	Renewal by mail must include a signed statement from an optometrist or ophthalmologist attesting to an eye exam within the past 6 months and the results. *C.R.S.A. §42-2-118*	Yes *C.R.S.A. §42-2-111*	Yes *C.R.S.A. §42-2-112*	If deemed appropriate, the DMV may require a driver involved in a fatal motor vehicle crash to submit to an examination. But if the DMV fails to mail notice within 90 days of receiving notice of the crash, the DMV shall not require examination based on that crash. *C.R.S.A. §42-2-111*
Connecticut	65 *C.G.S.A. §14-41a*	N/A	Yes – every 2 years (optional)[6]. Standard renewal – every 6 years. *C.G.S.A. §§14-41; 14-41a*	N/A	Yes *C.G.S.A. §14-46e*	Yes *C.G.S.A. §14-46b*	N/A
Delaware	N/A	N/A	No. Standard renewal – every 8 years. *21 Del.C. §2715*	N/A	Yes *21 Del.C. §2724*	Yes *21 Del.C. §2723*	N/A
District of Columbia	70 *18 DCMR §111*	In-person *18 DCMR §111*	No. Standard renewal – every 8 years. *18 DCMR §110*	Vision; doctor's statement deeming driver mentally and physically qualified to operate a motor vehicle *18 DCMR §302*	N/A	No	Discretionary refusal to renew is specifically noted with regards to persons with diabetes, seizure disorders, Alzheimer's, hearing impairment. *D.C. Code §18-106*

[6] Drivers age ≥ 65 are permitted to renew for either a 2-year period or the general 6-year period.

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Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
Florida	80 *F.S.A. §322.18*	In-person, unless a vision test was submitted electronically in advance by a doctor or optometrist. *F.S.A. §322.18*	Yes – every 6 years. Standard renewal – every 8 years. *F.S.A. §322.18*	Vision *F.S.A. §322.18*	Yes *F.S.A. §322.221*	Yes *F.S.A. §322.125*	N/A
Georgia	60/64 *Ga. Code Ann. §40-5-32*	N/A	Yes – every 5 years. Standard renewal – every 8 years. *Ga. Code Ann. §40-5-32*	Vision test for drivers age ≥ 64 *Ga. Code Ann. §40-5-32*	Yes *Ga Comp. R. & Regs. 375-3-5-.01*	Yes *Ga Comp. R. & Regs. 375-3-5-.01*	Every veteran's or honorary license[7] expires every 8 years until the holder reaches age 65. *Ga. Code Ann. §40-5-32*
Hawai'i	72 *HRS §286-106*	N/A	Yes – every 2 years. Standard renewal – every 8 years.[8] *HRS §286-106*	N/A	Yes *HAR §19-122-355*	Yes *HRS §286-4.1*	Any driver, regardless of age, must renew in person, or submit proof of an examination not more than 6 months prior to the license expiration date, which states the driver has met the physical requirements established by the state DMV. *HRS §286-107*
Idaho	63 *I.C. §49-319*	In-person for drivers age ≥ 70. *IDAPA 39.02.76.011*	No – But drivers age ≥ 63 must renew every 4 years. *I.C. §49-319*	N/A	N/A	No	N/A

[7] An honorably discharged veteran is entitled to a free veteran's driver's license.

[8] Standard renewal for drivers 24 years and younger is every 4 years. *HRS §286-106*

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
Illinois	75/81 *625 ILCS 5/6-109; 5/6-115*	N/A	Yes – every 2 years for drivers age 81-86; 12 months for drivers age ≥ 87. Standard renewal – every 4 years. *625 ILCS 5/6-115*	Vision test and actual demonstration of ability to exercise ordinary and reasonable control of the motor vehicle for drivers age ≥ 75. *625 ILCS 5/6-109*	Yes *625 ILCS 5/6-907*	Yes *625 ILCS 5/6-902*	Every driver shall report to the Secretary of State any medical condition that is likely to cause loss of consciousness or any loss of ability to safely operate a motor vehicle within 10 days of the driver becoming aware of the condition. *625 ILCS 5/6-116.5*
Indiana	75 *IC §9-24-12-1*	In-person *IC §9-24-12-5*	Yes – every 3 years for drivers age 75-84 and 2 years for drivers age ≥ 85. Standard renewal – every 6 years. *IC §§9-24-12-1; 9-24-12-10*	Vision *IC §9-24-12-5*	N/A	Yes *IC §9-14-4-1*	N/A
Iowa	70 *IA DMV*	In-person or by mail for drivers age 70 and over. *IA DMV*[9]	Yes – every 4 years for drivers age 70; 3 years for 71; 2 years for ≥72. Standard renewal – every 8 years. *IA DMV; I.C.A. §321.196*	Vision *I.C.A. §321.186A*	N/A	Yes *Iowa Admin. Code 761-600.4*	N/A
Kansas	65 *K.S.A. §8-247*	N/A	Yes – every 4 years. Standard renewal term – every 6 years. *K.S.A. §8-247*	N/A	N/A	Yes *K.S.A. §8-255b*	N/A

[9] All Iowa DMV references are sourced to information available to the public on that State's DMV Web site. *See* www.iowadot.gov/mvd/ods/olderdrivers.htm

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
Kentucky	N/A	N/A	No. Standard renewal – every 4 years. *KRS §186.412*	N/A	Yes *601 KAR 13:090*	Yes *601 KAR 13:090*	N/A
Louisiana	70 *La. R.S. §32:412*	In-person *La. R.S. §32:412*	No. Standard renewal – every 4 years.[10] *La. R.S. §32:412*	N/A	Yes *La. R.S. §§32:424; 40:1356*	Yes *La. R.S. §40:1351*	Persons age ≥ 60, applying for a license for the first time in LA shall attach a report from a doctor or optometrist indicating visual ability, and from a licensed doctor indicating physical condition, including any defects that would impair the driver's ability to exercise reasonable control of a motor vehicle. *La. R.S. §32:403.1*
Maine	40/62/65 *29-A M.R.S.A. §1303*	N/A	Yes – every 4 years for drivers age ≥ 65. *29-A M.R.S.A. §1406-A*	Drivers age ≥ 40 must pass a vision test at the time of their license renewal. Persons age ≥ 62 must pass a vision test at each renewal. *29-A M.R.S.A. §1303*	Yes *29-A M.R.S.A. §1258*	Yes *29-A M.R.S.A. §1258*	N/A

[10] Effective July 1, 2015, standard renewal shall be every 6 years.

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements
(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
Maryland	40 *MD Code, Transportation §16-115*	Vision test required for persons age ≥ 40; mail or electronic renewal is not permitted. *MD Code, Transportation §16-115*	No. Standard renewal – every 8 years. *MD Code, Transportation §16-115*	Persons age ≥ 40 must take a vision test upon renewal. *MD Code, Transportation §16-115.*	N/A	Yes *MD Code, Transportation §16-118*	If a person age ≥ 70 applies for a new license, he/she must present proof of previous satisfactory operation of a motor vehicle or written certification from a licensed doctor attesting to general physical and mental qualifications. *MD Code, Transportation §16-103.1*
Massachusetts	75 *M.G.L.A. 90 § 8*	In-person *M.G.L.A. 90 § 8*	No. Standard renewal – every 5 years. *M.G.L.A. 90 § 8*	Vision *M.G.L.A. 90 §8*	Yes *540 CMR 24.03*	Yes *M.G.L.A. 90 §8C*	N/A
Michigan	N/A	N/A	No. Standard renewal – every 4 years. *M.C.L.A. §257.314*	N/A	Yes *M.C.L.A. §257.320*	Yes *Mich. Admin. Code R. 257.852; Michigan.gov/SOS*	A doctor or optometrist who submits a report regarding a driver's physical or mental qualifications to operate a motor vehicle shall recommend a period of suspension (at least 6 months for an operator's license; at least 12 months for a CDL), upon a finding that the driver cannot operate a motor vehicle in such a manner that would jeopardize the safety of persons and property. *M.C.L.A. §333.5139*
Minnesota	N/A	N/A	No. Standard renewal – every 4 years. *M.S.A. §171.27*	N/A	Yes *M.S.A. §171.13; Minnesota Rules 7409.2800*	Yes *Minnesota Rules 7410.3000*	The Commissioner of Public Safety shall not require an examination for the reason that a driver has attained a certain age. *M.S.A. §171.13*

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
Mississippi	N/A	N/A	No. Standard renewal – every 4 or 8 years at the driver's option. *Miss. Code Ann. §63-1-47*	N/A	Yes *Miss. Admin. Code 31-1:9.4*	Yes *Miss. Admin. Code 31-1:9.4*	N/A
Missouri	70 *V.A.M.S. §302.177*	N/A	Yes – every 3 years. Standard renewal – every 6 years. *V.A.M.S. §302.177*	N/A	Yes *V.A.M.S. §302.291*	Yes *V.A.M.S. §302.292*	N/A
Montana	75 *MCA §61-5-111*	N/A	Yes – every 4 years. Standard renewal – every 8 years. *MCA §61-5-111*	N/A	Yes *MCA §61-5-207*	Yes *MCA §61-5-125*	The age of a driver, by itself, does not constitute evidence of a condition requiring reexamination or a medical evaluation. *MCA §61-5-207*
Nebraska	72 *Neb.Rev.St. §60-4,122*	E-renewal is not permitted. *Neb.Rev.St. §60-4,122*	No. Standard renewal – every 5 years. *Neb.Rev.St. §60-490*	N/A	Yes *Neb.Rev.St. §60-4,118*	Yes *Neb.Rev.St. §60-4,118.02*	N/A
Nevada	65/71 *NAC §§483.043; 483.430*	Mail renewal permitted for drivers age ≥ 71 only with a letter from a doctor attesting to the ability of the driver to operate a motor vehicle and the driver's visual acuity. *NAC 483.430*	Yes – every 4 years for drivers age ≥ 65. Standard renewal – every 4 or 8 years.[11] *NAC §483.043*	N/A	Yes *NAC 483.320*	Yes *NAC §483.400*	N/A

[11] Effective January 1, 2018, all license renewals shall occur every 8 years, except for drivers age ≥ 65.

www.nhtsa.gov NHTSA

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
New Hampshire	N/A	N/A	No. Standard renewal – every 5 years. *N.H. Rev. Stat. §263:10*	N/A	N/A	Yes *N.H. Rev. Stat. §263:6-b*	Every driver who appears in person to renew his/her license must complete a visual acuity examination. But every driver who is eligible to renew his/her license online[12] shall attest to the fact that he/she meets the visual acuity standards. *N.H. Code Admin. R. Saf-C 1007.01*
New Jersey	N/A	N/A	No. Standard renewal – every 48 months. *N.J.S.A. 39:3-10*	N/A	Yes *NJ DMV*	Yes *NJ DMV*	Every driver shall take and successfully pass a screening of his/her vision at least once every 10 years as a condition for renewal. *N.J.S.A. §39:3-10c*
New Mexico	67 *NMSA §66-5-19*	In-person or by mail. *NM DMV*[13]	Yes – every 4 years for drivers age 67-74; every year for drivers age ≥ 75. Standard renewal – every 4 or 8 years (at driver's option). *NMSA §66-5-19*	N/A	Yes *NMSA §66-5-31*	Yes *NMSA §66-5-6*	N/A
New York	N/A	N/A	No. Standard renewal – every 8 years. *Veh & Traf §506*	N/A	Yes *Veh & Traf §506*	Yes *Veh & Traf §541*	N/A

[12] A license may be renewed online only once in every other license renewal cycle.

[13] All New Mexico DMV references are sourced to information available to the public on that State's DMV Web site. *See* www.mvd.newmexico.gov/

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
North Carolina	66 *N.C.G.S.A. §20-7*	N/A	Yes – every 5 years. Standard renewal – every 8 years. *N.C.G.S.A. §20-7*	N/A	Yes *N.C.G.S.A. §20-29.1*	Yes *N.C.G.S.A. §20-9*	The DMV may not require a person who is at least 60 years old to parallel park a motor vehicle as part of a road test. *N.C.G.S.A. §20-7*
North Dakota	78 *NDCC §39-06-19*	N/A	Yes – every 4 years. Standard renewal – every 6 years. *NDCC §39-06-19*	N/A	Yes *NDCC §39-06-34*	Yes *NDAC 37-08-01-01*	A court may direct the DMV director to require an individual to submit to reexamination. *NDCC §39-06-34.1*
Ohio	N/A	N/A	No. Standard renewal – every 4 years. *R.C. §4507.09*	N/A	N/A	No	N/A
Oklahoma	N/A	N/A	No. Standard renewal – every 4 years. *47 Okl.St.Ann. §6-115*	N/A	Yes *Okla. Admin. Code 595:10-5-17; 47 Okl.St.Ann. §6-120*	Yes *47 Okl.St.Ann . §6-118*	N/A
Oregon	50 *OAR 735-062-0060*	N/A	No. Standard renewal – every 8 years. *O.R.S. §807.130*	All drivers age ≥ 50 must have their eyesight tested by the DMV prior to each renewal. *OAR 735-062-0060*	N/A	No	While there is no established medical advisory board, there is a medical determination officer who determines whether a person is eligible for a license in light of mental and physical impairment concerns. *O.R.S. §807.090*
Pennsylvania	N/A	N/A	No. Standard renewal – every 4 years. *75 Pa.C.S.A. §1514*	N/A	Yes 75 Pa.C.S.A. §1519	Yes 75 Pa.C.S.A. §1517	N/A

www.nhtsa.gov NHTSA

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
Puerto Rico	N/A	N/A	No. Standard renewal – every 6 years. *9 L.P.R.A. §5064*	N/A	Yes *9 L.P.R.A. §5071*	Yes *9 L.P.R.A. §5060*	N/A
Rhode Island	75 *Gen.Laws 1956, §31-10-30*	N/A	Yes – every 2 years. Standard renewal – every 5 years. *Gen.Laws 1956, §31-10-30*	N/A	N/A	Yes *Gen.Laws 1956, §31-10-44*	N/A
South Carolina	65 *Code 1976 §56-1-210*	N/A	Yes – every 5 years. Standard renewal – every 10 years. *Code 1976 §56-1-210*	Vision test *Code 1976 §56-1-220*	Yes *Code 1976 §56-1-270*	Yes *Code 1976 §56-1-221*	Any driver involved in 4 crashes within a 24-month period may be required to take any portion of the driver's license examination if the director of the DMV deems appropriate. *Code 1976 §56-1-225*
South Dakota	65 *SDCL §32-12-43.1*	Mail or electronic renewal permitted if vision statement is included. *SDCL §32-12-43.1*	No. Standard renewal – every 5 years. *SDCL §32-12-42*	Vision statement signed by a licensed optometrist or ophthalmologist. *SDCL §32-12-43.1*	Yes *SDCL §32-12-46*	No	N/A
Tennessee	N/A	N/A	No. Standard renewal – every 5 years. *T.C.A. §55-50-337*	N/A	Yes *Tenn. Comp. R. & Regs. 1340-01-04-.07*	Yes *Tenn. Comp. R. & Regs. 1340-01-04-.06*	A driver required to undergo re-examination may take the written and/or vision portion of the driver examination test without limitation, and the on-the-road skills portion up to 3 times. *Tenn. Comp. R. & Regs. 1340-01-04-.07*

NHTSA www.nhtsa.gov

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
Texas	79/85 *V.T.C.A., Transportation Code §§521.274; 521.2711*	In-person for drivers age ≥ 79. *V.T.C.A., Transportation Code §521.274*	Yes – every 2 years. Standard renewal – every 6 years. *V.T.C.A., Transportation Code §521.2711*	N/A	N/A	Yes *V.T.C.A., Health & Safety Code §12.092*	N/A
Utah	65 *U.C.A. 1953 §53-3-214*	N/A	No. Standard renewal – every 5 years. *U.C.A. 1953 §53-3-214*	Vision test *U.C.A. 1953 §53-3-214*	Yes *U.C.A. 1953 §53-3-221*	Yes *U.C.A. 1953 §53-3-303*	N/A
Vermont	N/A	N/A	No. Standard renewal – every 4 years. *23 V.S.A. §601*	N/A	N/A	No	The DMV may designate licensed doctors, ophthalmologists, oculists and optometrists as examiners of motor vehicle operators. *23 V.S.A. §637*
Virginia	75[14] *Va. Code Ann. §46.2-330*	In-person[15] *Va. Code Ann. §46.2-330*	Yes – every 5 years. Standard renewal – every 8 years. *Va. Code Ann. §46.2-330*	Vision test (unless proof of test completed within 90 days)[16] *Va. Code Ann. §46.2-330*	N/A	Yes *Va. Code Ann. §46.2-204*	N/A
Washington	N/A	N/A	No. Standard renewal – every 5 years. *RCWA §46.20.181*	N/A	Yes *RCWA §46.20.305*	No	N/A

[14] Effective January 1, 2015
[15] Effective January 1, 2015
[16] Effective January 1, 2015

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

State	"Older Driver" Age[1]	Restrictions on Licensing Renewal[2]	Accelerated Renewal & Term (if applicable)	Testing Mandates	State DMV Suspension Authority for Failure to Submit to Examination[3]	Medical Advisory Boards[4]	Other Information
West Virginia	N/A	N/A	No. Standard renewal – every 8 years. *W. Va. Code §17B-2-12*	N/A	Yes *W. Va. Code §17B-3-7*	No[17] *W. Va. Code §17B-2-7a*	N/A
Wisconsin	N/A	N/A	No. Standard renewal – every 8 years. *W.S.A. §343.16*	N/A	N/A	Yes *W.S.A. §343.16*	N/A
Wyoming	N/A	N/A	No. Standard renewal – every 4 years. *W.S. 1977 §31-7-119*	N/A	Yes *W.S. 1977 §31-7-122*	No	N/A

Notes:

Due to increased physical impairments that many drivers face as they age, most states have enacted legislation that places additional restrictions or requirements on older drivers. These laws include license renewal requirements, accelerated license renewal terms, and testing mandates. Medical Advisory Boards are addressed, as well.

Please note that most States have legislation specifying a process for a third party to request that a driver submit to examination or re-examination. For example, a criminal justice agency, physician or member of the general public may request cancellation of a driver's license, but must explain the need for re-evaluation. In some cases legislation specifies that such a request may not be anonymous. In most cases this process is not exclusive to older drivers. These provisions are not included in the table, as these provisions are common to most states and are typically not exclusive to older drivers, but can be applicable to any licensed driver with medical conditions.

Key Terms:

- "Older Driver" Age – the age at which a State may set forth certain requirements for driver's license renewal. Multiple ages may be noted, reflecting multiple requirements, as applicable.
- Restrictions on Licensing Renewal – Generally, this category includes type of renewal required (in-person versus online, electronically, by mail, etc.) once a driver reaches the "Older Driver" age.

[17] The code provides that "the driver's licensing advisory board shall continue to exist until the first day of July, [2009]."

www.nhtsa.gov NHTSA

Key Provisions of State Laws Pertaining to Older Driver Licensing Requirements

(Current as of October 2014)

- Accelerated Renewal & Term (if applicable) – addresses whether a State requires an accelerated, or shorter, renewal period once a driver reaches the "Older Driver" age, and if so, the term (i.e., every 5 years). Standard renewal term is also provided.
- Testing Mandates – includes types of testing required, if any, for older driver license renewal (i.e., vision test, physician's statement).
- Suspension Authority by State Motor Vehicle Department for Failure to Submit to Examination – indicates if a State's DMV has the authority to suspend or revoke an older driver's license for failure or refusal to submit to examination. An examination may include, among other things, a physical examination, vision test, written driver's test, or submission of medical reports from licensed physicians.
- Medical Advisory Boards – addresses whether the State has a legislatively authorized Medical Advisory Board in conjunction with the DMV.

APPENDIX C: WORKSHOP PARTICIPANTS

Name	Agency
Frank Belleque	ODOT
Doug Bish	ODOT
Keith Blair	ODOT
Tim Burks	ODOT
Rodger Gutierrez	ODOT
Marsha Hoskins	ODOT Public Transit
Mark Joerger	ODOT Research
Kelly Kapri	ODOT
Angela Kargel	ODOT
Marie Kennedy	ODOT
Ernest Kim	ODOT
Justin King	ODOT
Scott Kramer	ODOT
Heidi Manlove	ODOT
Christina McDaniel-Wilson	ODOT
Shelly Oylear	Washington County
Amanda Salyer	ODOT
Jeff Wise	ODOT
Chris Monsere	PSU
Sirisha Kothuri	PSU
Jason Anderson	PSU
David Hurwitz	OSU
Jasmine White	OSU

APPENDIX D: WORKSHOP AGENDA

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ODOT SPR 828
ADDRESSING OREGON'S RISE IN DEATHS AND SERIOUS INJURIES FOR SENIOR DRIVERS AND PEDESTRIANS

Tuesday 11/26/19
8 AM – 1 PM

ODOT Technical Leadership Center
4040 Fairview Industrial Dr. SE
Salem, OR 97302

Diamond Lake Room

WORKSHOP AGENDA

Objective: Help the research team identify policies, design guidance or systemic opportunities for improving safety based on your experience and responsibilities in transportation.

8:00–8:30	Check-in, Coffee, Pastries
8:30–9:15	Introductions and Project Overview
9:15–10:15	Breakout Session 1 – Older Driver Safety Issues
10:15–10:30	Break
10:30–11:30	Breakout Session 2 – Older Pedestrian Safety Issues
11:30–12:15	Working Lunch
12:15–1:00	Wrap up and Report Out